The Convergence of Geo-Space and Network Space in City Region Development in China: taking the Mid-Yangtze River City Region as an example

PhD in Real Estate and Planning

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Declaration of Original Authorship

Declaration: I confirm that this is my own work and the use of all materials from other sources has been properly and fully acknowledged.

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Abstract:

This thesis is an empirical examination of the spatial mechanisms of city region development in China taking the Mid-Yangtze River (MYR) city region as an example, and investigating in particular, how spatial mechanisms are affected by the relationships between spatial factors and network capital. Conventional city region theory assumes that regional development is spatially homogeneous across spatial units and determined by indigenous factors. By using GIS techniques, Social Network Analysis (SNA) and Spatial Econometric Modelling on data from the National Bureau of Statistics of China (NBS), the Zephyr database, and the State Intellectual Property Office of China (SIPO), this thesis challenges that assumption.

Chapter 2 outlines the interaction between cities and world economy change. Chapter 3 focuses on urban and regional change in the context of globalisation specifically, showing the importance of the city region in a new global economic context. Chapter 4 advances a spatial framework to investigate city region development, while Chapter 5 advances a network framework to investigate city region development, which builds two main research frameworks for the thesis.

The next three chapters represent the main empirical contribution of this thesis. In terms of spatial patterns, Chapter 6 shows that the MYR city region is characterised by coexisting spatial associations and heterogeneity. Chapter 7 calculates the network capital that is embedded in cities' strategic positions across territories. In terms of underlying driving mechanisms, Chapter 8 demonstrates that city region development is affected by the simultaneity of spatial spillovers based on geographic proximity and network capital based on strategic positions over spatial constraints.

Chapter 9 discusses the main empirical findings and concludes by operationalising complexity theory as a means of understanding city region spatial driving mechanisms. Combining geo-space and network space mechanisms in analysis is found to have value for dissecting the complexity of city region development.

Key Words: Spatial Heterogeneity, Spatial Association, Network Capital, Spatial Spillovers, City Region Development, China

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1. INTRODUCTION

The research reported on in this thesis is concerned with the convergence of geographical (geo-) space and network space in city region economic development in China. The city region is conceived for purposes of the research as an urbanised sub-national formation where a number of cities in geographical proximity to each other are interlinked by intensive functional relations (Hall and Pain, 2006). Pred (1977) contended that cities are not sustaining themselves independently but are interconnected economically and spatially in a broader regional context. The research investigates how Chinese cities are interconnected in a regional context from geo-space and network space perspectives and their association, taking the Mid-Yangtze River city region (MYR) as an example.

1.1 Background to Study

In the contemporary world, complex scale-sensitive geo-processes and structures can emerge from local interactions between cities. On the other hand, a complex network space can emerge from multidirectional inter-city interactions that are little affected by distance constraints. Thus, geo-space and network interaction mechanisms have been recognised as significant underlying drivers of contemporary regional development. Geo-spatial mechanisms are intrinsically based on city physical proximity, while network space mechanisms are derived from the new logic of a 'space of flows' structured by the circulation of virtual flows facilitated by advances in informational and communications technology (ICT) developments, which is superseding the logic of the 'space of places' (Castells, 1996). Nevertheless, few studies have investigated the relationships and associations between geo-spatial proximity and network properties in driving city region development in China, yet this is an important issue for major Chinese urbanisation and economic development programmes. In this context, the overarching aim of the research has been to fill this gap for a Chinese city region undergoing economic transition alongside urbanisation that has been identified in State planning policy as a 'growth pole' in a national context (see Section 3.4). Thus, in addition to building an analytical framework for the investigation of city region development by combining geo-spatial and network capital mechanisms, the subject of the research thereby has significance for China's regional development planning priorities. Empirically, the research attempts, first, to unveil the MYR city region geo-spatial patterns of economic activities, second, to identify the network capital that is embedded in MYR inter-city networks and, third, to incorporate spatial factors, indigenous factors and network factors in order to shed light on the city region economic development process.

1.2 Research Issue and Objective

The rationale of geo-spatial mechanisms is based on the ‘first law of geography’ as articulated by Tobler (1970, p. 234), that “everything is related to everything else, but near things are more related than distant things”. In other words, according to a geo-spatial logic, the intensity of inter-city relations will be determined by geographical distance, since overcoming spatial constraints will consume energy and resources that actors try to minimize as rational utility maximisers (Miller, 2004). Thus, cities that are physically proximate to each other will be defined by interactions that are advantaged by time-cost reductions which will, in turn, shape the pattern of development as an outcome. Furthermore, geo-spatial interactions and their patterns are emphasized by the ‘New Economic Geography’ (Puga, 1999; Fujita *et al.*, 2001) and endogenous growth theory (Aghion *et al.*, 1998; Aghion and Howitt, 1998) as significant factors in fuelling economic development in contrast to standard econometric models prioritising the independence of observations that have become less applicable in the context of intensive local interactions.

On the other hand, in the context of globalisation and technological breakthroughs, the cost of overcoming spatial constraints is reduced to a great degree, which challenges the first law of geography. In particular, the rise of the knowledge economy generates intensive virtual flows with few spatial constraints, such as knowledge, information, financialised capital that are characteristics of advanced business (producer) services (APS) and patterns of accumulation (Wood, 1991). As Castells (1999) claimed, urban spaces have become “the material arrangements” allowing for “simultaneity of social practices without territorial contiguity” (p.295). Therefore, geo-spatial thinking based on city physical proximity offers only a partial view in illuminating contemporary urban spatial relations which are now also characterised by virtual flows. The research therefore explores the contribution of city network capital in network space to city region development and its spatial association in the MYR city region.

In terms of the two distinctive geo-spatial and network space rationales, Watts (1999) discerned in *Small Worlds: The Dynamics of Networks - Between Order and Randomness,* that *near* and *distant* can interact to create complex city network interconnections. The city region is selected as the scale for the investigation of the convergence of *near* and *distant* in regional development in this research. This choice reflects the characterisation of the city region not only by locational proximity effects but also by synergy effects that are created by distance-free flows. As Scott (2001a, p18) articulated, "global city-regions come to function increasingly as the motors of global economy, as dynamic local networks of economic relationships caught up in more extended worldwide webs of interregional competition and exchange". However, there are few studies that explore the association between *near* and *distant* relations in the process of regional development for emerging city regions in China.

Reflecting pressing research issues and knowledge gaps in China, the thesis aims to shed light on the spatial mechanisms of city region development processes and establish a new conceptual framework to inform policies and economic actor investments and development strategies. The general research objectives are specified as:

1. Illuminate spatial patterns and spatial characteristics of the MYR city region economy.

2. Establish an MYR inter-city network where cities are nodes connected by distance-free flows, and calculate network centralities and individual cities' network capital.

3. Clarify the contribution of physical capital, human resources and technological advances to MYR city development and their spatial relationship with neighbouring cities within the city region.

4. Clarify the contribution of capital flows, human flows and commodity flows to urban growth and their spatial relationship with neighbouring cities within the MYR city region.

5. Test the contribution of MYR calculated network capital to urban growth and its embeddedness in local spatial mechanisms.

6. Build a conceptual framework relevant for policy, practice and MYR city region conceptualisation.

1.3 Research Development

Specification of the research questions and the methods identified to address them have emerged from the consideration of existing theoretical and empirical literature and the exploration of potential paths for the empirical research and obstacles encountered. This section briefly introduces the development of the research in chronological order as presented in the thesis.

The initial research proposal focused on the general research question, ‘What indigenous factors and diverse flows contribute to urban competitiveness under globalisation in China’. This question was inspired by Castells’ network society thesis (Castells, 1996, 1999) and Porter’s works on competitiveness (Porter, 1990, 1998), respectively. In terms of methods, it was originally intended to employ standard econometric models to identify indigenous factors in China on the one hand and Taylor’s Interlocking Office Network (ION) model used in World City Network analysis (Taylor, 2001a, 2004; Taylor *et al.*, 2002) to unveil the inter-city network in China on the other hand. The rationale behind adopting the ION model approach to analysis reflected Sassen’s (1991) ‘global city’ theory whereby the connectedness of cities in globalisation is characterised importantly by the concentration of APS[1] sectors (Sassen, 1991, 2000) and estimation of service values as an approximation of inter-city relations, and thereby city network structures.

Offices in banking/finance, accountancy, law, advertising, and management consulting APS networks located in global cities world-wide are studied in order to map how these intrafirm networks are connecting and interlinking cities globally (Taylor, 2001a; Taylor *et al.*, 2002; Taylor, 2004; Derudder and Taylor, 2016). Computing the strategic importance of cities in all APS networks reveals otherwise invisible patterns of city connectivity that are an outcome of a spatial dynamic of global office dispersal and global city concentration (Sassen, 1991). By estimating the office functions of APS firms for cities worldwide, Taylor’s ION model thereby unveils inter-city networks in the global city system. However, the use of service values as a proxy for the inter-city flows and the actual degree of connectivity between any two cities has been subject to critical debate (see for example, Nordlund, 2004). Furthermore, a pragmatic problem for the MYR research revealed by preliminary investigation of the Chinese urbanisation context is that global APS sectors are not sufficiently representative of its economic structures which are undergoing early stage economic transition in globalisation (see the discussion in Section 5.3). Given active direct capital flows and data availability in the MYR city region, the research interest therefore

[1] APS sectors are defined as the business service sectors that provide wholesale specialised services or high-value knowledge products to producers, including banking and financial service, accountancy, consultancy, advertising, and law services.

shifted from indigenous factors and global APS connectivity to *near* vs *distant* spatial associations between inter-city financial flows that are more directly representative of network capital in the 'fuzzy ends' of the World City Network (Markusen, 2003). Specifically, the focus turned to Mergers & Acquisitions (M&A) flows as direct flows interlinking MYR cities, with Social Network Analysis (SNA) and Spatial Econometric Modelling (SEM) as appropriate analytical methodologies (see literature review in Chapters 4 and 5).

The specific focus of the research object reflects the recent rise of the city region in China as a focal point for the development of inter-city relations and spillover processes and the void in local studies of these processes. A review of Scott's work (2001b) pointed to the city region is an ideal laboratory for testing economic development processes associated with both inter-city networks and indigenous factors. In addition, a review of empirical studies in China specifically found that most studies have put a spotlight on growth dynamics in coastal city regions (Yangtze River Delta, Pearl River Delta and Beijing-Bohai Rim 'Jing-Jin-Ji'), leaving a research void for China's inland city regions. In particular, during ongoing economic transition, the State focus on the MYR city region as a national growth pole has postulated that the region has become a strategic location for the absorption of surplus productivity from the coast and for the formation of connectivity between the developed east and the underdeveloped west of China (see evidence presented in Section 3.5). The final research design reflects a decision to address the research gap on inland growth dynamics by exploring the contribution of productive indigenous factors and financial capital flows to the economic development of the MYR city region.

Study of the city region literature indicates that traditional 'central place' (Christaller, 1966) and 'city competitiveness' (Porter, 1990) theories may not be compatible with the contemporary development processes of city regions internally. Recent city region literature instead puts more weight on functionality and associated synergy effects (for example, Scott, 2001b; Hall and Pain, 2006) rather than on the hierarchical relations implied by service provision of central places to regional hinterlands or the competitive aggregation of city attributes. Therefore, the exploration of indigenous factors alone in regional growth models may fail to represent and explain economic development in city regions appropriately. A review of related international empirical works found that the detection of spatial associations and the use of spatial econometric models can improve regional growth models and explain synergy effects across territorial boundaries. The research interest therefore shifted from indigenous factors specifically to their spatial association in a city region growth model.

In terms of the second original research interest in ‘diverse flows’, given the intention to apply spatial econometric models to improve growth modelling for a rapidly urbanizing city region, network space is another important aspect in the investigation (Castells, 1996). Network conceptualization as applied to city region development remains subject to debate, however review of the ‘calculative’ network capital discourse in the international literature suggested that such capital presented a potentially theoretically strong methodology for use in the MYR research context (Bathelt and Taylor, 2002; Huggins, 2010; Kramer *et al.*, 2011). Rather than one kind of structure, the concept of calculative network capital regards a network as a strategic resource that can generate actual profit. However, network capital analysis has rarely been applied in empirical studies in a spatial sense, particularly for city region studies. A decision was thus taken to examine both spatial associations and network capital in the MYR city region. If network capital can be regarded as an endogenous growth factor, understanding the spatial association of network capital in regional development becomes possible, shedding light on the resonance between spatial effects and network capital in city region development processes. Review of empirical studies of network capital found that the spatial association of network capital has not been explored, making the findings from the final direction of the research an original contribution to the literature. The title of the thesis reflects the final research direction: *the convergence of geo-space and network space in city region development in China: taking the MYR city region as an example*.

The decision taken by the end of the first year of the research to examine both geo-space and network space mechanisms in city region development was followed by the testing of methodological options and issues, and the development of appropriate analytical techniques to build city region growth models. In the first step, several spatial statistical techniques and GIS skills were acquired to unveil the spatial patterns of economic activities in the MYR city region by detecting spatial heterogeneity and associations. In order to incorporate network capital in the city region growth model, the calculation of network capital embedded in inter-city networks is also necessary. As already discussed, in scoping appropriate methodologies, it was evident that the ION model was not an appropriate analytical approach for the MYR city region due to the nature of the city region in terms of economic activity and related conceptual and methodological contradictions (see discussion in Section 5.3). The ION model was developed for analysis of cities where global APS sectors are well established, however the MYR is an emergent globalising city region where manufacturing remains the predominant industry; in consequence, data on APS sectors at the firm level, are neither available nor relevant metrics for the MYR case. Review of related network analyses found that SNA from which ION analysis was originally derived (Smith and Timberlake, 1995; Taylor 2001, 2004) is nonetheless an appropriate methodological approach since it does not rely on any specific sector and can investigate any network constructed by direct flows. The SNA approach can thereby estimate network patterns and city positions which correspond with the network capital discourse. Therefore, the research design employed an SNA approach to calculate MYR network capital. Econometric modelling was adapted for specifically spatial econometric modelling in order to build a spatial regional growth model that would illuminate the convergence of spatial proximity effects and distance-free network capital in driving the MYR city region economy.

Finally, following the review of the analytical research results and relevant literature, it was decided to introduce a Complex Adaptive System (CAS) paradigm, or complexity theory, as a conceptual framework for discussion of the findings. Despite the drawback of adopting a case study approach to the research in terms of inability to generalise on the basis of the city region specific results, it is hoped that methodological learning from the MYR case regarding the convergence of geo-space and network space will inform research development in other emerging functional city regions to benefit the practices of economic agents and policy makers.

1.4 Selection of Research Case and Data

There are four main reasons for the selection of China's MYR city region as the research case. Firstly, given increasing competition from other emerging economies and rising labour costs in China, the national government is implementing a series of policies to facilitate economic restructuring from a low value-added manufacturing to a high value-added services and knowledge economy. At the same time, policies are seeking to promote the transfer inland of industrial activity from the economically developed coast in order to achieve a more geographically balanced and sustainable economy and to relieve regional inequality (see Section 3.4). As shown in Figure 1, the MYR city region has a relatively strong industrial base and low labour costs (Wang *et al.,* 2013) coupled with an advantageous geographic location that is proximate to the economically developed coastal Yangtze River Delta and Pearl River Delta city regions and it is also well connected by transportation arteries to the eastern and southern coasts (see Section 3.4). Thus, the MYR city region has been identified in a series of policies as one of five national level city regions in China's planning scheme that are expected to support economic transition and industrial transfer strategies, for example, the *Rise of Central China* (State Council, 2004), *National Major Functional Region Planning* (State Council, 2010), *State Council Instructions on Improving the Yangtze River Economic Belt* (State Council, 2014) and *Mid-Yangtze City Region Development Plan* (State Council, 2015) (see policy review in Section 3.4). Secondly, as discussed in Section 2.2, China's developmental path is characterised by heterogeneous regional models (Peck and Zhang, 2013; Zhang and Peck, 2016). In contrast to the coastal city regions which have established relatively mature coordinative economic development mechanisms, as an emerging functionally networked economic region, the MYR city region is subject to strong policy incentivisations, which can provide important insights to shed light on an inland city region development model. However, the MYR city region has thus far received little research attention, creating a research void that can be filled by this case study. Thirdly, cities in the region have historical and cultural linkages. For example, the city region is strongly influenced by the Chinese 'Chu Culture[2]' and was under the same regional jurisdiction during the Warring States period and Han, Tang, Yuan and Mining dynasties. Lastly, regarding the spatial scale of the city region studied in this research, by referring to the official regional planning scheme for the city region, all cities from the Hubei, Hunan and Jiangxi provinces are included in the empirical analysis allowing comprehensive investigation of the spatial patterns and network structures of the emerging nationally significant functional city region economy.

[2] Chu culture is a historically significant strand of Chinese culture, covering most of the Hubei and Hunan provinces and part of Jiangxi Province. It is known for its high production level of ritual bronzes, silk and embroidery, and pottery etc., its great achievements in artistic fields, e.g. the Odes of Chu, shared similar dialects, and local religious beliefs.

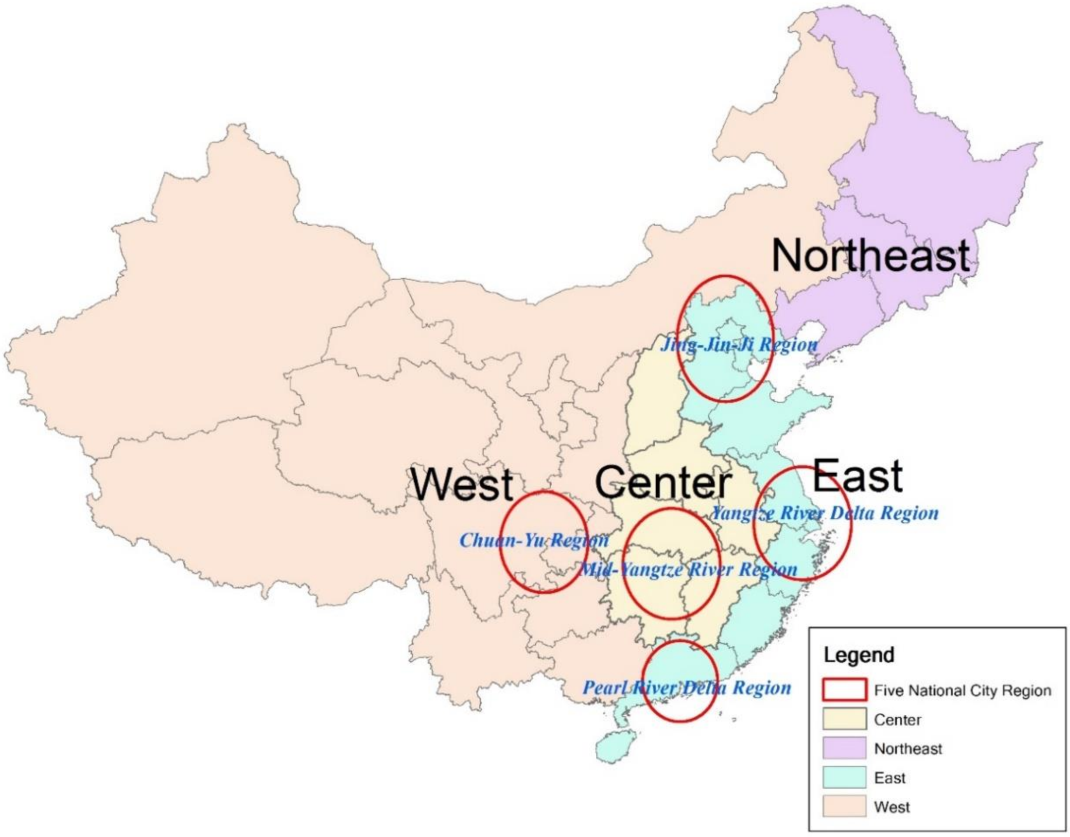

Figure 1 The Five National City Regions in China.

Empirical city data used are from the National Bureau of Statistics of China (NBS),[3] the Zephyr database supported by Bureau von Dijk[4] and the State Intellectual Property Office of China (SIPO).[5] The cross-sectional data from NBS and SIPO are used to discover the contemporary spatial patterns in the MYR city region in Chapter 6. The time-series network data[6] are derived from the Zephyr database to construct the inter-city network. Lastly, the panel data from the above three sources are used to investigate how indigenous factors, cross-territorial flows, and network capital contribute to regional development simultaneously from one year to the next.

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[3] NBS is the only authorised agency under the state council in collecting statistical data and economic accounting in national scope.

[4] The Zephyr database supported by Bureau von Dijk includes the most comprehensive data worldwide on M&A deals, updated hourly.

[5] SIPO is the official bureau under the State Council responsible for patent processes.

[6] The distinction between network data and standard data is that the network dataset describes an actor-actor matrix as opposed to an actor-attributes matrix.

The reasons for the selection of M&A data as the flow metric to be used in analysis are discussed in Chapter 7. In brief, these were, first, that alternative flow data related to urban growth that are emphasized in the international literature, such as elite exchange, information sharing and knowledge transfer etc., are not traceable for use in MYR city region analysis; second, that M&A deals not only relate to capital mobility but also to long-term city interactions, which may generate other flows important for city region development; and third, that the operations of M&A deals normally involve APS locally.

1.5 Research Outline

Chapters 2 to 5 inclusive are dedicated to general literature review and the generation of research hypotheses. The four literature review chapters build a basic conceptual and theoretical framework for the research while literature relevant for each part of the empirical analysis are specified and discussed in the respective empirical chapters themselves.

In Chapter 2, the literature concerning the survival of cities beyond the ‘end of geography’ (O’Brien, 1992) and ‘death of distance’ (Cairncross, 2001) discourse are reviewed. In brief, the significance of arguments highlighting that agglomeration economies underpin the decline vs the revival of cities undergoing structural change, is critically evaluated. O'Flaherty (2005) argued that the crisis of cities can be attributed to decreasing returns to scale. However, the underlying mechanism of agglomeration economies has shifted from mass production to specialised high value knowledge economy production, argued to generate the revival of declining cities. Thereby, cities are no longer generally seen as the “leftover baggage from the industrial era” (Gilder, 1995, p. 56) but instead as dynamic and resilient spaces in the knowledge economy. The current vitality of cities has come to be widely regarded as represented by the concentration of thriving APS and commanding functions in large cities (Sassen, 1991). Thus, in the Chapter 2 review of relevant literature it is argued that cities undergoing economic globalisation and transition are persistent for the foreseeable future since their interactions are generated by human learning, know-how and practices and they can adapt to dynamic changes in production modes. In addition, in Chapter 2, two main theoretical strands guiding urban studies are briefly reviewed: neoliberalism and neoliberal globalisation. Neoliberalism is the ideological foundation for the investigation of economic expansion and capital mobility under globalisation, reflected in spatial extension and capital flow networks in city region development, which contribute to the development of a fundamental understanding of the relationships between new economic processes and appropriate urban governance.

In Chapter 3, two significant prevailing urban forms under contemporary globalisation are considered in the context of the international literature, namely global cities and city regions. Global city studies generally draw heavily on Sassen's (1991) global city theory. In addition, global city theory contributes to literature developments in city region studies since prime cities in city regions are frequently defined as global or globalising cities. Sassen focused on the concentration of APS sectors as the main criterion to define global cities as commanding nodes in the world economy, whereas the city region literature examines the effects of globalisation on aggregate regions on the basis of physical proximity and/or functionality, or territorial definitions. Scott (2001b) contended that the global city region is not simply the sum of urban cores but is a well-organized and functionally connected regional entity or actor involved in global competition. In contrast to global city studies at the international scale, city region studies commonly pay more attention to the synergy effects that exist across cities within a city region. Given the evolving economic and policy status of the MYR region in China, this research therefore focuses mostly on cities' functions and synergy effects across metropolitan boundaries within the city region rather than on global city APS sectors with a worldwide span. Specifically, the functionality and synergy effects highlighted in city region theory are specified in the discussion of spatial associations and network positions in Chapters 4 and 5 and in relevant literature review sections of the empirical chapters.

In Chapters 4 and 5, existing models and empirical studies informing geo-space and network space thinking are considered respectively. Technically, the application of spatial statistics, spatial econometric models and network capital's calculating methods is reviewed and discussed in order to frame and inform the empirical analyses to be undertaken in subsequent chapters. Finally, in Section 5.4, four general research questions and corresponding hypotheses identified from the review of existing literature to be pursued in the subsequent in-depth empirical analyses are specified. In order to address the four general research questions, each question is further specified in sub-questions posed in each of the empirical chapters and the conclusion chapter respectively.

Chapter 4 begins by reviewing geo-space thinking that highlights the effects of distance and physical proximity in shaping regional economies based on Tobler's first law of geography (Tobler, 1970). As already referred to briefly, economic agents, as rational decision makers, tend to initiate interactions and economic activities in nearby spaces in order to reduce the consumption of resources in overcoming spatial constraints (Miller, 2004). Endogenous theorists also conceive spatial associations as an endogenous variable in driving economic development as highlighted by economic geographers. Meanwhile, spatial econometrists highlight the importance of spatial heterogeneity in shaping economic patterns. Thus, it is hypothesized firstly, that *spatial association and heterogeneity co-exist in the MYR city region*.

In terms of network space thinking, Castells' (1996) space of flows discourse and Huggins' (2010) calculative network capital discourse are heavily drawn upon in Chapter 5. Castells (1999) asserted that ICT facilitated new economy development in a 'network society' has led cities to provide "the material arrangements" allowing for "simultaneity of social practices without territorial contiguity" (p.295). However, most urban network studies regard network space as a relatively simplistic structure interconnected by bilateral relations. In order to delve more deeply into network space, Huggins argued that network capital is a calculative strategic resource embedded in the complex patterns and network positions that are determined by multidirectional ties and the attributes of ties (Huggins, 2010). When network capital is applied in a spatial sense, it can therefore be argued that cities within functionally defined city regions are characterised by functions that correspond to different network positions, generating strategic profit in distributing diverse productive flows. Thus, it is hypothesized secondly, that *cities in the MYR city region hold different regional network space positions in conducting distinctive functions*.

By referring to urban agglomeration and spatial econometric studies discussed in Chapter 4, it is found that spatial factors may play an important role in the investigation of regional growth. Meanwhile, by referring to space of flow theory and calculative network discourse discussed in Chapter 5, it is found that incorporating flow factors and network position factors in a regional growth model using network space thinking can also potentially shed light on city region development by testing the contribution of productive inter-city flows and the network positions of cities. By combining the potential contribution of spatial factors, productive flows and network positions to regional growth, it therefore is hypothesized thirdly, that *urban growth across cities in the MYR city region is spatially interdependent, and indigenous factors, distinctive inter-city flows and network positions not only contribute to city region development but also generate spatial spillovers*.

The major original contribution of this thesis developed in Chapters 6, 7 and 8, is thereby a theoretically informed empirical analysis which highlights the effects of spatial association and network capital on MYR city region development. To avoid repetition, discussion in each of the empirical chapters is limited to those findings of relevance to the specific analysis. The sequence of discussion in the three chapters begins with the illustration of MYR spatial patterns in Chapter 6, the calculation of network capital in Chapter 7, and ends in Chapter 8 with an exploration of spatial factors, indigenous factors and network capital as simultaneous drivers of the city region economy. The operation of spatial mechanisms and inter-city network processes in regional development remains vague in previous studies, however evidence from the three analyses reveals their co-existence and mutuality in city region development.

Although spatial analysis techniques have become increasingly sophisticated over time with advances in GIS techniques, applications at a city region scale have to date been rare, particularly for emerging city regions in developing countries such as China. Based on geographic proximity, Chapter 6 aims to identify the spatial characteristics of economic patterns in the MYR city region by analysing spatial heterogeneity and the association of important economic activities. First, the findings mirror the association between manufacturing and APS sectors in the MYR city region. Second, it is found that economic activities are concentrated around ‘hotspot’ cities and are oriented in distinctive directions rather than being evenly distributed. In addition, spatial heterogeneity and spatial association are identified as coexisting in these economic patterns. Chapter 6 thereby builds a basic understanding of the MYR city region space economy and provides justification for spatial heterogeneity and associations in a regional growth model.

Although city region research has drawn much attention to network thinking popularized by Castells’ theorization of a space of flows, there is still a general deficiency of studies that combine the concepts of the city region and calculative network capital. Chapter 7 articulates how regional development not only resonates with spatial proximity but also with borderless flows which have few spatial constraints. Thus, it is argued that cities can be advantaged by the network capital embedded in a dynamic, multidirectional flow, and borderless network space, to facilitate strategic decision-making and resource distribution. Conceptualising cities as ‘nodes’ (as in ION analysis) and M&A deals as ‘ties’ in the city region, SNA is used to calculate the network capital of cities in the process of MYR city region development. It is found that the MYR inter-city network is a centralized network space where ‘power’, ‘prestige’ and ‘hub’ positions are highly concentrated in big cities (Wuhan, Changsha, Nanchang and Yichang) while functional proximity and clustering are sparsely distributed in MYR medium size cities. Associated implications of the network capital identified for regional development policy are discussed.

Few studies have investigated the mechanisms underlying the resonance between spatial spillovers and calculative network capital in a regional growth model, hence in addition to indigenous factors and diverse flows Chapter 8 aims to shed light on the contribution of calculative network capital to MYR economic growth and its resonated spatial effects. The development of a spatial regional growth model demonstrates that the MYR city region is growing significantly economically under the simultaneous effects of the contribution of indigenous input factors (capital stock, labour pool and technology), cross-territorial flows (human, commodity and capital flows) and network capital (network authority). However, MYR cities are confronted with territorial competition with their neighbours, indicating a lack of coordinated development. It is argued that the MYR city region is still undergoing an initial agglomeration process drawing resources into core areas and accentuating a core-periphery development pattern as opposed to positive spillover effects and the balanced distribution of network capital across the city region. The implications of the findings for aggregate regional growth and coordinated development strategies across metropolitan areas are discussed.

Finally, in Chapter 9, the results from Chapters 6, 7 and 8 on the MYR spatial mechanism and network mechanism which are the two main analytical frameworks used in the research, are discussed. A CAS paradigm is then adopted to frame consideration of the most pertinent findings from these empirical chapters and to dissect the complexity of the city region system. The CAS paradigm highlights the interactional complexities but also the adaptive capacities that underpin the city region system providing a conceptual framework for discussion of the overall findings. A fourth hypothesis for interrogation therefore in Chapter 9 is that *the city region is a complex adaptive system generating an emergent balanced urban configuration in a state of economic and spatial transition.* Understanding of individual MYR cities’ indigenous factors cannot inform a holistic understanding of the regional development process because, according to the CAS paradigm, multiple city region economic agents are interacting and adaptive, and it is through their practices that emergent city region patterns are generated.

The final discussion of the implications of the research findings focuses on how the city region as a complex system, adapts to underlying spatial mechanism and network properties and how these could promote economic regional integration and resilience. It is concluded that in light of the resonance between geo-space and network space shaping the city region economy, the MYR space of places and space of flows cannot be considered separately in regional development theory and analysis. The corresponding policy implications for the city region are presented in the final section which addresses the question how to adapt to a dynamic complex context for economic agents and policymakers and thereby support the city region development process as a whole, and how to avoid market fragmentation and territorial competition between city administrations.

2. CITIES AND ECONOMIC CHANGE

Cities are the places where human and production activities are agglomerated and where intense interactions, creativity and innovations are generated. The United Nations (2014) predicted that 64.1 per cent and 85.9 per cent of the developing and developed worlds respectively would be urbanized by 2050. Much of this development refers to the world's largest urban agglomerations that will in future contribute a major proportion of global GDP (Dobbs *et al.*, 2011). Cities and regions are "the expression and outcome of ongoing worldwide economic, political and socio-spatial transformations" (Brenner and Keil, 2006, p.7). With the rise of the knowledge economy, urban areas are becoming active in knowledge-based activities and in interactions. However, urbanisation has not been a consistent process of development and increasing economic vitality. Cities have variously over time, been confronted with crises of stagnation and decline. Thus, reviewing how the revival of cities occurs provides important context for understanding contemporary urban development and city dynamism. This review of relevant literature examines first the process of city revitalization, second the neoliberalism paradigm in planning that has influenced this process, and third, the reshaping of the urban system under neoliberal globalisation. The rationale for the structure of the Chapter 2 literature review is illustrated in Figure 2.

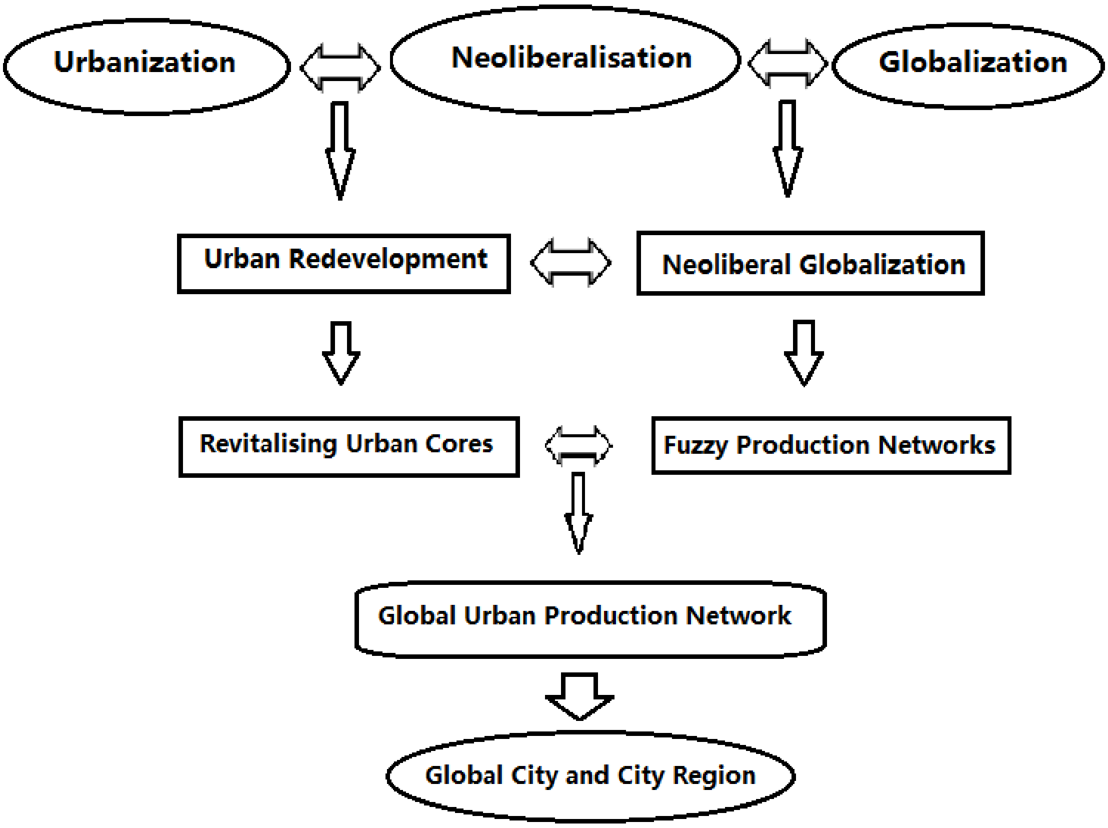


Figure 2 Conceptual Framework of the Review of Cities and Economic Change Literature.

2.1 Cities: Persistent Space or Dynamic Process?

Urban studies have traditionally defined cities based on the physical proximity of people and the scale of human settlements such as population size and built up area (Goodall, 1987). The formation of the world's earliest cities has been attributed to the Neolithic revolution when increasing labour force was released from farming and began to take on specialized occupations such as trade and business (Bairoch, 1988). Although it remains subject to debate which city in the world is the oldest, there is evidence that the first generation of cities was located in the river valleys of Mesopotamia, India, China and Egypt, where farming was developed in around 3000 BC (Mumford, 1961). However, urban growth was relatively stagnant until the 'industrial revolution'. In 1800, only three percent of world population lived in urban areas (UN Habitat, 2010). By 1900, approximately 14 percent of total population was urbanized, however only 12 cities had a population surpassing one million (UN Habitat, 2010). In spite of huge human loss and malaise during the two twentieth century 'world wars', the urbanisation rate rose to 30 percent in 1950, and increased to 54 per cent by 2013. It is expected that 66 percent of world population will be urbanized by 2050 (UN Habitat, 2010). In addition, the number of cities that accommodate more than one million population exceeded 500 by 2010 and 28 mega-cities have more than 10 million population, accounting for 12 percent of the world population (UN Habitat, 2010). Dependent on definition, Tokyo remains the world's largest city with 38 million inhabitants, followed by Delhi with 25 million, Shanghai with 23 million, and Mexico City, Mumbai and São Paulo, each with around 21 million inhabitants (UN Habitat, 2010). It is therefore recognised that emerging countries have become the major world sources of increasing urbanisation and urban population.

The unprecedented speed and scale of urbanisation in emerging markets has generally been attributed to the major change of production modes (Harvey, 2008; Jackson and Senker, 2011; Lu, 2012). Industrialization[7] initiated the process of modern urbanisation and reversed economic stagnation associated with principally agricultural economies (Fishman, 2005). Urbanisation in medieval times was motivated mostly by political and military factors such as the status of capital cities, religious centres, transportation centres and military strongholds (Fishman, 2005). This situation changed a little after the development of maritime international trade, which stimulated the emergence of port and commercial cities, such as Amsterdam, Liverpool, Antwerp and New York, however the number of such cities was limited. This is attributed to the fact that agriculture and later maritime trade prior to industrialization did not have a high demand for labour agglomeration and cross-sectoral cooperation; on the contrary, industrialization called for huge labour forces and a high level of cooperation in order to boost scale economies (Fishman, 2005; O'Flaherty, 2005). Theoretically, O'Flaherty (2005) attributed the formation of modern cities to their prominent advantages known as increasing returns to scale or economies of scale, which will be examined in a Chinese context in Chapter 4 of this thesis.

Nevertheless, urbanisation has not progressed consistently since the industrialization process started in western countries. Early in the 1920s and 1930s, the Chicago School articulated that urban vitality had been weakened by emerging urban issues such as crime, poverty and poor environmental conditions, which were attributed to the failure of social

[7] Different countries went through industrialization at different times and a large number of developing countries are still in the early process of industrialization. In addition, the content of industrialization has changed with technological advances. Thus, as industrialisation has rolled out over time it has been linked to hegemony. However, since developed countries have witnessed the major process of industrialization and urbanisation to a large extent, this section draws on international literature on relationships between urbanisation and the change of production modes that reflect a developed economy perspective.

institutions and social relationships (Sutherland, 1924; Thrasher, 1927; Frazier, 1932). After the two world wars, more attention was given to urban regeneration and to ideological debate concerning the role of institutions in addressing market failures. In particular, the 'cold war' hindered the process of globalisation and economic development, leading to the slowdown of urbanisation. Especially in the late twentieth century, intertwined with deteriorating urban environments, massive suburbanisation and developments in ICT, the role of cities was questioned as illustrated by 'end of geography' (O'Brien, 1992) and 'death of distance' (Cairncross, 2001) predictions. In the context of telecommunications advances and the shrinkage of city 'downtowns', Gilder (1995, p. 56) went so far as to claim that "cities are only leftover baggage from the industrial era", suggesting that virtual communications would make face-to-face contact redundant. During this period, metropolitan areas were plunged into crisis characterized by the decline of industrial centres, the decentralization of urban functions, environmental decline and social protests and blackouts, such as the riot in New York in 1977 and the blackouts in New York, Cleveland and Detroit in 2003 (Glaeser, 2012). Furthermore, suburbs established in the late twentieth century were depicted as "decay in the great, dull, grey belts" by Jacobs in *The Death and Life of Great American Cities* (1961, p.4).

However, these predictions have been proved too simplistic, since they assumed that telecommunication has simply substituted for physical human interactions. On the contrary, Couclelis (2000) found that the rise of telecommunications had been paralleled by a corresponding increase in travel demand at all geographic scales. With reference to Silicon Valley, Glaeser (2012, p. 8) also argued that accelerating electronic communication had vitalized "the urban ability to create collaborative brilliance" through face-to-face contact, as opposed to replacing it as Gilder (1995) had predicted; instead of wiping cities out, technological advances facilitated the intensification of face-to-face interactions concentrated in cities. Therefore, these predictions comply with Jevons paradox[8]. They assume that the technological advances of telecommunication will diminish the desirability of face-to-face communication, however, face-to-face communication becomes more

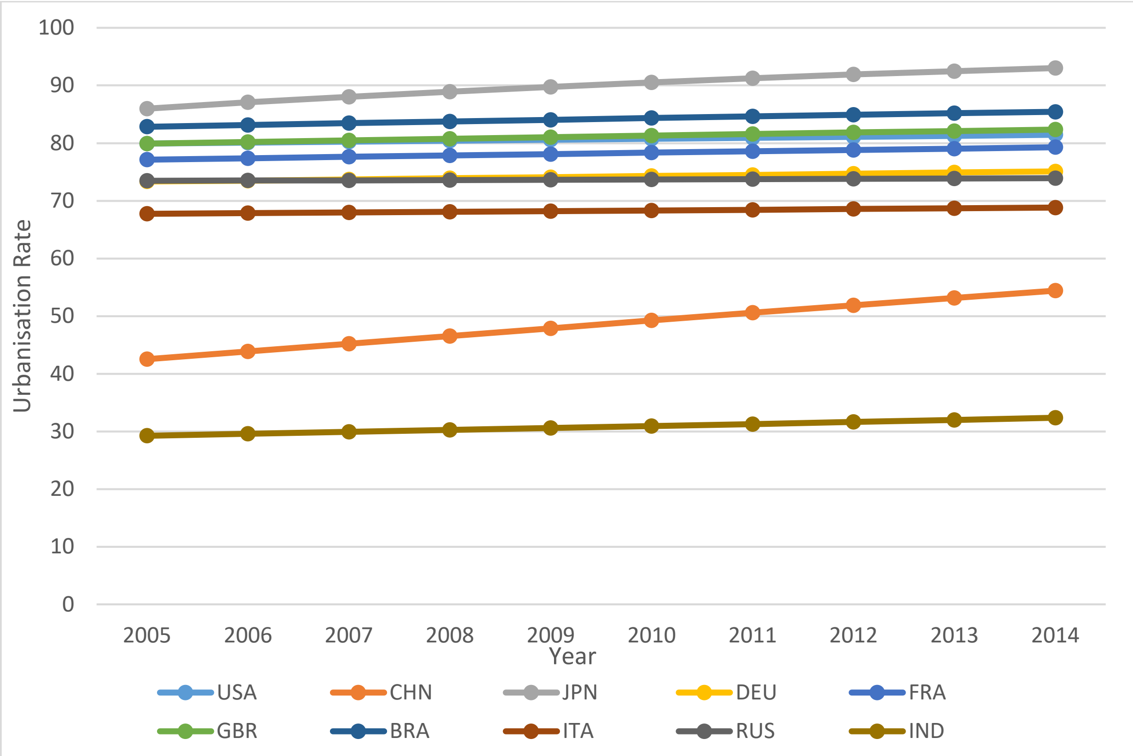
[8] The typical Jevons paradox is mostly applied in environmental economics. It indicates the situation that technological advances promote the efficiency of using a resource, but in fact the consumption of this resource rises.

necessary needed in human and business interactions under knowledge economy (Glaeser, 2012).

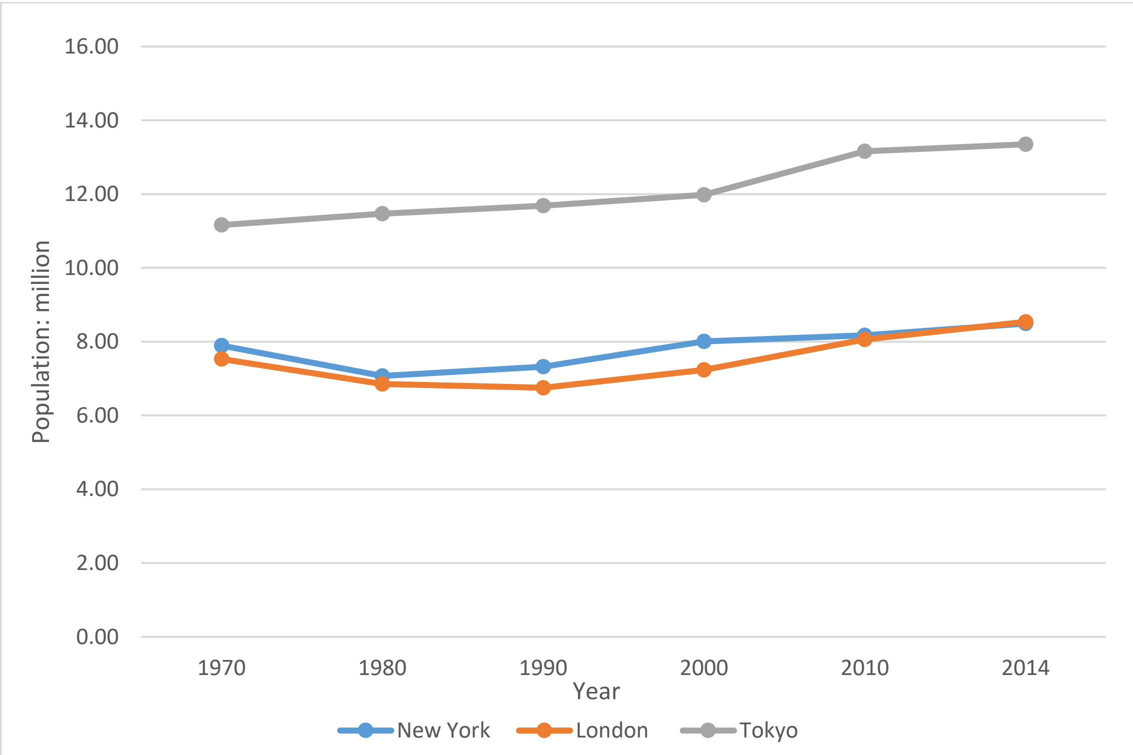
In the re-urbanisation of cities, urban migration started to flow back to city centres from suburbs and rural areas. Fishman (2005) characterized this phase as the ‘glory time’ of cities. To date, urban areas have thereby been salvaged from the threat of disappearance, ‘planned shrinkage’ and ‘the systematic withdrawal of city services’ (Mumford, 1961; Starr, 1976). As shown in Graph 1, the urbanisation rates of the world’s ten biggest economies have all increased consistently since 2005. Among them, Japan maintained the most urbanized country at more than 90 per cent, while China, as the second biggest economy and the most populated country, made the biggest upward leap from 42.5 per cent in 2005 to 54.4 per cent in 2014 (World Bank, 2015).

In terms of established global cities, New York, London and Tokyo illustrated the process of city resurgence as shown in Graph 2. In the 1970s, the three cities experienced substantial population loss, particularly New York and London, until the 1990s when the process of resurgence took off; although Tokyo’s overall population did not fall but instead increased very slowly until the year 2000 and then leapt up in the first decade of the twenty-first century (World Bank, 2015). New York for example, which had experienced blackout in 1977 and city bankruptcy, reached its peak population to 2015 while its violent crime rate dropped dramatically. Twin contemporary processes of globalisation and immigration thereby resonated with re-urbanisation as globally interconnected advanced production networks and the demand for labour in knowledge intensive and supporting services enhanced the vitality of downtowns (Sassen, 1991; Loukaitou-Sideris, 2000).

In addition to the reversal of city out-migration, the revitalization of cities was boosted by the value-adding capabilities of globally concentrated headquarter activities in APS sectors, financial and linked business services, to be examined further in Chapter 3. As discussed by Sassen (1991), locations such as New York, Tokyo and London came to be focal points for globalisation as highly concentrated world locations for APS corporate headquarters dependent on specialized decision making, creativity and innovation (Graham and Marvin, 2002). These services that are mainly clustered in downtowns require proximity to high-skilled international labour, other service suppliers, clients, and linked economic actors in order to be globally competitive in new modes of flexible production and the knowledge economy. The skylines of such ‘global cities’ have been reshaped by downtown redevelopment providing offices and residential districts both occupied by and invested in by these 'new economy' services (Lizieri, 2009).



Graph 1 The Urbanisation Rate of the Biggest Ten World Economies (source: World Bank).



Graph 2 Historical Population of New York, London and Tokyo (source: World Bank).

In conclusion, the once predicted disappearance of cities (Castells, 1996) has so far generally proved to be elusive. As O'Flaherty (2005) argued, "cities could persist—as they have for thousands of years—only if their advantages offset the disadvantages" (p. 12). Based upon Jacobs' (1961) theorisation that city and city region vitality are products of how a city system operates, it would seem then that understanding and responding to city economic development and its spatial expansion as an inherently socially generated process will be essential for the persistence of advantageous urban agglomeration economies. By 2025, 136 new cities in developing markets, of which 100 will be located in China, are predicted to enter the world's top 600 'economic giants' (Dobbs *et al.*, 2011). Given the diversity of urban development paths worldwide, theoretical constructions and empirical studies in new domains of globalisation, such as China, are necessary to understand emerging urban processes and dynamics, and this is the motivation behind this research.

2.2 Neoliberalism and Urban Development

As discussed in Section 2.1, cities have persisted through the restructuring of production modes represented by the rise of the knowledge economy in recent decades. Meanwhile, urban revival is illustrated by large-scale downtown redevelopment projects. Addressing pressing questions about emerging urban processes and dynamics presenting in China, in the context of the major city region spatial and economic extension, this thesis explores the city region as a phenomenon that is in part an effect of spatial associations and in part an effect of network capital that can underpin regional development and inject economic vitality. However, prior to considering the literature concerning city region development and definition, two major contextual ideologies are next reviewed - neoliberalism and globalisation - in order to gain insight into underlying processes shaping changing relations between urban economic development and urban form. The next two sections explore academic perspectives on the emergence and transmission of global neoliberalism as an urban governance mode and its convergence with China's idiosyncratic institutionalization to inform the investigation of the MYR city region and corresponding policy implications of the empirical findings.

Neoliberalism has inherited the basic paradigm of liberalism and has developed a number of new characteristics. The liberalism paradigm derives from western capitalism and the free-market economy. As Jessop (2002, p.453) articulated, liberalism hinges on the basic idea that “economic, political and social relations are best organised through free choices of formally free and rational actors who seek to advance their own material or ideal interests in an institutional framework that, by accident or design, maximizes the scope for formally free choice”. In terms of economic scope, liberalism underscores the significance of private capital and market rule, mirroring wide-scale privatization, commodification, labour mobilization, and the roll-back of government interventions (Jessop, 2002). In contrast to liberalism, contemporary neoliberalism is a resurgence of market-based institutional reshaping that was initiated in Britain and the US in the 1980s in order to mediate deteriorating conditions associated with the Fordism framework under former liberalization. These conditions have been reflected in the crisis of cities discussed in section 2.1, for example, economic recession, decreasing returns to mass production, welfare system crisis, and environmental concerns (Fourcade-Gourinchas and Babb, 2002; Jessop, 2002; Brenner and Theodore, 2005). The new characteristics of neoliberalism resonate with flexible production, the rise of the knowledge economy and advances in information technologies (Brenner and Theodore, 2002). Another new characteristic of neoliberalism is its reliance on the vitality of advanced business (producer) services (APS), such as banking, financial services, accountancy, auditing and consultancy etc. At the same time, Keil (2002) has argued that the rise of neoliberalism has constituted a successful ideological project to make a competitive-market ideology hegemonic. In addition, the contextual embeddedness of economic transition and network cooperation strategies across territories are significant claims highlighted by neoliberals, represented by American liberal market mode and German coordinative market mode (Brenner and Theodore, 2002; Wilson, 2004).

In conclusion, in contrast to mass production, skills, and international trade highlighted in liberalism, neoliberals articulate that flexible production, technology, and multi-scalar capital mobility have become newly fundamental drivers for global economy. Therefore, in addition to legitimizing free market operations through regulations in order to maximize the formal freedom of economic agents (Jessop, 2002), new governance mode should put more weights on stimulating knowledge-based sectors (e.g. ICT, high-end manufacturing and life science sectors etc.) and advanced service sectors (e.g. financial and business services) (Brenner and Theodore, 2005). In other words, the reshaping of institutionalization is designed to facilitate multi-scalar capital mobility, to incentivise financial sectors and business services, and to stimulate entrepreneurships and innovations. In addition, in order to facilitate multi-scaler capital mobility, governments not only continue to enhance the deregulation of transactions at national level highlighted in liberalism, but also pay more attention to the deregulation of transnational transactions, transboundary operations at a regional level, and industrial clustering at a local level, reflecting multi-level deregulation (Brenner and Theodore, 2002). Meanwhile, through reshaping institutionalization, governments have started to take on some attributes of the private sector, such as an emphasis on consumer identity, leaner and flexible organization, and diverse relationships with external players (Stoker and Mossberger, 1995). There is no doubt that economic restructuring under neoliberalism across the world is in fact successful to mitigate deteriorating issues under Fordism and revitalise new knowledge-based sectors (Brenner and Theodore, 2002; Jessop, 2002).

However, given the underlying mechanism of the successful transmission of production mode under neoliberalism, there is a consistent debate between orthodox neoliberals and regulation theorists. Neoliberals emphasize that it is the regime of accumulation[9] that determines the success of economic restructuring and drives society forward (Jessop, 1993). Neoliberals conceive that following the legitimisation of market codes by temporary government interventions, ideally, the influence of governments will be 'rolled back' to a minimal role focused on the protection of free market mechanisms and a self-organising society whereby neoliberal projects can reinvent themselves in conjunction with emerging dysfunctions (Jessop, 2002). While regulation theorists[10] articulate that the endogenous contradictions of capitalism determines the demand for consistent government interventions through the neoliberalisation process, which is vividly reflected in confronting polarization, urban fragmentation, economic insecurity, social resistance and institutional conflicts between central and local government (Tickell and Peck, 1995; Brenner and Theodore, 2005; Grengs, 2005; He and Wu, 2009). They articulated that the ease of endogenous contradictions of capitalism relies on the design of regulation mode[11] rather than the market self-organisation (Fainstein and Campbell, 1996). They concerned that associated with massive financialization, the roll back of governments after transition

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[9] Accumulation regime specifies the nature of the economic processes (e.g. investment, production and consumption)

[10] Regulation theory is derived from the works of some Marxist economists such as Michel Aglietta, Robert Boyer and Alain Lipietz, looking into the regulation mode in mediating crisis of capitalism. It is often referred as the regulation approach.

[11] The mode of regulation specifies the interactions of relevant political and sociocultural institutions

phase may endanger people's citizen identity which is taken over by consumer identity, which leads to the deterioration of disadvantaged communities and social and economic instability (Miller, 2007). For example, the most recent global financial crisis has challenged previous neoliberal 'common sense' which encourage financial innovations (Gonzalez and Oosterlynck, 2014). In conclusion, the debate between orthodox neoliberal and regulation theorists centres on the relationship between the accumulation regime and the regulation mode (Jessop, 1993; Fainstein and Campbell, 1996).

It is contended that the relationship between the accumulation regime and the regulation mode is contingent upon developmental phases and institutional contexts through path-dependent transformations across different countries, which is in line with perspectives of Harvey (2005) and Liew (2005). For western countries that have a long history of liberalization and market hegemony, arguably, economic restructuring primarily derives from the regime of accumulation. Meanwhile for new developmental countries such as South Korea, Singapore, Taiwan, their economic rise in the period between the late 1960s and the 1990s was initially driven by the change of regulation mode (Zhu, 2004). These newly industrialised countries implemented strong government interventions and social policies to integrate local resources and attract foreign investments at the beginning of their liberalization. Chang (2003) attributed the success of these newly industrialised countries to the effectiveness of state interventions in providing economic macro-vision, institution building, and conflict management. Nowadays, China has become another developmental hotspot for understanding the relationship between the accumulation regime and the regulation mode due to its idiosyncratic development path and institutionalization. In contrast to western countries, China had not experienced long-run free-market economic development and liberalization before the introduction of the open door policy which opened China up to international markets in the late 1970s. Its segmented labour markets, rural-urban divide, labour-intensive sectors, state-dominated setting, weak protection of property rights and state-controlled financial system are argued to reflect this distinctive developmental path (Peck and Zhang, 2013). In contrast with newly industrialised countries, China has experienced a relatively long-term centrally planned economy under the paradigm of socialism prior to the open door policy. It has therefore had relatively less industrial infrastructure left by either western countries or the Soviet Union, particularly after the developmental devastation associated with Mao's Cultural Revolution. These characteristics are significant in defining China's idiosyncratic developmental path and its relationship with orthodox neoliberalism. As Peck and Zhang (2013, p.385) claimed, China’s neoliberalisation under deepening globalization has its own developmental path, illustrating ‘an unlikely marriage of entrepreneurial developmentalism with Leninist party discipline’ known as a ‘socialist market economy’ or party-state neoliberalism (Chu and So, 2010), which is distinct from the American liberal market mechanism, German coordinative market mechanism or other developmental mechanisms associated with orthodox neoliberalism. However, Peck and Zhang (2013) also highlighted that China’s neoliberalization should be an exploration based on developed capitalism varieties and western neoliberalism forms rather than a unique exceptionalism.

State-led initiation of open door policy and subsequent economic reform resonates with regulation theory, mirroring the influence of the change of regulation mode on economic changes. Throughout the process of China’s recent rapid economic growth, government interventions and strategic planning have been consistently active in steering directions of economic reform which are reflected not only in macroeconomic policy-making but also in the control of strategic resources[12] and financial systems by state-led capital. However, along with the growth of domestic private capital and deepening integration with international markets in neoliberal globalization (Peck and Zhang, 2003), the relationship between the accumulation regime and the regulation mode in China is becoming a mutual feedback mechanism as opposed to a one-way determination as in the initial stage of economic reform. Thus, in the current development phase, economic policy-making by the Chinese government is more responsive to market conditions and capital demands, however state-led capital remains influential in strategic sectors, resonating with the neoliberal argument (He and Wu, 2009). In conclusion, China’s market reform has been characterised by the dynamic interaction of inherited state-led capital, powerful global capital, active private capital and powerful government strategic planning, indicating the conjuncture of regulation theory and neoliberalism (Harvey, 2005; He and Wu, 2009).

In addition to the mutual feedback mechanism of the accumulation regime and the regulation mode in China’s market reform at state level, spatial rescaling and regional heterogeneity characterise China’s ‘variegated capitalism’ (Peck and Zhang, 2013; Zhang and Peck, 2016), as seen in decentralisation to city councils (Swyngedouw et al., 2002) and the coastal to inland rebalancing experimentation process which is more relevant to city

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[12] Strategic resources include land rights, power generation, energy resources, e.g. oil, petroleum, coal and gas, telecommunications, aviation and shipping, and mining resources and metals etc. (Zhang, 2005).

region research. Firstly, cities and city regions, as the new engines of global economic development in a post-industrial era and information society, become the "strategically crucial geographical arenas" (Brenner and Theodore, 2002, p. 349) and the ideal laboratories where "a variety of neoliberal initiatives along with closely intertwined strategies of crisis displacement and crisis management have been articulated (p.351)". The City Planning Act enacted in 1989 initiated the decentralisation process which transfers the power of economic planning and local fiscal revenue from central government to city government (He and Wu, 2009). Since decentralisation, central government has retained control of macroeconomic policy, market regulation and strategic resources, while city governments have managed local state-owned resources such as land right which have been commodified, and focus on localised labour market regulation, preferential tax policies, and local infrastructure (Keil and Boudreau, 2005; He and Wu, 2009). These urban policies hinge on the stimulation of innovation and entrepreneurships, attraction of investment, emphasis on partnerships and networks, and increased labour flexibility in order to improve urban competitiveness at a local scale (Jessop, 2002). Thus, cities, as the strategic frontier of China's economic reform, play a significant role in the spatial convergence of local growth and international competitiveness. Investigating urban factors such as capital accumulation, labour force, knowledge stock and network flows which are emphasized by neoliberals as significant for understanding the underlying driving mechanism of an urban economy. Secondly, China's economic reform is a gradual experimentation process through opening selected sectors and special economic zones (in a coast to inland order), for trialling new business arrangements and governance models (Zhang, 2012), which leads to the regional heterogeneity. As Zhang and Peck (2016) articulated, regional heterogeneity has become an endogenous factor influencing regional positioning in global production networks in the process of China's liberalization. They found that the liberalization of coastal regions is characterised by an outward orientation, developed private capital and entrepreneurship, and the rapid growth of technology-driven sectors. By contrast, that of inland regions is characterised by a dominance of state-led capital and emerging incentives for external capital (from both coastal regions and international markets). Thus, given the inland location of the MYR region, more attention should be paid to the steering function of governments in city region development (see Section 3.4 and Chapter 9). Linked government support is a potential catalyst for city region emergence in response to evolving MYR intercity economic flows and urban functional interactions at the interface of regulation and market mechanisms.

In conclusion, accumulation regime and regulation mode are interactive in steering China's economic reform, illustrating heterogeneous regional neoliberal models and interlinking cities in complex global production networks simultaneously, which leads to China's variegated capitalism rather than orthodox capitalism or neoliberalism forms derived from the west (Peck and Theodore, 2007; Peck and Zhang, 2013; Zhang and Peck, 2016). It is inappropriate to categorise it in terms of established neoliberalism forms, though there is no doubt that China's economy is no longer centrally-planned under the paradigm of socialism alone. In other words, due to the idiosyncratic conjuncture of the market logic and the communist party-state, the mode of China's development is still an 'open-ended' question, demanding more dynamic multi-scale investigations. Given this, the MYR city region, as the subject of the research, associated with regional heterogeneity and national policy planning under China's variegated capitalism, is reviewed in the next chapter.

2.3 Neoliberal Globalisation and World Urban System

The influence and outcomes of neoliberalism are not limited to intensive privatization, commodification, labour market flexibility and the rolling back of government (deregulation), but extend to deepening globalisation and increasing network complexity modified by distinct local interventions/regulations, and mirrored in the association of global production networks and business-led clustering at a local level (Leitner and Sheppard, 2002). Theoretically, it is argued that a neoliberal regime attempts to amplify the effects of capital mobility in order to promote economic globalisation (Purcell, 2007). In consequence, neoliberal globalisation has been reshaping the spatial patterns of urban development substantially (Scott, 2001b; Brenner and Theodore, 2002; Jessop, 2002; Fishman, 2005; Purcell, 2007). Thus, prior to reviewing specific new urban forms emerging in the contemporary world, the urban influence of neoliberal globalisation is reviewed.

The concept of globalisation has been subject to debate for more than a decade (see Hirst and Thompson, 1995, 1996; Amin, 1998; Chase-Dunn, 1999; Sklair, 1999; Held and McGrew, 2000; Dicken *et al.*, 2001; Sassen, 2007). As an ongoing extension of markets worldwide, deepening globalisation in the contemporary world has been regarded as a feature of neoliberal capitalism and is thereby an unprecedented historical process, restructuring world systems and urban hierarchies (Hirst and Thompson, 1996).

According to proponents of world systems theory (see Amin, 1991; Wallerstein, 1974; Arrighi, 1994, 1999; Chase-Dunn and Grimes, 1995), the origins of the capitalist 'world system' date back to the sixteenth century European 'Age of Discovery'. The ensuing development of the world-system was characterised by uneven relations and the dependence of 'peripheral' on 'core' economies. Cumulative accumulation of capital, people and knowledge over time under capitalism and neo-liberalism, has underpinned persistent core-periphery inequalities (Krugman, 1991; Krugman and Fujita, 1995; Krugman, 1997; Chase-Dunn, 1999). Taylor (2000) references Arrighi's (1994) contention that the first 'wave' of globalisation began at the turn of the nineteenth century with the rise of United States hegemony. Similarly, the influence of ICT (Castells, 1996) compared with that of previous new communication technologies, for example, at the end of the nineteenth century (Harvey, 1989) as the driver of globalisation, has been subject to debate. However, ICT-accelerated globalisation from the end of the twentieth century has generated a previously unknown explosion of world-wide flows of information, people and capital (Pain and Van Hamme, 2014).

In many social science disciplines, globalisation is seen as, not simply a progression of internationalization (Sklair, 1999), but as representing a neoliberal paradigm change to more intense economic transition facilitated by the acceleration of new technological developments and qualitatively distinctive new relations between economic actors (Robinson, 2011). As discussed in the last section, this restructuring can be manifested in the displacement of industrial manufacturing, the rise of knowledge-based economy, and thriving financial and business services in developed economies. In terms of economic activities, the new technological advances in communication are creating a distinctive new environment for carrying out economic transactions and taking advantage of virtual monetary mechanisms. Generally, contemporary globalisation is characterized by unprecedented flows of goods and services, massive labour migration, a knowledge-based economy, and extensive financialization at global scale (Pain and Van Hamme, 2014). Furthermore, the spatial implication of neoliberal globalisation is the new importance of 'core-making' with the decline of the nation state as a major actor on the world economic stage and the rise of the 'informational city' (Castells, 1989), or global city (Sassen, 1988, 1991), as the operational headquarters for major global corporates (Taylor *et al.*, 2014). This process explains the attempts of state authorities to reterritorialize the 'space of flows' in globalising cities and city regions as in the case of China's development plans for the MYR city region.

Associated with neoliberal globalisation and the rise of the knowledge-based economy, the global city concept proposed by Sassen in 1991, emphasized the role of specific cities as strategic sites for the operation of the globalized economy. The global city thesis introduced a new economic geography field focus on the agglomeration of transnational strategic APS business functions alongside worldwide APS dispersal, which is discussed in the next chapter. The theory is partly based on Friedmann and Wolff's (1982) research agenda and Friedmann's subsequent 'world city hypothesis' based on a world systems theory perspective in which,

> World cities are key cities throughout the world are used by global capital as 'basing points' in the spatial organization and articulation of production and markets (Friedmann, 1986, p. 71).

Based on the term 'world city' attributed by Hall (1966) to Geddes (1915) and referred to as 'supervilles' by Braudel (1984), the (1986) world city hypothesis identified the concentration of strategic urban functions, 'producer services', transnational corporation (TNC) headquarters, international institutions, transportation infrastructure and population, as structuring world economy relations. Friedmann's (1986) map of the late twentieth century world economy illustrated a spatially uneven world resulting from patterns of concentration of these resources in a hierarchical urban system (Chase-Dunn, 1999).

Building on Friedmann's focus on the concentration of strategic urban functions in a world perspective, Sassen (1991) referred to the global city as a "space of centrality that is partly deterritorialized and takes place largely in digital networks, but is also partly deeply territorialized in the set of cities" (Sassen, 1991, p. 350). Many of the resources (headquarters control, research and development (R&D), and global operations and coordination) necessary for hypermobile global economic activities are deeply embedded in global city places (Sassen, 2000). Meanwhile, Scott (2001a) highlighted global city capacities to expand their influence in terms of leading sectors and powerful endogenous mechanisms. Global cities have come to be regarded as the places where APS sectors and international elites concentrate forming global 'knowledge hubs' and headquarters for worldwide trade, interlinking the global economy (De Propris and Hamdouch, 2013).

In conclusion, it is argued that urban neoliberal globalisation is converging on a 'single global urban network' across territorial boundaries (Jessop, 2002; Taylor, 2004; Bathelt and Glückler, 2011). Consequently, ongoing neoliberal globalisation has become seen as substantially reshaping the urban system, giving rise to new urban forms, namely global cities and city regions whose operating mechanisms are reviewed in detail in the next chapter.

3. NEW URBAN FORMS: GLOBAL CITY AND CITY REGION

In this chapter, key theories articulating global city and city region development processes in the context of neoliberal globalisation are reviewed as a prelude to consideration of relevant empirical analytical paradigms in Chapters 4 and 5. In order to contextualize the conceptual and methodological approaches adopted in the research and the discursive themes that structure the thesis, first, the central theoretical debates surrounding the rise of global cities, their driving mechanisms and their positions in the global economy, are reviewed. Second, the theories and research concerning the definition of city regions, their operating mechanisms and expansion processes under conditions of neoliberal globalisation are reviewed in order to frame subsequent empirical investigation of the MYR case study. Finally, the MYR city region is introduced, including its national planning regulatory context as a strategic region and growth pole for China's economic transition.

3.1 Global City Emergence: Global Headquarters of Advanced Service Economy

As discussed in the last section, Friedmann's world city hypothesis (1986) emphasized the location of command and control functions in the world city system. While Sassen argued, "Global cities are…not only nodal points for the coordination of processes….also particular sites of production (Sassen, 2001, p.5)". Furthermore, Beaverstock *et al.* (1999) described such cities as the production sites where "innovations in corporate services and finance have been integral to the recent restructuring of the world-economy now widely known as globalisation (p.126)". Sassen's global city theory therefore drew attention to the global operational practices of APS firms (financial and linked business services) leading to the worldwide dispersal and concentration of offices servicing decentralised manufacturing (Sassen, 1991). These locational dynamics have proved to give rise to a process of global city formation specific to the globalisation era, that is strongly linking cities once defined as peripheral in Friedmann's (1986) analysis, to the world city system (Taylor *et al.*, 2002; Taylor, 2004; Taylor and Aranya, 2008; Taylor *et al.*, 2010; Derudder *et al.*, 2010). As Sassen predicted, "the massive trends toward spatial dispersion of economic activities at the metropolitan, national and global level, which we associate with globalisation, have contributed to a demand for new forms of territorial centralization of top-level management and control operations" (Sassen, 2005, p.32). The emergence of global cities thereby meets the demand for control function centralities in a globalized world economy and the vitality of global and globalising cities has been attributed to the spatial clustering and agglomeration economies of APS activities (Sassen, 1991).

As leading sectors in shaping global cities, APS firms supply specialized services to producers with increasingly complex operations, business structures, and financing (Beyers and Lindahl, 1996). Porter (1998) further specified the concentration process in terms of business clustering:

> Clusters are those geographical concentrations of interconnected companies, specialist suppliers, service providers, firms in related industries and associated institutions… in particular fields that compete but also co-operate (p.197).

Major TNCs operating on a worldwide scale, integrating global production networks (Gereffi and Korzeniewicz, 1994; Coe *et al.*, 2004, 2008) are dependent upon APS whose activities as specialised service suppliers anywhere in the world underpin global value chains. APS office networks provide support to TNCs in the form of "flexibility needed to switch its investments continually from the lines of business that face diminishing returns to the lines that do not" (Arrighi, 1994, p. 8) and to other APS (Pain, 2007). APS thereby facilitate financial investments and flows across the world and in so doing themselves generate flows of people and knowledge between agglomeration cities embedded in value chains. In conclusion, the spatial clusters of APS firms in global and globalising cities are regarded as the urban spaces where knowledge, innovation, trust and reciprocity are generated (Taylor *et al.*, 2002), driving firm and local economic growth as an outcome.

Among the APS sectors, banking and financial services firms are noted to play a critical role in supporting and sustaining global city activity (Taylor *et al.*, 2002; Taylor and Pain, 2007). There is evidence that financial service firms that locate in strong clusters grow faster than average and that strong financial clusters attract a disproportionate volume of new firm entries (Pandit *et al.*, 2001). Although the world financial crisis in 2008 led to volatility and systemic risk in finance-related sectors and international capital in global cities, the dominance of leading international financial centres has in fact recovered surprisingly rapidly (Lizieri and Pain, 2014). Regardless of aggregate international investment decrease, cross-border capital flows have thickened and concentrated on selected major global cities such as London, New York, Paris, Singapore and Hong Kong (Hoyler *et al.*, 2014). Furthermore, the financialization and internationalization of real estate investment has made global city commercial office property that is both the physical infrastructure allowing APS networks to function and a financial investment asset class an important conduit for inter-city capital flows (Lizieri and Pain, 2014).

However, much as developed economy global cities are the strategic sites of APS sectors providing the physical infrastructures through which the global service economy functions, they are no longer a 'spatial fix' (Harvey, 2001; Lizieri, 2009) for mobile flows of capital. In her more recent publications, Sassen (2002) has acknowledged that cities are not only places of agglomeration but are functionally interconnected by global networks and circuits of flows. Market expansion, the rise of the 'consuming class' and of demand for APS in emerging economies, especially in China, is creating new geographies of economic globalisation (Derudder *et al.*, 2010; Dobbs *et al.*, 2011; Derudder, *et al.*, 2013). Virtual flows remain dependent on material infrastructures (e.g. trade centres, real estate, transportation, Internet cable) and urbanisation in emerging economies is an essential component of the reshaping of processes of concentration exploiting market size and unstable market conditions in once 'sticky' places (Markusen, 1996). This leads to the empirical analytic interest of this research on a city region that is at an early stage of linking into transboundary networks (Gugler, 2004) in an emerging economy.

In conclusion, the first decline of major world cities initiated by the transition from a manufacturing to a knowledge-based economy has been mitigated by the rise of specialised advanced services that add value to global production in global and globalising cities. Meanwhile, the location of advanced services is a response to a spatialised logic that is reshaping Friedmann's (1986) world city core-periphery relations and, potentially with this, city regions in emerging world locations where neoliberal urbanization regimes are opening up to economic globalisation and networks.

3.2 Emergent Urban Functional Scale: City Region

Associated with the rise of global and globalising cities in new globalisation domains, city region becomes a significant articulation for investigation of how cities grow economically, and interact and expand in geographical space (Jacobs, 1969, 1984). In contrast to Mumford's prediction of foreseen a 'decline post metropolis' decline

(Mumford, 1961), metropolitan areas are becoming actively integrated functionally (Gottman, 1961; Scott, 2001a, 2001b; Hall and Pain, 2006).

A variety of terms has been used in the literature to describe the processes underlying these developments. However, it has become evident that what may appear to be similar regional urban formations morphologically may have very different underlying functional relations (Pain, 2017) fuelling debate concerning the definition and relevance of once taken for granted fixed notions of what a region is (Harrison, 2008; Harrison and Pain, 2012). Yet, under the influence of neoliberalism, 'new regionalists' go so far as to claim that contemporary capitalism is best regulated through the decentralisation of socioeconomic decision-making and associated policy implementation to the regional scale (Cooke and Morgan, 1994; Florida, 1995; Storper, 1997; Scott, 2001b). Empirical research into the dynamics of urban growth and the functional integration of cities at a sub-national regional scale is thereby necessary to guide governance processes, especially where neoliberal strategies are unfolding in once unexpected places such as China.

Recent prominent definitions of regional urban formations highlight the emergence of functionally interlinked structures:

> 'Megalopolis': formed by a unique cluster of metropolitan areas, where the traditional or political limits are bypassed and also the distinction between rural and urban' (Gottman, 1961, p. 4-5).
>
> 'Galactic metropolis': a vast phenomenon with varying sized urban centres, sub-centres and satellites; it is fragmented and multi-nodal, with mixed densities and unexpected juxtapositions of form and function.' (Lewis, 1983, p.31)
>
> 'Global city region': "organised as dense and intensely localized networks of producers with powerful endogenous growth mechanisms and with an increasingly global market reach" (Scott 2001a, p.820).
>
> 'Polycentric city region': "a series of anything between 10 and 50 cities and towns, physically separate but functionally networked, clustered around one

> or more larger central cities, and drawing enormous economic strength from a new functional division of labour" (Hall and Pain, 2006, p.3).
>
> 'Megaregion', or 'megapolitan region': integrated networks of metropolitan areas, principal cities, and micropolitan areas (Florida *et al.*, 2008; Lang and Knox, 2009).
> 'Functional city region': consisting of highly densely populated municipalities (urban cores) as well as any adjacent municipalities with high degree of economic integration with the urban cores, measured by travel-to-work flows (any municipality that has at least 15 per cent of its employed residents working in a certain urban core is considered part of the functional urban area.) (OECD, 2013)

City regional definitions of official institutions have traditionally frequently reflected historical regional associations (Harrison, 2008) and urban systems thinking based on local topography and physical trade and labour flows between geographically proximate cities (for example, Christaller, 1966; Whebell, 1969; Burghardt, 1971). However, the city region defined by more recent scholars has included more diverse functions and extensive intercity relations (Ke, 2010). A common theme underlying recent definitions is that core growth in economic actor networks is initiated in city nodes that concentrate so-called global 'gateway' functions and spills over metropolitan boundaries to form functionally integrated city regions characterised by cross-boundary complementarities and it is this basis for definition that has drawn the attention of China's central government to inform the Chinese institutional context:

> The massive spatial agglomeration of proximate cities, consisting of at least one mega city and three major cities that are connected by advanced transportation and telecommunicate infrastructures, resulting in a massive multi-nuclei city system where constituent cities achieve coordinated development and functional balance (Ministry of Housing and Urban-Rural Development of China, 2005).

Scott (2001a, p18) described the process by which global city regions "come to function increasingly as the motors of global economy, as dynamic local networks of economic relationships caught up in more extended worldwide webs of interregional competition and exchange". According to Scott, the city region is not just the sum of its separate urban cores but is a well-organized and functionally connected region which gets involved in global competition as a cohesive entity.

Empirically, studies by Meijers (2005) and Hall and Pain (2006) found that city regions, as networks of proximate cities and towns have cooperative and complementary relationships, making them more than a sum of their parts. It is also found that the majority of Multi-National Corporation (MNC) activities, such as investments, sales and R&D, tend to be placed in the city region where headquarters functions are located (Rugman, 2005; Peri, 2005). In addition, the results from research examining the position of Europe in a globalising world with reference to diverse flows (maritime and air traffic, trade of goods, APS services, FDI, stock exchange, migration, knowledge and students) found that the processes of regionalization and globalisation are becoming more prominent as simultaneous space-economy dynamics (Van Hamme and Richard, 2013). Together these conceptual and empirical findings suggest that a paradigm change in city region modelling is needed however this must take into account the specificities of local development contexts.

3.3 The Operating Structure of City Region

In order to appropriately historicise the structural interaction between the world economy and cities, it is necessary to differentiate between classical and recent models. A review of classical models of urban configurations in chronological order can provide valuable context for considering the evolution, roles and functioning of cities and the conceptualization of city regions over time. For example, in the early nineteenth century, Von Thunen's (1826) investigation of agriculture land use included transport costs and locational rents in his model explaining an urban structure which is illustrated by circular rings of agricultural land surrounding a central market place (Figure 3). Although Von Thunen's model was based on agriculture and an isolated central market, it illuminates two important factors in the shaping of urban structure: transportation cost and land value. Despite ongoing speculation by some commentators that ICT still heralds O'Brien's (1982) end of geography, transportation costs and land values that reflect proximity and location, remain influential global and regional geo-space mechanisms (Pain and Van Hamme, 2014). Von Thunen's model was further developed by Burgess in his concentric zone model (1925) created to reflect the rise of the Chicago metropolis at the beginning of 20th

century. The Burgess model is the first model to include functional divisions in an urban structure based on bid rent theory, depicting urban land use with sequential concentric rings from a central business district, factory zone, transition zone, working class zone and residential zone to a commuter zone (Figure 4). Burgess's zones valuably depict the historically specific urban pattern that reflects economic development stage, which still has relevance for emerging economies and for industrial cities that lack knowledge-intensive advanced services.

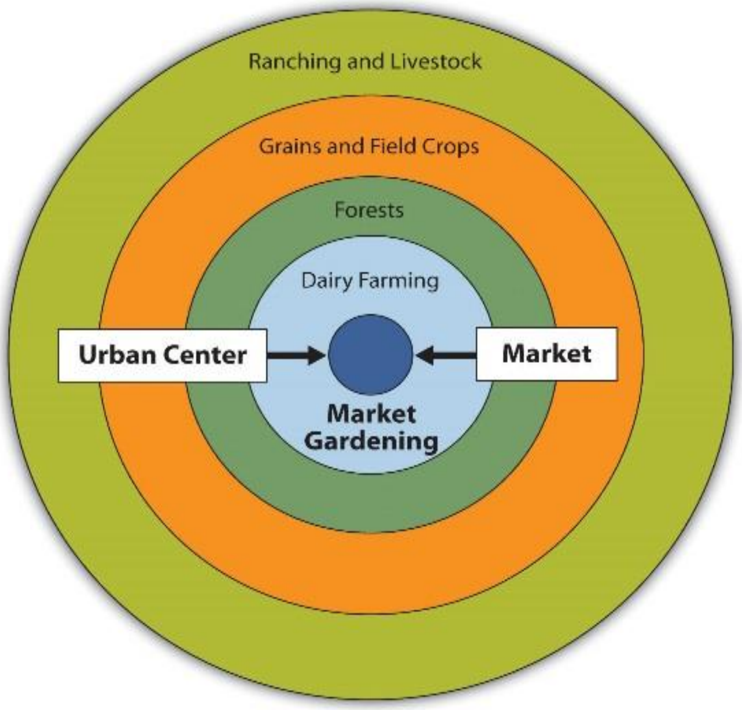


Figure 3 Von Thunen's Classical Model (source: https://thegreenhorns.wordpress.com/2014/08/08/the-von-thunen-model-a-very-cool-lesson-in-agricultural-geography/).

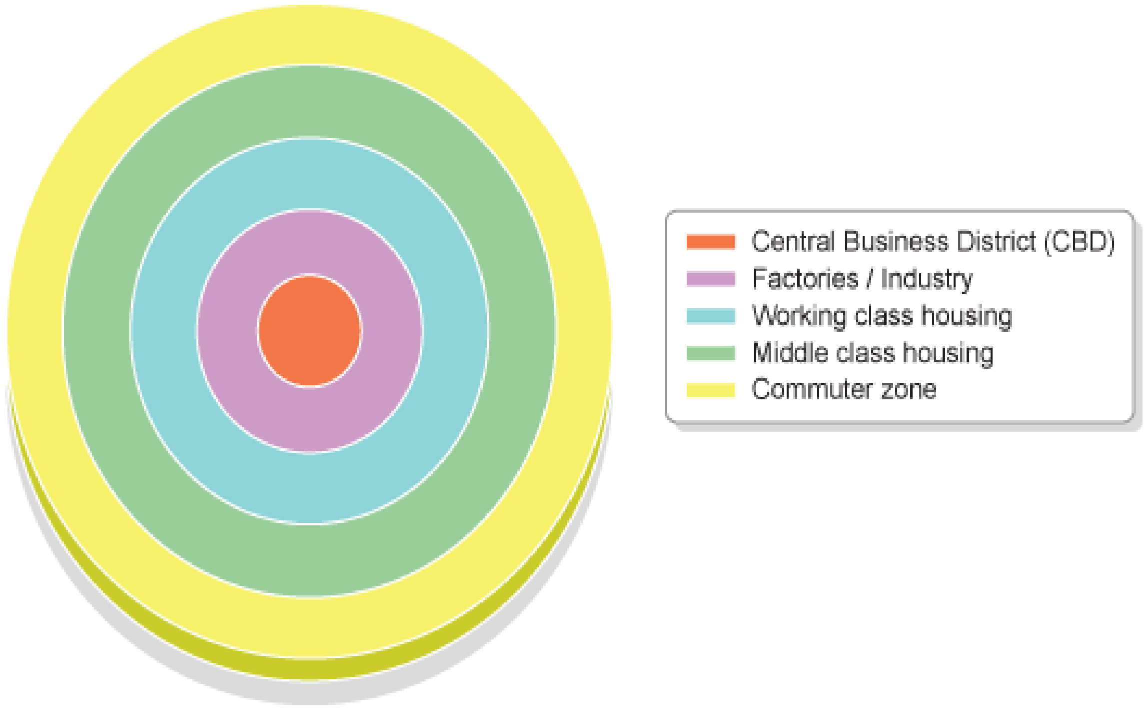


Figure 4 Burgess's Concentric Classical Model (source: https://commons.wikimedia.org/wiki/File%3ABurgess_model1.svg).

Hoyt's (1939) modification of the Burgess model aimed to depict the unbalanced spatial pattern of urban development associated with the location of transportation arteries (Figure 5). Hoyt was working at the time when entirely new business corridors were developing routes from the city to airports, such as the Dulles corridor in Washington and the Arlanda corridor in Stockholm. The model illustrates the spatial effects of the growing importance of a city's external connectivity albeit the consequences of that connectivity beyond the individual city, are not depicted. Further modification of urban modelling conducted by Harris and Ullman (1945) in their multiple nuclei model attempts to illustrate multiple growth points (nuclei) related to transport facilities, industrial specialisations and housing conditions associated with mass suburbanisation and manufacturing decentralization within cities (Figure 6). The model has value in depicting the emergence of 'edge cities' and new downtowns in peripheral locations later noted for example by Garreau (1991).

In conclusion, it is contended that formal classical models retain residual value in explaining emerging urban spatial patterns associated with interlinked technological, economic and societal changes in different development stages and contexts. However, notably, they only focus on the spatial pattern of the individual city and its contiguous hinterland, but omit the increasing economic interdependencies between neighbouring cities that recent studies identify as a significant contemporary development dynamic.

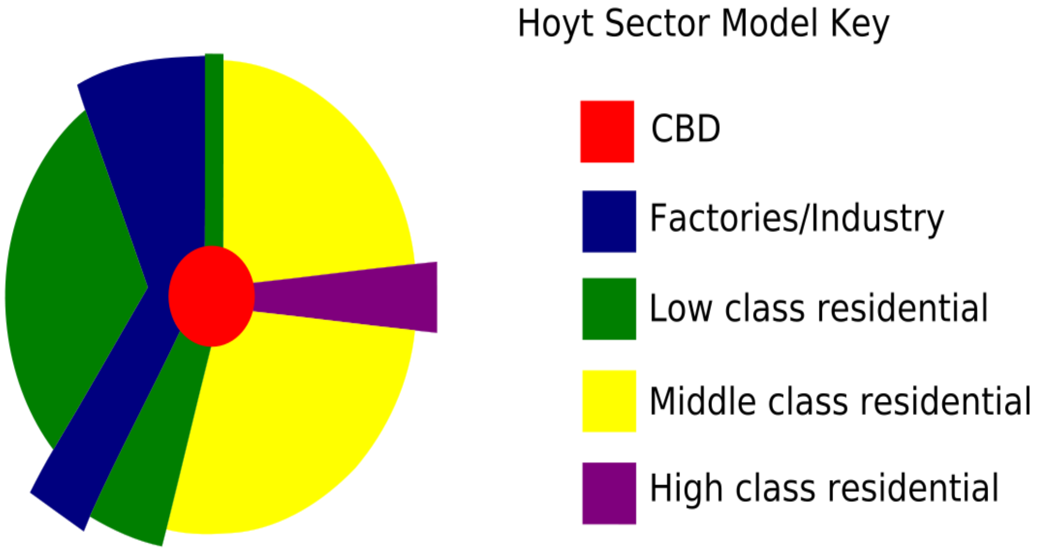


Figure 5 Hoyt's Sector Classical Model (source: https://upload.wikimedia.org/wikipedia/commons/2/2d/Homer_hoyt1.png).

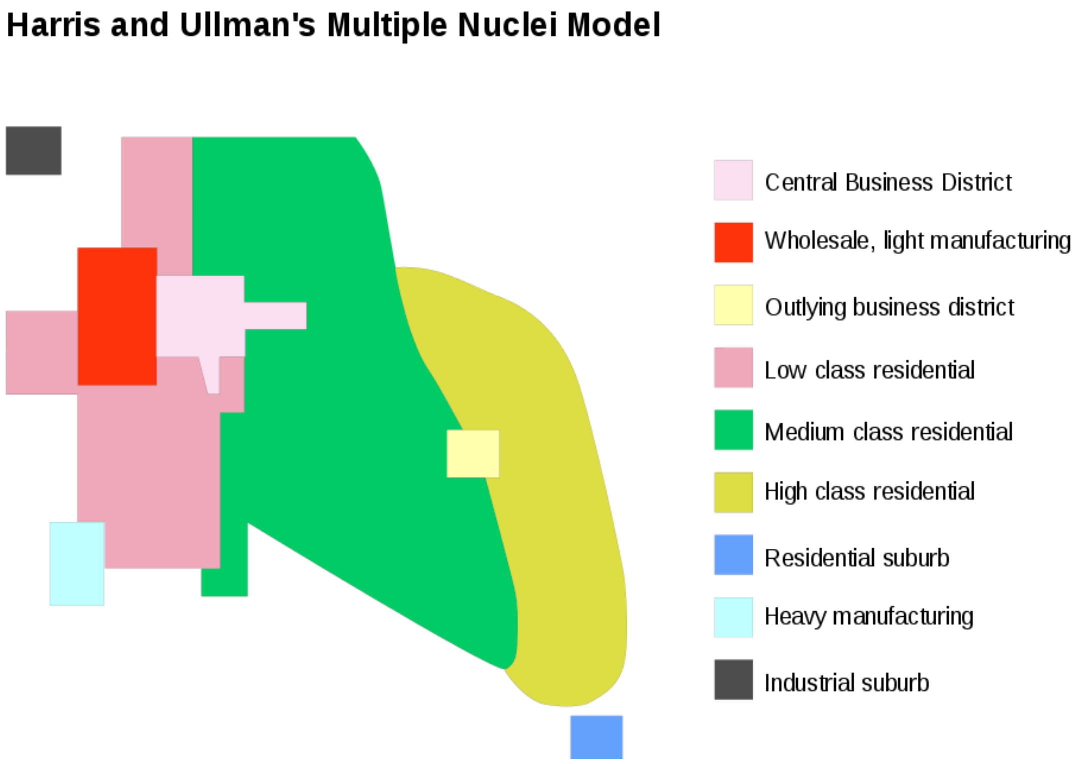


Figure 6 Multiple Nuclei Model (source: https://commons.wikimedia.org/wiki/File%3AMultiple_nuclei_model.svg).

Christaller (1966) has become well-known as the pioneer who developed an urban model capable of accounting for a system of cities representing an urbanized space where contiguity represents functional relations between urban places of different sizes. Central place theory highlighted the hierarchical order of specialized services in proximate urban places and consequent interactions between those places, depicted by the hexagonal form of market areas (Christaller, 1966) (see Figure 7). The theory inspired numerous subsequent studies concerning functional urban regions (FURs) (for example, work by Hall and Hay, 1980; Cheshire and Hay, 1989; Cheshire 1995, 1999; Cheshire and Carbonaro, 1996; Magrini, 1999) and Krugman (1993) who used central place theory in a microeconomic model to explain metropolitan emergence. The major contribution of central place theory is that it began explorations into the functional connectivity between proximate cities within regional markets, however the model is historically limited by its consideration of hierarchical inter-city regional relations.

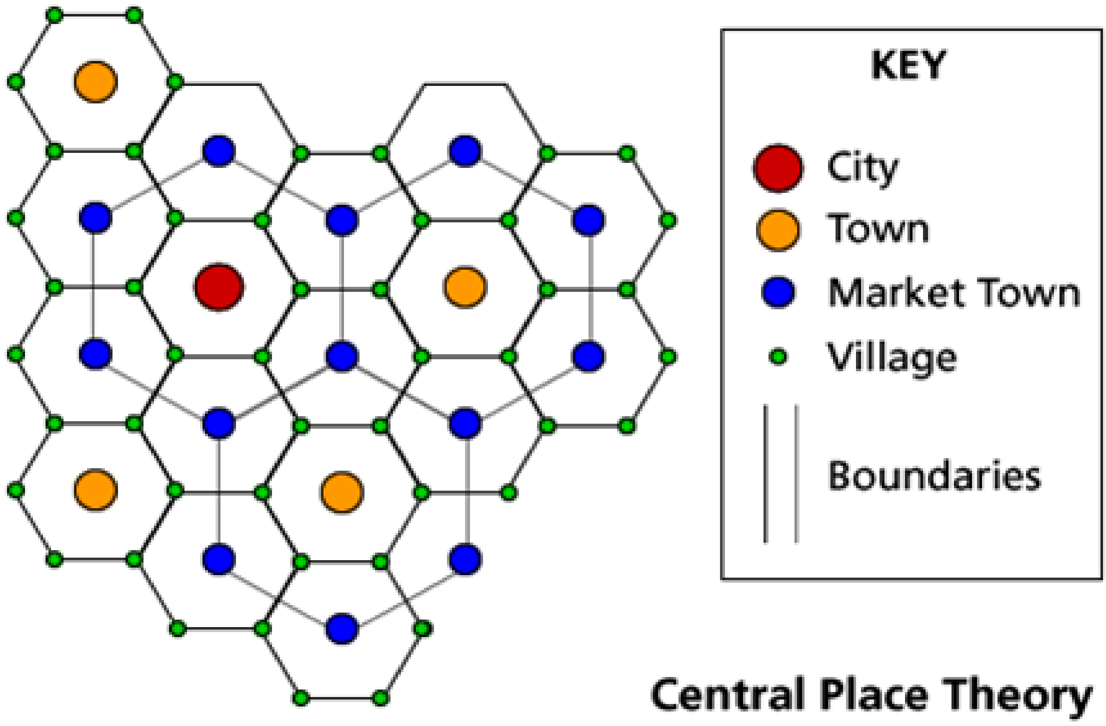


Figure 7 Christaller's Central Place Model (source: https://www.e-education.psu.edu/geog597i_02/node/679).

As the handling of information and the production of services have replaced the handling of goods as the dominant urban economic activity and interactions between cities have intensified and become more complex in a globalized and networked world, academic and policy attention to classical urban planning theories and models has diminished (see Castells, 1989, 1996; Storper, 1997; Graham and Marvin, 2001, 2002). Along with the rise of the knowledge economy and flexible production, studies concerning regional spatial patterns have transcended the centre-hinterland structure and have instead paid more attention to functionality and complementarity (Hall and Pain, 2006). As Duranton and

Puga (2001) argued, cities are increasingly recognized by their functions rather than by their industrial sectors.

The spatial patterns associated with functional relations between cities have become the prime interest of discourse surrounding the ‘polycentric city region’ (PUR) initially studied in depth in European studies (for example, Kloosterman and Lambregts, 2001; Kloosterman and Musterd, 2001). Put simply, in contrast to a monocentric pattern of development, a polycentric pattern depicts the operating structure of city regions characterized by functional interrelations. There are two aspects to understand the operating structure: the concentration of specialized advanced services (most notably APS) in primate cities and the dispersal of linked activities in secondary cities that generate localization economies, reflecting the combination of functionality and complementarity. Arguably, first identified in the multiple nuclei model by Harris and Ullman (1945), a polycentric city region development pattern has several urban cores that are interrelated in complex ways through exchanges of people, goods and information, each having their own specialized but complementary functions (Hall and Pain, 2006). Van Oort *et al.* (2010) argued that:

> The outcome of functional polycentricity is a considerable regional cohesion in personal, occupational and corporate relationships of people, organizations and firms that transcends the boundaries of the traditional metropolitan areas (p. 726).

Thus, it is necessary to explore the underlying flows that define a city region functionally to shed light on the spatial patterns of contemporary economic activity. Functional relations and functional polycentricity were based empirically on APS firms’ office locations in eight North West European regions by the multinational POLYNET[13] group of researchers: the Randstad, Central Belgium, Northern Switzerland, Rhine-Main, Rhine-Ruhr, Paris Region, Greater Dublin and South East England (Hall and Pain, 2006). Through the investigation of city regions in North West Europe, two distinctive urban processes have been identified: Process A – ‘mega-city region economic expansion’ and Process B – ‘mega-city regions of proximate cities’ (Taylor and Pain, 2007). Process A is

[13] POLYNET was a three-year 2003-06 project funded by European Regional Development Fund that examines changes in functional connections and information flows in major city regions across North West Europe.

distinguished by the functionally polycentric multi-sector clustering which generates Jacobsean economic enveloping and the upgrading of towns and cities surrounding a major globally networked city, whereas process B is distinguished by the morphological urban polycentricity and sectoral specialisation which generate less globally networked regions (Pain, 2008). The significant feature of the study was the finding that functional polycentricity did not map onto the eight city regions' morphological forms, revealing the mismatch of Process A and Process B. It is found that all eight (mega) city regions were found to have just one global city with intense cross-border flows in the World City Network, illustrating that functional primacy is invisible when only morphological polycentricity is considered.

For example, the Rhine-Ruhr is the most morphologically polycentric city region, but this does not translate to functional polycentricity (Knapp et al, 2006). Similarly, in South East England city region functional polycentricity found to be associated with London's supreme global APS network connectivity belies its morphological description in European strategy as a monocentric region due to London's economic size (Pain, 2008). While Paris ranks fourth city in the world for connectivity to APS global networks, the Paris city region lacks functional polycentricity due to a legacy of regulatory policies limiting its development (Halbert, 2006). Similarly, Central Belgium is also characterised by a hierarchical structure where prime city Brussels dominates urban functional connectivity (Vandermotten *et al.*, 2006; Hanssens *et al.*, 2014). Interviews with APS firms in offices across the eight city regions revealed that multi-office networks at the regional scale are not necessarily representative of actual flows between urban places (Pain and Hall, 2008). Therefore, it is found that morphological polycentricity cannot reveal the underlying complementary functionality in city regions, calling for more network analysis based on *actual* interactions and flows between cities, which is a major motivation behind the empirical study reported in Chapter 7.

Lastly, in order to clarify the developing process of urban models, Table 1 shows a comparison between classical models and a polycentric model based on urban functional relations and interlinkages. In summary, it is found that in former times, city region models were based on by urban cores serving agriculture hinterlands and spatial interactions that reflected topography and transport costs. But more recently, globalisation and technology advances have given regional core cities a new role in the service economy at larger scales (Taylor, 2001b). The centrality and polycentricity paradigms therefore represent an ‘uneasy union’ in recent urban development studies (Hall and Pain, 2006, p12) whereby contemporary global network centrality seems to influence city region functional polycentricity. Thus, regardless of morphological structures, developments in the research literature suggest that the extension of city region research in China should focus on the functionality and complementarity across cities derived from data on actual transboundary city network interactions and associated spatial effects.

Urban Models	Spatial Pattern	Influential Factors	Spatial Relationship	Economic Foundation
Von Thunen Model (1826)	The circular rings of agricultural land surrounding a central market place.	Transport cost and rent.	Centre-hinterland.	Agriculture and workshop production.
Burgess Model (1925)	The concentric rings from central business district, followed by factory zone, zone of transition, working class zone, residential zone and commuter zone.	Inner-city functional division and bidding rent theory.	Functional centre-hinterland.	Industrialisation and mass production.
Hoyt Model (1939)	The concentric rings in Burgess Model with spiky transport arteries.	Transport connectivity and attached agglomeration.	Functional centre-hinterland.	Industrialisation and mass production.
Multiple Nuclei Model (Harris and Ullman, 1945)	Multiple growth points within cities.	Modern transportation, complex specialisations and housing conditions.	Multiple centres-hinterland.	Fordism and customisation production.
Central Place Model (Christaller, 1966)	The hexagonal shape of several contiguous cities.	Specialized services and transport connectivity.	Hierarchy of urban centres.	Fordism and customization production.
Polycentric City Region Model (Hall and Pain, 2006)	Several cores that interrelate in complex ways through exchanges of people, goods and information, and have their own specialized functions.	ICT technology and APS sectors.	Interlinked cities in integrated functional economic area.	Post-Fordism (flexible production) and Knowledge economy.

Table 1 Urban Spatial Models Comparison.

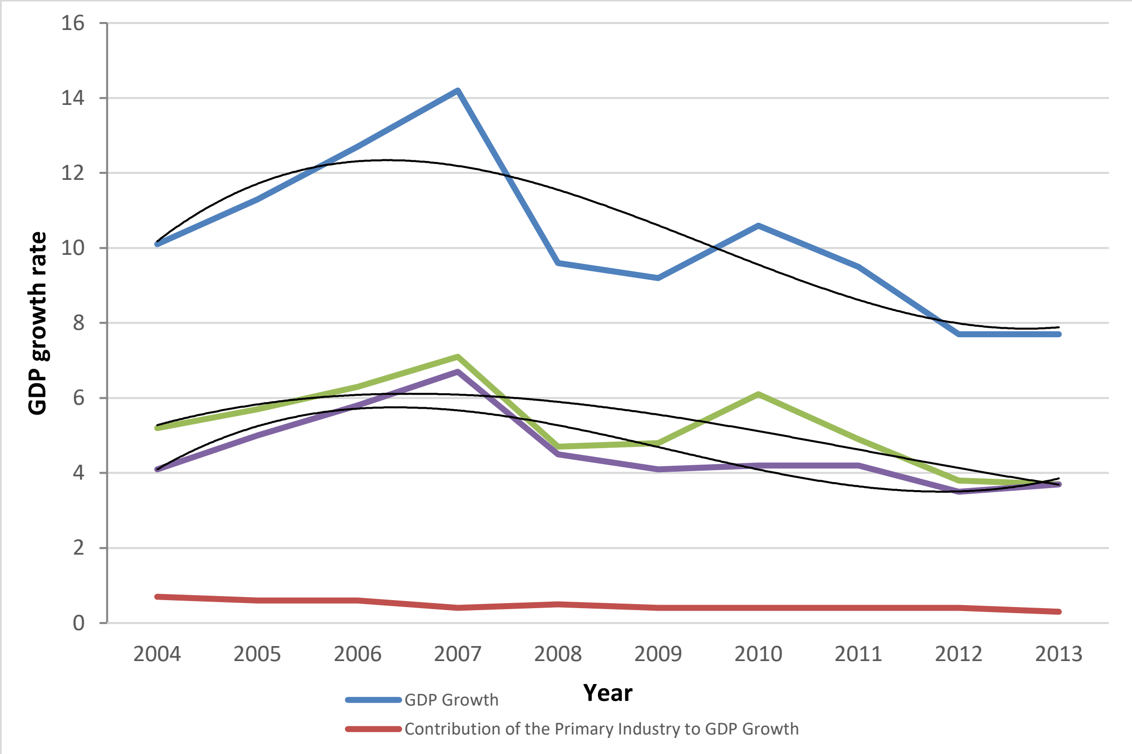
3.4 Focal Area: MYR City Region

As the second biggest economy in the world, China's major urbanisation is giving rise to new city region emergence. Since economic reform and the open door policy allowing China's integration in the world economy, the urbanisation rate has boomed, rising from 18.62 per cent in 1979 to 54.41 per cent in 2014 (World Bank, 2015). The Chinese variant of urbanisation is characterised by city region formations of a population size, physical extent and economic weight that makes them some of the largest in the world. Currently, there are three 'globalized city regions' recognised for their increasing integration in the advanced service economy: Pearl River Delta, Yangtze River Delta, and Jing-Jin-Ji region (or Bohai economic rim) (see Figure 1) (Derudder *et al.*, 2010; Derudder *et al.*, 2013). According to 2013 statistics; these three regions together accounted for 41.1 per cent of China's national GDP, 20.7 per cent of national finance-revenue and 72.7 per cent of national export-import volume (NBS, 2013). Since the 12th five-year-planning-scheme issued by central government China's city regions and their integration have been a focus of national strategies (Xinhua News Agency[14], 2012). The importance of functionality and connectivity in city regions has been emphasized by urban governments and business actors in order to enhance their economic competitiveness.

In particular, along with rising labour costs, competition from other emerging economies, and recent global economic malaise, China's economic development has been slowing down and is regarded as unlikely to maintain its 'workshop of the world' status solely by producing labour-intensive manufactured goods. As shown in Graph 3, over the decade from 2004 to 2013, China's economy has lost its double-digit growth rate, stabilizing at around eight percent (a polynomial trendline[15] is used to explain fluctuating data). In terms of the three industries' contribution to GDP growth, primary industry does not affect the dynamic of GDP growth while second and tertiary industries correspond better with aggregate GDP growth. However, as shown in Graph 3, secondary industry has the most similar trajectory to aggregate GDP growth, which indicates its ongoing major influence on economic growth.

[14] The Xinhua News Agency, as a ministry-level institution of Chinese central government, is the most influential official media in China, serving as the state media platform to communicate government policies to the public.

[15] A polynomial trendline is a curved line that is used when data fluctuates.



Graph 3 China GDP Growth Rate and Industries' Contribution over 2004-2013 Contribution (source: NBS).

China is undergoing a crucial transition period from a labour-intensive and capital-driven economy to a more advanced and potentially resilient economy by the expansion of added-value activities. As Sassen (2000) argued, advanced service sectors that are equipped with high value-adding activities and outstanding connectivity, especially APS, are the direction of contemporary Chinese economic transition and policy. Particularly for the Yangtze River Delta and Bohai Economic Rim world-class city regions and more recently the Pearl River Delta (see Zhang, 2015) economic restructuring their economies from manufacturing to advanced service sectors and high-end production industries, has been the key policy. The transition is likely to substantially change the national economic pattern further and a central government objective is to replicate this transition in emerging city regions across China. Advanced services and high-tech production in the most developed city regions alone cannot accommodate China's huge labour pool and sustain its growing service market. In consequence, the transition process is seen as being a long journey which will initially be accompanied by widening regional disparity and the danger of industry hollowing out[16] (Kanbur and Zhang, 1999; Meng, *et al.*, 2005).

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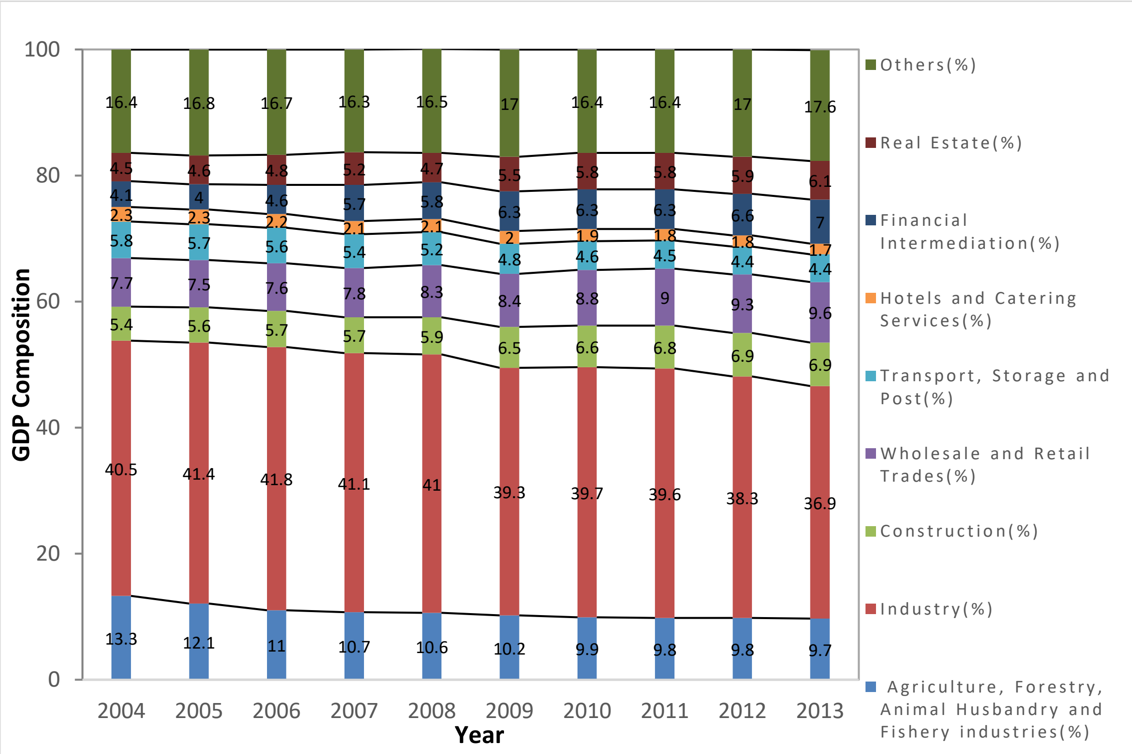
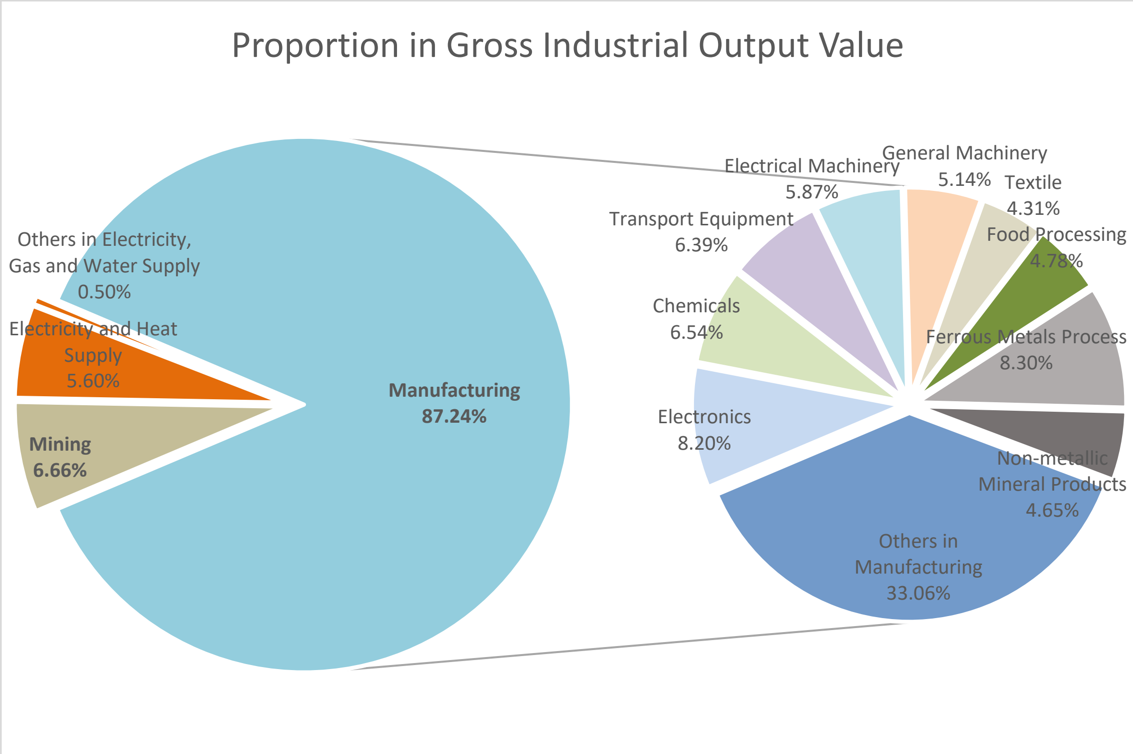
[16] Massive volumes of materials and capital in manufacturing are transferred overseas rapidly from the domestic market, causing the sharp decline of manufacturing in China's economic structure composition and a severe imbalance between physical manufacturing and service production.

Graph 4 illustrates the shares of different industrial sectors in GDP which highlight that China's economic development is associated with the simultaneous process of the rise of advanced services (finance and real estate) and the decline of traditional secondary industries. However, despite an increasing volume of advanced services activity in China important for competitive economic transition, secondary industry remains the cornerstone of the present national economy, accounting for approximately 40 percent of GDP. In terms of contribution to national industrial output value, as shown in Graph 5, manufacturing still dominates. In conclusion, it is necessary to consider both rising advanced service sectors and advanced manufacturing that leverages value-added by APS, in order to accomplish economic transition successfully. An overemphasis on one or other of these industries would not be conducive to the China's economic development process at this specific stage of its metamorphosis. Thus, in order to avoid a so-called 'hard landing' and balance regional disparity, China presently aims to establish more national city regions that are equipped with a well-established industrial base to stabilize the transition process and recharge the slowing economy (China Central Government, 2011).

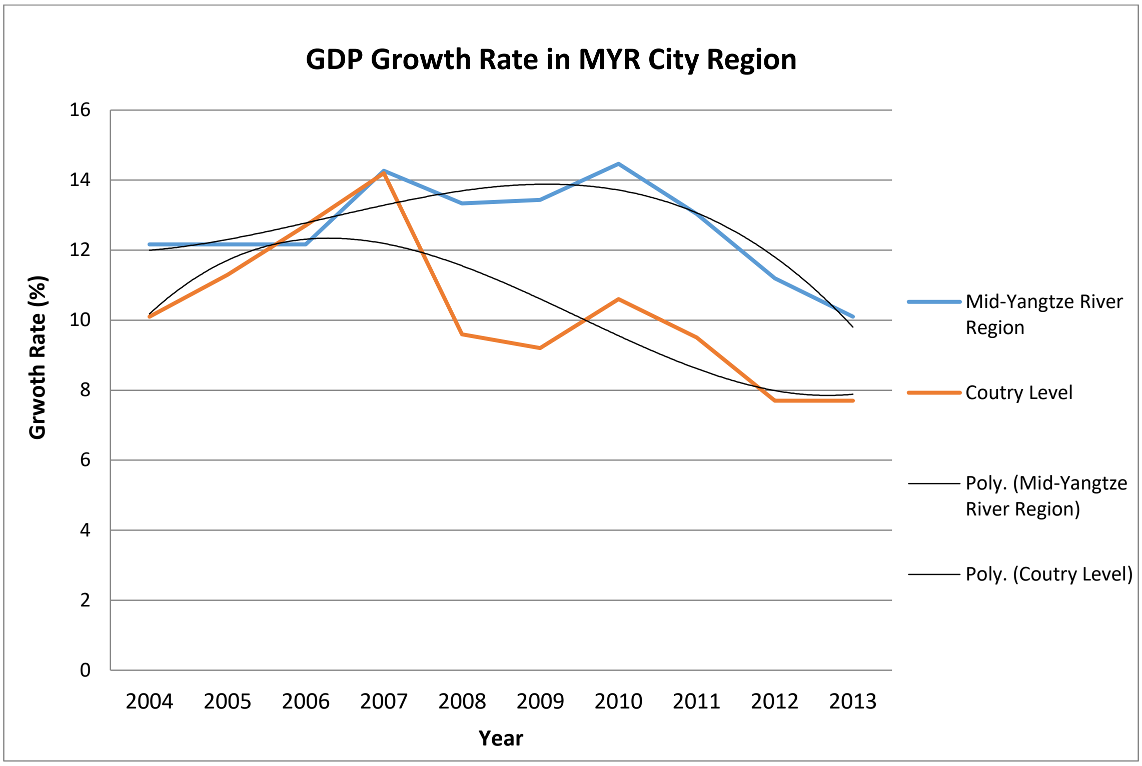


Graph 4 GDP Sectoral Composition over 2004-2013 (source: NBS).



Graph 5 Industrial Output Value Composition in 2013 (source: NBS).

In China's national planning scheme, the MYR city region located in central China (see Appendix Figure A1) has been selected to be the strategic growth region (growth pole) in China's economic transition phase due to its established industrial base, well-developed infrastructure system, developed higher education, well-qualified labour etc., and its geographical location which makes it a conduit between the east and the west. The MYR city region represents more than half the weight of central China's economic activity against several economic indicators: 53.19 per cent of GDP, 55.05 per cent of fixed asset investment and 51.22 per cent of fiscal revenue (NBS 2014). Furthermore, as shown in Graph 6, the MYR city region's economic development is maintaining a double-digit growth rate. In particular, since the 2008 economic crisis, in contrast to the national decline in growth, the MYR city region maintained a robust and higher growth rate, which indicates its resilience compared to other regions in China. The present MYR city region research therefore has potential significance for empirically informed understanding relevant for the realisation of China's space economy rebalancing and associated governance challenges in the context of Chinese neo-liberalisation.



Graph 6 GDP Growth Rate in the MYR City Region over 2004-2013 (source: NBS).

The MYR national level city region status[17] has been reinforced by several government policies. Early in 2004, Chinese central government proposed the 'Rise of Central China Plan' and emphasized the strategic significance of the city region as the 'the core growth pole' to undertake industrial transformation away from the already transforming coastal areas. In 2010, Chinese central government issued one national policy, 'National Major Functional Regions Planning' in which the MYR city region was first officially singled out as one of six strategic city regions on a national level. In 2011, China issued its most important periodic planning scheme, the '12th 5-year Planning Scheme' setting out how the Government planned to establish a modern infrastructure system by 'two horizontal arteries and three vertical arteries'[18] seen as economic corridors to stimulate the national economy and support economic transition. The MYR city region is located at the conjunction of the Yangtze River waterway and Harbin-Beijing-Guangzhou arteries, which

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[17] In China's national planning scheme, the city region is termed as '城市群 (cheng shi qun)' in policy documents. Up until to 2013, five national level city regions under central government support were identified: Jing-Jin-Ji, Yangtze River Delta, Pearl River Delta, the MYR, and Cheng-Yu city regions, which are all circled in Appendix Figure A1.

[18] The five arteries are five national arteries interconnecting important city regions and ports in order to facilitate economic transition, including the Silk Road Corridor (horizontal), Yangtze River Waterway (horizontal), Coastal Artery (vertical), Harbin-Beijing-Guangzhou Artery (vertical), Baotou-Kunming Artery (vertical).

indicates its outstanding topographical position which is seen as advantageous in China's new planning scheme. In 2012, the Government proposed the policy, 'Further Promotion of the Rise of Central China' in which the strategic position of the MYR city region was reinforced in the national planning scheme. In 2014, the issue of 'State Council Instructions on Improving the Yangtze River Economic Belt' relying on the 'Yangtze River Gold Waterway' as a national strategy, designated the MYR as the core city region along the 'Yangtze River Economic Belt'. Economic transition, deepening urbanisation and regional coordinated development are the three principles highlighted which underpin the policy. In particular, the function of the MYR city region in supporting industrial transfer from the coastal area is emphasised with Wuhan city identified as becoming the MYR hub city and service centre for central China. In addition, the National Development and Reform Commission (NDRC), which is the highest economic policy-making bureau in China, put forward the 'Mid-Yangtze City Region Development Plan' in 2015, which reinforced the MYR city region's national status and guaranteed financial support. The policy clarified the 'new growth pole' position of the MYR city region during the economic transition and aimed to benchmark it as a successful development template in deepening urbanisation and a free trade zone for other inland regions. Coordinative functional development across MYR cities is highlighted as the most important principle for facilitating its economic development. With this in mind, financial grants are increasing, especially for infrastructure investment. For example, high-speed rail planning for the MYR city region has reduced the commuting time between its major cities (Wuhan, Changsha and Nanchang) to within two hours. Meanwhile, high-speed rail services were introduced between these cities and other major Chinese cities such as Beijing, Shanghai, Guangzhou and Chongqing. However, as discussed in Chapter 1, there are few studies, especially empirical studies, that investigate the conditions for coordinated functional development in early stage city region economic transition and in the MYR city region specifically.

Wuhan, as the leading city of the MYR city region, is the most important manufacturing centre, educational centre and transportation hub in central China. It is the largest city in central China in terms of population size (with more than ten million people) and its development was the second-fastest amongst major Chinese cities (only behind Tianjin) (NBS, 2013). Wuhan ranked sixth after Shanghai, Beijing, Guangzhou, Shenzhen, Tianjin, and Chongqing among metropolitan centres in China in terms of both its urban size and total GDP in 2013 (Passport, 2014). In the early 1990s, the establishment of Chinese special economic development zones has assisted Wuhan manufacturing base upgrading by introducing more value-added activities. The expansion of advanced services along with these value-added (advanced) manufacturing activities, combined with significant investment in infrastructure and a well-educated labour force, has led to Wuhan's improved labour productivity (1.4 times higher than the national average) (Passport, 2014). The Wuhan local government aims to transform the city into a global centre for manufactured advanced products, services and a major national transportation hub, as outlined in its '12th 5-Year Plan' (covering the years 2011to2015). As one of the most important educational centres in China, Wuhan boasts 79 higher education institutions (making it the second educational centre in China, only behind Beijing) and 1.2 million university students (one of the highest figures in the world) (Passport, 2014).

In conclusion, the MYR city region is a strategic regional formation in China that is seen by central and local government as having a pivotal role in the process of national economic transition. However, the region has not attracted sufficient attention theoretically and empirically in an international perspective, which is a motivation behind the present research. As Huggins (2016) articulated, in addition to focusing on endogenous accumulation of indigenous capitals (see discussion in Chapter 4), institutional context is another important aspect underpinning the dynamics of the city region economy. Thus, given the strategic position of the MYR city region in China's planning scheme, the research can also provide meaningful insight into the association between the Chinese variant of neoliberal governance and city region development.

The two main analytical trajectories pursued in this research, the geo-space mechanism and the network space mechanism, are reviewed next in Chapter 3 and Chapter 4 in order to explain how their underlying theories have been applied in regional empirical studies and inform the development of the basic methodologies employed in the empirical chapters of the thesis.

4. GEO-SPACE IN URBAN DEVELOPMENT

The geo-space mechanism of regional development is basically derived from urban agglomeration economy based on indigenous growth model and its spatial spillover effects across territories. The first section will review the literature concerning the agglomeration economy and its indigenous growth studies. The second section will review the rational of spatial analysis in regional studies. Through combining the two rationales discussed in the first two sections, the third section reviews spatial econometric modelling briefly in terms of methodological issues and related empirical studies.

4.1 Urban Agglomeration and Indigenous Growth

There are two main paths to explain agglomeration economies: a top-down macroeconomic vision and a bottom-up microeconomic vision. In terms of the macroeconomic vision, as early as 1920, Marshall had articulated three sources of agglomeration economies: labour pooling, scale economies of intermediate input and tacit knowledge spillovers, as the basic model with which to analyse an urban economy (Fujita, 1988). According to the Marshallian perspective, agglomeration gives rise to mass production (now devolved to product differentiation and flexible specialisation), a highly specialized labour pool based on the accumulation of human capital and face-to-face communications, the availability of specialized input services, and the existence of modern infrastructure. Later, technological progress is included as another determinant affecting urban agglomeration and the spatial distribution of urban economic activities (Asheim and Gertler, 2005). In reference to the Marshallian economy, endogenous growth theory highlights the accumulation of human capital, knowledge stocks and physical capital investment as significant endogenous factors in urban growth (Fujita and Ogawa, 1982; Helsly and Strange, 1990). According to the endogenous growth theory, these indigenous input factors are characterised significantly by path dependence tendencies and location inertia (Henderson, 1991; Kim, 1995). As Bathelt and Taylor (2002) emphasized, economic development is largely dependent on the exploitation of indigenous resources even in the context of globalisation and massive transboundary activities. In Porter's urban competitiveness theory, these indigenous factors become the competitive resources that cities are striving for. Porter (1990) argued that core competitiveness is derived from upgrading the local industrial base and adding more value to its products. Porter advocated that industrial clustering is a beneficial spatial pattern to encourage the awareness of competitiveness which can stimulate innovations and the circulation of knowledge and information (Porter, 1998). Pursuing the same line of Porter's competitiveness theory, cities are seen as competing with each other in order to secure various productive resources on a large scale. As Turok (2004) highlighted, urban development should be transferred from spatial policy to the exploitation of indigenous strengths in order to improve competitiveness. These prevailing competitiveness arguments have broadly been applied in many development policies worldwide.

From a macroeconomic perspective, in addition to basic input factors such as labour, capital, material and knowledge, there are two different agglomeration forms for urban growth: specialisation agglomeration or diversity agglomeration. The specialisation agglomeration concept is elaborated in orthodox endogenous growth theory which highlights the contiguous spillovers of the same activities (Henderson et. al, 1995). Henderson (1997) found that intra-industry specialisation produced positive externalities over cross-industrial diversification in the US during the period 1977 to 1990. In competitiveness theory, industrial specialisation is also advocated to upgrade the industrial base, improving urban competitiveness as an outcome. On the other hand, Jacobs (1984) argued that it is local diversification that generates positive externalities to urban growth, emphasizing the priority of heterogeneity over homogeneity and parallelism over hierarchism. Boschma (2004) also articulated that it is the variety of economic activity that leads to knowledge creation and extended learning processes.

It is still disputed which development form is more favourable to urban competitiveness and economic development, however pro-diversity studies are becoming prevalent in the international literature in recent years. Jacobs (1984) asserted that knowledge spillovers generated across diverse industries are more active and innovative than those generated across specialized clusters. The Jacobean theory has motivated a large number of empirical studies in exploring the effect of diversification on driving regional growth and producing innovations, which supports the importance of diversification (related variety) in the process of regional development (see Frenken *et al.*, 2007; Boschma and Iammarino, 2009; Brachert *et al.*, 2011; Boschma *et al.*, 2012; Tavassoli and Carbonara, 2014). In addition, the positive externalities of diversification are not limited to related industries. Castaldi *et al.* (2014) discovered that the agglomeration of unrelated industries would also contribute to urban innovation capacity at a regional scale, which indicates the existence of tacit knowledge in diversified agglomeration. They argued that unrelated variety is positively associated with regional capability to produce breakthrough innovations. The typical example of pro-diversity policy makers is the foundation of the incubator model in practice to attract firms and entrepreneurs from different sectors, firm sizes, and firm types in planned cities and towns, which is widely applied in technology and enterprise zones.

However, based on the consideration of literature in Chapters 2 and 3, it is speculated in this research that specialisation and diversification agglomeration forms are not two separate paths to urban growth. These two agglomeration forms are more likely to coexist in cities and to be highly concentrated in big cities (Ellison and Glaeser, 1999). Ellison and Glaeser (1999) found that larger cities tend to be more diversified and specialized in services as opposed to manufacturing sectors, while small cities are more likely to specialize in specific industries. However, Duranton and Puga (2001) also argued that although knowledge-based activities and advanced services tend to locate in diversified big cities, they may still relocate to specialized cities when their products and services enter mature or recession stages. Pain (2008) found that in the case of functionally polycentric city region, South East England, advanced services have relocated to form multi-sector clusters in smaller cities and towns outside London in order to engage with a growing regional market. Moreover, in morphologically polycentric city regions, advanced services specialisation has supported weaker functional integration and polycentricity (Pain and Hall, 2006). In the case of China, manufacturing production remains the dominant national industry. Meanwhile, the rise of knowledge economy and advanced services provides capacity for promotion of advanced manufacturing. Thus, a balanced urban system may not be one where all cities are equally specialized or equally diversified, but one where both diversified and specialized cities coexist.

From a microeconomic perspective, Krugman and Fujita (1995) attributed urban agglomeration to the production and consumption of differentiated products that motivate firms and labour to concentrate in cities (not only in metropolitan centres but along with the increasing size of cities, also in hinterlands). They explained that firms agglomerate in urban areas in order to search for increasing returns, monopolistic power and lower transaction costs, and that labour forces flow into cities due to higher income prospects and convenient facilities, which triggers spatial agglomeration and new ‘frontier cities’ as an outcome. Krugman and Fujita popularised the New Economic Geography which emphasizes a ‘lock-in’ effect or ‘circular causation’ (historical path dependence) based on a continuous agglomeration phenomenon (Fujita and Mori, 1997; Dosi and Nelson, 2010). Furthermore, Henderson (2003) specified the 'circular causation' of urban agglomeration by investigating the characteristics of different industries. For example, he testified that high technology firms are capable of benefitting from positive technology spillovers, while manufacturing firms continue to be decentralised with few positive agglomeration spillovers. Spencer (2015) also found that creative industries were apt to locate in mixed-use neighbourhoods while science-based industries were apt to locate in suburbs with a lower density and single existing land use. In addition, given financial firms, Taylor *et al.* (2003) found that financial services firms agglomerate striving for proximity to competitor firms and linked APS firms that they supply services to and with whom they collaborate. Together, these microeconomic studies highlight the feedback effects of economic actors' behaviour on agglomeration economies e.g. industrial clustering and transaction costs.

It would seem then that, regardless of distinctive research paths, the equilibrium state of urban agglomeration will be manipulated by the relative strength of centripetal forces (specialized labour pool, market size, spillover effects of clustering and other positive externalities) and centrifugal forces (increasing transaction costs, land rents, congestion, imperfect market and other negative externalities) (Cook *et al.*, 2007). By virtue of the positive signal of urban revitalization described in Chapter 2, current centripetal forces are outweighing centrifugal counterparts which is a drastically prominent spatial dynamic in global cities and city regions, for example South East England (Pain, 2008). Especially in the clustering of advanced services and knowledge-intensive activities, the need for face-to-face communication and geographical proximity are seen as fundamental conditions in creating an efficient productive system (Saxenian, 1994) and an indispensable stimulus to build trust (Pain, 2006). However, intertwined with industrial dynamics, diversified economic activities and an idiosyncratic institutional context, urban agglomeration has become much more complex and complicated from a microeconomic perspective, which makes the use of economic actor behaviour at city level less applicable in explaining city region development. In other words, a microeconomic view is efficient in explaining economic patterns within cities, but for the investigation of urban economic expansion into the city region scale, a more comprehensive approach is necessary.

4.2 The First Law of Geography in Shaping Urban Economic Patterns

As introduced in Section 1.2, the underlying spatial mechanism of city region is intrinsically based on the first law of geography "everything is related to everything else, but near things are more related than distant things" articulated by Tobler (1970, p. 234). In other words, human interactions and economic activities are easier to access in 'near' (proximate) spaces, since overcoming spatial constraints will consume energy and resources that people try to minimize (Miller, 2004). Especially associated with the rise of knowledge economy, Maurseth and Verspagen (2002) articulated that spatial proximity has become more significant for firms' value-added activities and that spatial clustering is an important way for these firms to attain strategic knowledge. Boschma (2004) also argued that knowledge externalities are geographically bounded, since proximate actors agglomerating in near spaces are more likely to capture privileged access to information flows, knowledge transfer and interactive learning.

Thus far, several studies have confirmed the significance of spatial proximity based on the first law of geography in gaining knowledge and driving regional development. Specifically, quantitative and qualitative interview-based research conducted in London's multi-sector APS cluster, the 'Square Mile', demonstrated the outcome of this proximity premium (Taylor et al, 2003; Pain, 2007). Davenport (2005) found that small and medium sized enterprises (SMEs) could benefit from spatial proximity to similar firms and research institutions in gaining knowledge. In addition, Autant-Bernard and LeSage (2011) identified the effects of spatial proximity on transmitting interdisciplinary knowledge. They attributed the knowledge transfer to that spatial proximity enhances the opportunities for face-to-face contact and the exchange of information and knowledge across space as an outcome. Overall, spatial proximity still plays an important role in illuminating spatial associations and positive externalities in regional development (see also Redding and Venables, 2004; Fingleton and Lopez-Bazo, 2006; Ertur *et al.*, 2006; Parent and LeSage, 2012). Thus, the first law of geography is still applicable in providing a basic understanding of the relevance of spatial association.

In classical models, spatial proximity was only considered in the discussion of transport cost; thus 'relatedness' in the first law is restricted to commodity exchange. However, in context of contemporary production flexibility and knowledge economy, facilitated by modern transportation systems and information technology, 'near things' (in terms of spatial proximity) have become more 'related' than ever before in complex economic interactions which give rise to heterogeneous spatial associations and spillovers across territories (McCann, 2005). Rey and Janikas (2005) also provided evidence to show that, supported by increasing capacity in transport accessibility and ICT, 'near' urban entities not only become physically contiguous but also generate more heterogeneous spatial associations. They attributed the emergence of these massive associations to 'cumulative' and 'complicated' interactions initiated by economic actors through overcoming spatial constraints. In conclusion, the spatial proximity concept has come to absorb characteristics of complicated economic interactions beyond commodity exchange, which makes the effects of distance on 'relatedness' (distance decay effect) become disproportionate. For example, instead of proportionate distance decay, Cicoone (2002) found that spatial proximity to large markets is particularly beneficial to industrial firms in order to capture productivity gain; this finding is supported by Fujita and Thisse (2003).

In addition to increasing complexity of spatial proximity, the first law of geography is challenged by intensifying distance-free flows in 'network society' (Castells, 1996). Especially under conditions of globalisation, global cities are more transnationally connected and have more intense linkages with other big cities than with their neighbouring cities (Pain and Van Hamme, 2014). As Johansson and Quigley (2004) emphasized, network thinking which is based on the intensity of flows rather than geographical proximity is therefore necessary to understand contemporary urban agglomeration drivers. Network thinking will be introduced in Chapter 5 as the other research mechanism that can shed light on the economic development of the MYR city region. Especially in China, network thinking is mainly confined to business and institutional cooperation strategies, and has not been recognized and applied widely in urban development analysis or economic and spatial strategies. This research thereby contributes a novel insight into the city region as not only a geographically and territorially (institutional administratively) bounded entity but also as a functionally interconnected space.

4.3 The Spatial Econometrical Models for Regional Development

As argued in the last two sections, urban agglomeration is the premise for the generation of cross-metropolitan boundary spatial associations, while distance decay effect[19] which follows the first law of geography continues to play a part in city region spatial associations (cities proximate to each other have more interactions than distant ones). Although studies concerning urban agglomeration and its spatial effects have a long history, initial empirical studies were confronted with data deficiencies and analytical technique difficulties, which hindered the development of spatial analysis. Since the information technology revolution, GIS techniques and computational technology become much more sophisticated, providing apposite geographical data and analysis packages. Spatial econometric modelling has developed rapidly and has become an essential modelling technique in examining the effects of spatial proximity in shaping economic patterns. The basic idea of spatial econometrics is that spatial interdependence and spatial heterogeneity across territories should be taken into account in order to enhance standard economic models. The classic growth model highlights the dominating contribution of indigenous input factors such as capital stock, labour pool, natural resources and technological level etc. to local economic growth. In other words, the spatial econometric model argues that economic development not only depends on indigenous factors but also on their neighbours' performance and the spatial effects of these neighbouring factors via spatial association (Fingleton and Lopez-Bazo, 2006). Essentially, spatial spillover effects on regional development are illuminated by the contiguity matrices of spatial units and delivered in a physically contiguous order. Although Gibbons and Overman (2012) expressed concern that the contiguity matrix (W) is an endogenous matrix in the function, interfering with the robustness of results, Corrado and Fingleton (2011) have provided experimental evidence proving that spatial econometric models can produce consistent results based on a strong theoretical argument.

In standard econometric theory, indigenous growth models assume the independence of urban markets as observations and the homogeneity of observations, which omits the effects of spatial interactions with neighbouring cities and spatial heterogeneity across territories. In other words, missing spatial dependence and spatial heterogeneity will

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[19] Distance decay effect is a geographical term, stating that the interaction between two spatial units declines as the distance between them increases.

produce inconsistent results in inference processes in classic growth models (Corrado and Fingleton, 2011). Thus, at an early stage, Christaller (1966) noted that urban growth models were restricted to indigenous factors and regarded cities as isolated markets, proposing central place theory which incorporated spatial interactions. His argument, that the interactions of cities are reshaping the regional market, motivated regional scientists to take into account spatial effects in urban growth models. In the late 1990s, Krugman's New Economic Geography became a prevailing theory, emphasizing the simultaneity of spatial proximity and indigenous input factors in illuminating urban economic patterns, especially in the discussion of trade cost and market accessibility (Krugman, 1991; Fujita *et al.*, 2001; Redding and Venables, 2004). Currently, the consensus is that cities should not be regarded as independent markets in growth models and that cities are engaging in spatial interactions with other cities in their hinterlands (Hall and Pain, 2006; Van Oort *et al.*, 2010). In particular, with reference to China's ongoing high manufacturing, per capita GDP and regional differentiation, Krugman (2011) acknowledged that:

> It turns out that the concepts and approaches of the new economic geography aren't backward-looking after all. They're utterly relevant to understanding developments in the world's fastest-growing economies (p. 16).

In terms of applicable techniques, the spatial autoregressive (SAR) model was firstly proposed by Cliff and Ord (1973), which started to popularise the applications of spatial econometric modelling in regional development studies. Afterwards, a series of spatial econometric models were put forward such as the Spatial Error Model (SEM) (Ord, 1975), the general Spatial Autocorrelation Model (SAC) (Anselin, 1988) and the Spatial Durbin Model (SDM) (LeSage and Pace, 2010). Essentially, the principle of spatial econometrics is based on Tobler's (1970) first law of geography, assuming 'near' entities are more related than 'distant' entities. The rationale of employing spatial econometric models in regional development studies is attributed to the following main reasons:

- Spatial heterogeneity of spatial units leads to spatial standard error autocorrelation.
- Spatial association leads to spatial dependence of observations.
- Spatial disaggregation of global spatial association leads to clustering and hot spots.

Anselin and Rey (1991) attributed spatial heterogeneity to the mismatch between institutional administrative boundaries and economic market boundaries. According to spatial heterogeneity, SEM is designed to correct the bias caused by this spatial influence in disturbing error terms. In contrast to SAR, SEM specification does not require a theoretical foundation for spatial interaction, but, instead, is a special case of a non-spherical error covariance matrix. In terms of spatial association, Manski (1993) clarified three distinctive spatial interactions: the endogenous interaction effects, where the performance of a spatial unit depends on the performance of other spatial units to some degree; exogenous interaction effects, where the performance of a spatial unit depends on the characteristics of other spatial units to some degree; correlated effects, where similar unobserved environmental characteristics result in similar performance.

In contrast to SEM, the SAR model is based on the assumption of the endogenous interaction effects and estimates the spatial effect of dependent variable y on the levels of y in neighbouring regions, termed spatial lag. In essence, a spatial lag operator constructs a new variable that consists of the weighted average of the neighbouring observations, with the weights as specified in W. By contrast, the SAC model is the combination of SAR and SEM which allows the coexistence of spatial lag and spatial error. One motivation for this is that in addition to detected spatial lag, spatial autocorrelation is also detected in testing the residuals of the SAR model. In addition to the inclusion of spatial lag and spatial error, SDM extends the SAC model by adding average-neighbour values of the independent variables to the specification, which corresponds to the exogenous interaction effects. LeSage and Pace (2010) testified that SDM can produce unbiased results with the presence of an unobserved but relevant variable following a first-order autoregressive process, and advocated the application of SDM in large sample analysis.

Empirically, spatial econometric modelling has been widely used in regional convergence and knowledge spillover studies. Ertur *et al.* (2006) found strong spatial spillover effects at significance level existing in the convergence process of 138 European regions over the 1980 to 1995 period. Fingleton (1999) also estimated economic convergence in Europe and identified technology spillovers across the regions by employing the SAC model, based on a dataset of 178 European Union regions. Afterwards, Van Oort (2007) adopted the SAR model to estimate the effects of agglomeration economies on the neighbouring regions in the Netherlands and found significant spatial dependence of growth externalities at city level. Ke (2010) also made use of spatial econometric modelling to estimate the spillover effects of urban economic development in China, and found that urban productivity has positive spillover effects in neighbouring regions within a radius of 100 km. Pursuing the same line, Ke *et al.* (2014) adopted the simultaneous equation model with spatial variables to test the synergy effect between producer services and manufacturing in China, but they only detected the intra-city synergy effects of the two industries significantly, other than the synergy effects across cities.

Given the direction of spillover effects discourse, consensus has not been reached yet. On the one hand, it is widely argued that technology is transferred from advanced regions to less advanced regions (Parent and LeSage, 2012). On the other hand, Bottazzi and Peri (2003) found that innovation spillovers are circumscribed in their neighbouring regions that have similar development level and economic configurations. In addition, the characteristics of distinctive input factors are also likely to influence the scale of spatial effects. In conclusion, as Autant-Bernard and LeSage (2011) argued, spatial effects should be incorporated in analysis to complement the indigenous growth model in order to understand spatial economic dynamics in play comprehensively.

However, Huggins (2010) has criticized the direction of discussion regarding the pre-defined proximate order of spillover effects (the strength of spatial relations decays proportionately as distance increases). He articulated that the spatial effects of input factors' interactions are multidirectional and profit-driven. Furthermore, these multidirectional and profit-driven associations transcend the proximate order 'from *near* to *distant'* under the first law of geography largely facilitated by advanced technology and capital financialization. Therefore, in addition to detecting spatial spillovers in spatial econometric models that complies with the first law of geography, the investigation of flows overriding the proximate order is also significant to shed light on spatial effects in city region development, which is the motivation behind the review of the network space mechanism in the next chapter.

5. NETWORK SPACE IN URBAN DEVELOPMENT

In this chapter, the way in which the network space mechanism reshapes urban patterns and city systems is reviewed. The first section discusses urban connectivity in the 'information age' as cities' 'second nature'. It is found that upgrading the local industrial base that is based on competitive indigenous factors, is beneficial to local growth however the influence of cities' connectivity which is second nature in the associated growth of cities cannot be overlooked. In the second section, network capital theory based on urban connectivity and the estimation of network capital are discussed. It is argued that network positions embedded in multidirectional and profit-driven flows that transcend the proximate order that follows the first law of geography is the main criterion with which to calculate network capital. The third section reviews empirical approaches calculating the network capital. Lastly, general research questions and corresponding hypotheses derived from literature review are presented prior to following empirical analysis chapters.

5.1 The Second Nature of Cities

As early in 1945, Harris and Ullman had discussed the 'nature of cities'. In their perspective, the nature of cities is determined by the characteristics of their local economy and the central service centre for their hinterlands, which is called the 'first nature of cities'. Their argument is based on Adam Smith's land productivity theory. As Adam Smith stated, the land must produce a surplus in order to support cities. As Harris and Ullman (1945) argued:

> Cities are the focal points in the occupation and utilization of the earth by man. … Each city is unique in detail but resembles others in function and pattern. … The service by which the city earns its livelihood depends on the nature of the economy and of the hinterlands (p.7).

At that time, mass production and manufacturing determined the nature of cities. Nevertheless, in addition, Harris and Ullman also paid attention to cities' interactions and connectivity, by emphasizing the importance of transportation hubs and ports. However, due to technological limits, consideration of cities' connectivity was restricted to physical transportation and waterways. The research content on urban connectivity was focused on the accessibility of manufactured products through trading and their relationships with delivery distance (Hoare, 1975; Marshall, 1987). Another research hotspot at that time was concerned with how the delivery distance was distorted by the assembly of roads, waterways, rail, and aviation associated with the advances in modern transportation infrastructure. Regardless of adjustments of production modes and advances in economic theories, urban economic analysis did not break with the framework provided by Harris and Hallman's first nature theory, which focused on exploiting indigenous factors in depth and physical connectivity via infrastructures. Later, during the ICT revolution, as information technology has been applied in productive activities, financial markets and human interactions, urban patterns and city systems have been dramatically reshaped.

Associated with the ICT breakthroughs and the development of high-speed modern transportation, the spatial constraints of economic activities have been largely freed (Friedman, 2005). In particular, Lechner (2009) attributed the emergence of massive inter-city connections under globalisation to the transnational division of labour emphasized in the core-periphery pattern of the world city system. In addition, under the rise of the knowledge economy, many products and services have become virtualized and purchased online, creating massive virtual flows interconnecting territories. Currently, cities are operating like data factories where labour, capital, information, commodities and traffic flows are circulating through conduits. The conduits can be any economic actors, firms, or cities and regions who connect their counterparts together and construct massive networks full of different flows on different scales. In contrast to the emphasis on the local industrial base in competitiveness theory, Burt (2009) has articulated that competition is a relationship issue essentially, as opposed to competition between players themselves. Bair (2009) also has pointed out that indigenous factors have become less applicable in explaining factor mobility. Therefore, investigating cities' connectivity has become an indispensable influential instrument in urban growth studies, which is referred to here as the 'second nature of cities'.

Thus, it is argued that while upgrading a local industrial base which is based on competitive indigenous factors is beneficial to local growth, we cannot avoid the influence of cities' connectivity as the second factor associated with the growth of cities. In fact, as early in 1964, Berry had claimed that urban geography essentially focused on 'cities as systems within systems of cities' (Berry, 1964), which illustrates the need to look at cities in a broader perspective and emphasize their connectivity, such as the complementary functions and business links between cities. Therefore, in contrast to Harris and Ullman's argument regarding the nature of cities (1945) which emphasized cities as central places in surrounding areas, cities' connectivity is regarded as the second nature of cities in this research, which breaks the boundary associated with hierarchical centre-hinterland relations and builds inter-city networks through massive flows across geographical spaces.

Empirically, Hakansson (1987) looked at business markets and found that cooperative connections with external partners were tremendously beneficial to improve the capability of product development. Powell *et al.* (1996) also provided evidence that building resultant connections provide significant channels through which firms obtain access to external knowledge. Similarly, establishing inter-city connections is significant for economic actors to absorb external knowledge and boost regional productivity as an outcome (Nicolini *et al.*, 2003; Bathelt *et al.*, 2004; Mahroum *et al.*, 2008; Huggins and Thompson, 2015). In addition to virtual connections, international air connectivity between cities is found to be positive in the location decisions of firms' headquarters (Bel and Fageda, 2008) and local technology-related employment (Button, 1999). It is argued that air connectivity is an important pathway to circulate the international elite who carry knowledge and valuable information (Derudder and Witlox, 2005; Derudder *et al.*, 2007; Grubesic *et al.*, 2008).

Furthermore, Meijers (2007) has classified the complex links to vertical and horizontal connections simultaneously in explaining how connectivity shapes urban patterns: vertical connections play a complementary role whilst horizontal connections give rise to collaboration. Meijers (2007) argued that the connections between cities tend to be more complementary than competitive or dependent, in order to take advantage of scale economies, knowledge exchange and synergies. In practice, Belderbos *et al.* (2004) discovered that building up horizontal connections with universities and competitors is beneficial to improve firms' growth, while the vertical connections with suppliers and customers are not identified as improving firms' performance. In addition, the effectiveness of connections is also contingent on both ends of connections (characteristics of partners). Van Hamme *et al.* (2015) did not detect the positive impact of urban connectivity on economic development by analysing APS office connectivity, air connectivity and maritime connectivity relative to city level GDP except for major global cities. This result suggests the supreme importance of connectivity of all kinds for huge APS concentration and productivity and may also reflect the arbitrary status of metropolitan boundaries as a scale for the assessment of economic development.

In conclusion, urban connectivity, particularly horizontal connections, as the second nature of cities, has become an inevitable lens through which to shed light on urban dynamics and regional patterns. However, the effects of urban connectivity on economic development are still vague and demand more dedicated attention due to the complexity of contemporary connections. In particular, systematic analysis concerning the effects of urban connectivity on economic development is still deficient in China, which is another motivation to investigate urban connectivity in its designated national level city region, the MYR city region. Based on the discussion of urban connectivity, network thinking is regarded as a significant paradigm to investigate urban connectivity, to be reviewed in the next section. Pursuing this same line of thinking, the methods required to estimate network capital are reviewed in last section.

5.2 Network Capital and Inter-City Networks

In order to illuminate contemporary urban connectivity under globalisation, this research draws heavily on Castells' (1989) space of flows theory that inspired network thinking for regional development. Castells (1996) asserted that 'new economy' development has transcended territorial boundaries and in a 'network society' where trans-boundary flows of products, services, labour, knowledge interconnect separate markets (Pain and Van Hamme, 2014; Lizieri and Pain, 2014; Coe and Yeung, 2015) creating synergies across cities as an outcome (Massey *et al.*, 1999). Castells put forward the space of flows theory in order to "conceptualize new forms of spatial arrangements under the new technological paradigm" (Castells, 1989, p.146). As he defined: "the space of flows is 'the material arrangements allow for simultaneity of social practices without territorial contiguity (Castells, 1999, p.295)". The 'material arrangements' comprise technological infrastructure for information systems, telecommunications and transportation facilities, working places for the actors that operate networks, and electronic spaces (Castells, 1999).

Consequently, the 'material arrangements' in the space of flows are creating a globally connected network through flows of labour, commodities, information, knowledge and traffic. Initially, this network thinking was inspired by the emphasis on social interactions in explaining urban meaning by the Chicago School (Blumer, 1969). It was argued that definition does not simply randomly happen, instead, it results from ongoing social interactions and thinking (Charon, 2010). Nicolini (2003) also conceived that the market should stem from the social network that yields positive effects on regional productivity.

Powell *et al.* (1996) concluded that the network is an area where ideas, thoughts, innovation and learning can be generated and shared.

In network space, the network performance of actors depends upon the constraints and opportunities that arise from how they are embedded in a network structure which is determined by the intersections of complex flows. These complex flows are characterised by borderless-ness and multi-directionality. Although the New Economic Geography highlights the significance of relations between cities in shedding light on cities' spatial economic patterns (Krugman, 1991; Fujita *et al.*, 2001), the focus is mostly on the simultaneous effects of spatial proximity and the local embeddedness of economic activities, especially in the discussion of trade cost and market access (Redding and Venables, 2004), which ignores the multi-directionality and borderless-ness of inter-city flows in a network sense.

In order to bridge the gap in analysing the intangible networks constructed by multidirectional and borderless flows, the notion of calculative network capital is proposed in recent studies (see Huggins, 2010; Huggins and Johnston, 2010; Kramer *et al.*, 2011; Kramer and Diez, 2012; Smith *et al.*, 2012). The notion of calculative network capital argues that network capital is embedded in the functional positions that are determined by network nodes' multidirectional ties and the attributes of ties. They articulate that a network is not only one kind of structure but also strategic capital which can generate opportunities and constraints for network actors through calculating embedded positions. Bathelt and Taylor (2002) asserted that strategic network position is not only an indicator of economic performance but also becomes an important endogenous factor in driving economic development. Empirically, for example, Breschi and Lenzi (2014) examined the impact of inter-city connections on urban innovation by using co-inventorship and labour mobility data, and found that capturing external network links are significant for the renewal of general local knowledge bases. In addition, they also found that since urban knowledge bases are highly localized and specialized, the cities holding gateway positions are advantageous to produce innovations through transcoding information and providing broker services.

Generally, although networking strategies and the positions in networks are emphasized in business and political cooperation, they have not attracted sufficient attention on the part of urban and economic planners, especially in emerging markets like that of China. Hence, this research aims to illustrate developing inter-city networks in China and to clarify what are the positions of cities in networks using the MYR city region as an example to feed into strategy making.

Essentially, the calculative network capital discourse is based on several assumptions:

- Building trust relationships between actors is a cumulative process as network actors interact and adapt to each other through participation in transactions over time (Hakansson and Snehota, 1995; Rodriguez-Pose, 1999).

- In addition to the local ‘buzz’ that produces positive externalities (Storper and Venables, 2004), trans-boundary linkages are significant for actors to absorb external knowledge and expand their markets (Bathelt *et al.*, 2004; Doloreux, 2004; Gassmann, 2006; Drejer and Vinding, 2007; Crevoisier and Jeannerat, 2009; Huggins and Thompson, 2015).

- The structural roles and positions of actors in network space can influence actors’ performance and generate network capital (Walker *et al.*, 1997; Inkpen and Tsang, 2005; Burt, 2009).

In terms of territorial sense, we can apply network capital theory in explaining how cities, as active nodes, operate in a system of cities interconnected by massive flows. Thus, networking thinking can build the network space scenario where cities themselves can be seen as networked nodes and their connectivity can be quantified by inter-city flows (Castells, 1996; Taylor, 2004). For example, global cities are identified as pivotal nodes in connecting other cities through complex global production connections, which confers on these cities important ‘gateway’ roles and functions (Pain, 2011) advantageous to integration of the world economy (Friedmann and Wolff, 1982; Rozenblat, 2010). Based on the space of flows theory and linked networking thinking, the inter-city network is an appropriate approach to shed light on the effects of urban connectivity on regional development. Different inter-city networks can be established through cities as nodes with distinctive flows (investments, information, knowledge, human resources, commodities and branch offices) as linkages. Thus, the closeness between cities in inter-city networks is determined by the strength of network ‘edges[20]’ and network positions rather than merely geographical proximity.

On the other hand, the network capital discourse is criticised since network capital is difficult to capture empirically. By investigating knowledge and innovation spillovers in networks, Döring and Schnellenbach (2006) argued that network capital was a scarce resource and strictly confined to small group networks. However, their network analysis is limited to intentional interactions at an organizational level. However, in addition to formal partnerships between organizations, network capital is initiated by unintentional interactions and embedded in the accumulation of these interactions, which demands attention in a spatial perspective. In addition, Hoang and Antoncic (2003) expressed concern that the accumulation of homogenous interactions will form sealed circuits, which exclude new entrants. However, this situation mostly exists in dyadic relationships at organizational level, while cities as dynamic network spaces are full of heterogeneous flows and complex interactions, and are thereby unlikely to have repeatedly homogenous interactions and sealed circuits. In conclusion, investigating established inter-city flow networks is significant to understand urban economic dynamics and contributes to understanding city region development particularly during the deepening process of globalisation that is apparent in China where cities’ network capital is likely to be increasingly embedded in their network positions determined by intangible, multidirectional, and borderless inter-city flows.

5.3 How to Calculate Network Capital

In contrast to previous theories, network capital discourse emphasizes that network capital is the calculative strategic resource where actors can invest in and get access to necessary knowledge (Huggins and Thompson, 2015). In this section, three main calculative approaches are reviewed briefly: the Global Production Network (GPN) approach that highlights chained linkages and synergy effects at organizational level, and the Interlocking Office Network (ION) model that highlights the office functions in determining urban connectivity of global cities, and the Social Network Analysis (SNA) approach that highlights the importance of multi-directional linkages and flexible structural

[20] The links connecting nodes in network structure are termed as edges in network approach.

positions in networks; the SNA approach is adopted in the thesis and the functions of calculative network capital are specified in Chapter 7.

5.3.1 The GPN Framework

Resonating with Global Value Chain (GVC) theory, GPN is the network where territories are integrated in a transnational sense through value-added production processes (from decision-making, R&D, design, production, distribution, through to sales and services) in a globalized economy. GPN emphasizes the value creation processes that are distributed and controlled in spatialised networks. Actors are theorized in the GPN framework not as individual agents per se, but as a constitutive part of the wider network through which emergent power and effects are realized over space. However, in contrast to GVC theory with reference to Hopkins and Wallerstein (1986) and Gereffi and Korzeniewicz (1994), GPN pays more attention to path dependence, institutional contexts, and the local embeddedness of global production activities, which contributes to local upgrading as an outcome (Dicken *et al.*, 2001; Henderson *et al.*, 2002; Hess and Yeung, 2006; Coe *et al.*, 2008; Derudder and Witlox, 2010). In addition, beyond the 'linear progression of the product or service' (Coe *et al.*, 2008), GPN supporters emphasize the importance of intricate relations that economic actors build which interconnect territories, which leads to the investigation of heterogeneous network configurations and the spontaneous process of extending global relations and local concentration (Bathelt and Glückler, 2011; Coe and Yeung, 2015). Essentially, GPN calculates network capital by the embeddedness of global production activities and 'local buzz' but is limited to the analysis of one-dimensional and directional chained linkages in the adding of value to final products, which is more suitable for microeconomic analysis and industrial research at an organizational level.

Although GPN has started to pay more attention to multi-scale analysis, there has not been a new methodology beyond the GVC framework which can integrate value-added processes and sociocultural embeddedness, and delve into network capital occurrence arising from multi-directional linkages and overlapping structures. Given the epidemic application of GPN in network studies, Coe and Yeung (2015) expressed concern regarding the narrow scope of intra-firm relations in explaining GPN configurations, and advocated more focus on horizontal relations with intermediaries, strategic partners, institutions etc. Furthermore, in terms of the network capital in city networks, the critical concern about the GPN approach is its limited spatial scale in specific metropolitan contexts at transnational scale and in terms of the hierarchical relations between cities due to unequal value distribution across chain segments. In addition, the GPN approach is confronted with the danger of overemphasizing social relations at the expense of investigating direct economic ties across territorial boundaries (the space of flows). Therefore, although the GPN approach is useful to illuminate inter-city networks by the association between GVC and the embeddedness issue, it is not compatible with investigation of the network capital embedded in multi-directional linkages across cities within city regions and non-production processes. In particular, capital mobility cannot be inserted in chained production processes directly but drives production through every segment of GVCs. When considering the content of connections interlinking territories such as in M&A deals across cities in the MYR city region, the GPN framework would offer weak explanatory power, as would the ION model.

5.3.2 The ION Model

Taylor's Globalisation and World City (GaWC) research group developed the ION model which uses the office locations of global APS firms as the proxy for inter-city flows and connectivity to delineate the (inter-city) World City Network quantitatively (Taylor, 2001, 2004; Taylor *et al.*, 2002; Taylor *et al.*, 2010). The ION model is based on Friedmann's (1986) world city hypothesis which emphasized functionality and big cities' commanding roles in a world city hierarchy and Sassen's (2001) global city theory which emphasized the significance of APS sectors in forming global cities. As already discussed in Chapter 3, in the ION model, the network capital of global cities is calculated by the functions of APS firms' offices[21], based on the assumption that the strength of inter-city work flows is determined by office functions in organizational networks. With reference to Sassen's global city theory, GaWC chooses APS firms as research targets for two significant reasons: first, since APS firms need to provide specialized services to clients, they require access and closeness to skilled labour pools, information-rich and prestigious environs, superior offices, and transport and telecommunications infrastructures, all of which are predominantly found in big cities (Harrington and Campbell, 1997); second, APS firms have formed their own global service networks as a new force amongst MNCs (Moulaert and Daniels, 1991; Aharoni and Nachum, 2002; Harrington and Daniels, 2006; Derudder *et*

[21] The hierarchy of offices is ranked by headquarter, national office with additional transnational functions, national office, regional office, local office or back office.

al., 2010). As Taylor (2000) argued, any world city is the creation of the service firms located there, and its position in the World City Network depends upon those firms, particularly their patterns of offices across other world cities. Essentially, as Scott (2001a, 2001b) argued, the concentrated service functions in global cities not only capture the geography of powerful positions in commanding the global economy but also disseminate their power to counterparts through their international operations. Taylor *et al.* (2010) elaborated two generic processes of urban connectivity: town-ness which creates urban-hinterland relations and city-ness which creates inter-urban relations. It is argued that the ION model is illustrative in reflecting city-ness, which is interconnecting global cities in one network.

Empirically, the most notable changes in the World City Network in the present millennium relate to the relative decline in the connectivity of cities in Europe and Northern America, and the rising connectivity of East European and Asia-Pacific cities in general, and of Chinese cities in particular (Derudder *et al.*, 2010; Derudder et al, 2013) with political economy changes. However, as Yang and Yeh (2013) suggested, China's producer services are less 'advanced' in the sense that many of these services are strongly integrated with industrial bases. In particular, they found that the spatial location of global APS firms is highly concentrated in Beijing, Shanghai, Shenzhen and Guangzhou, accounting for nearly 40 percent of national aggregate APS representation. Thus, focusing only on APS sectors may not reflect the actual panorama and diversity of the spatial economy in developing inland city regions, namely the MYR city region. This is another reason why the ION approach is unsuited to this research despite the relevance of global APS for secondary sector added-value going forward.

In conclusion, the ION model is a plausible method with which to calculate the network capital of global cities where APS sectors are pillar sectors, especially when direct economic ties across territories are not traceable. Nevertheless, the application of the model is critiqued for several reasons. The first reason is concerned with the relatively static office locations of APS firms and thereby the weakness of the ION model for elaborating the dynamics associated with the complexity of World City Network relations explicitly. According to location theory, firms would not willingly move to an alternative location unless their zero-profit equilibrium is broken. In addition, although a wider range of cities has come to be represented in the ION world map due to the geographical rebalancing of the advanced world service economy, the mere location of APS firms' offices may not reflect the real network positions of cities because it is an indirect proxy, and qualitative evidence of inter-city relations is incomplete. These drawbacks matter in particular when the aim is to explore the insertion of ‘less obvious’ or specialized cities and ‘fuzzy end’ regional city-systems in world city network mapping (Brown *et al.*, 2002; Robinson, 2005). The assumption that APS firms use their international office networks for sharing information still needs further empirical verification particularly within city region systems (Lambregts, 2008; Parnreiter, 2010).

In essence, inter-city networks established by APS firm locations have a tendency to reflect a core-periphery pattern due to the assumed vertical structure of headquarters, regional headquarters, national offices and local branch offices. Qualitative research conducted by GaWC indicates that this relational pattern has changed dynamically (see Pain and Hall, 2006; Pain, 2008; Hoyler *et al.*, 2014), Jones (2002) investigated transnational investment banks and management consultancy firms, and found that the corporate structure of these two APS industries did not correspond to the often assumed centralized systems of control. He argued that these MNCs often display features of a decentralized and diffused structure supporting the GaWC interview results. In some circumstances, due to advantageous local competences, subsidiary offices may become creative and generate bottom-up information to feed parent offices (Meyer *et al.*, 2011; Hennemann, 2011). However, the quantitative ION approach cannot evaluate the actual soft horizontal interactions between APS offices, firms and production firms, and thereby the complex lateral transactions between cities, directly. In terms of the prevalence of the application of the ION model, Coe *et al.* (2010) asserted their concern about the “potential dangers of essentializing the global system as one that is primarily shaped by certain kinds of connections—namely the intra-firm relationships of APS firms—between certain kinds of cities—namely the leading tiers of global cities” (p.138). Lastly, from a microeconomic viewpoint, firms set up offices for indigenous markets and these markets are too heterogeneous to demand homogenous working flows operating in hierarchical corporate structures.

Brown *et al.* (2010) attempted to clarify the reciprocal relationship between GPN and ION to understand the spatial patterns in the world city network where value is created along GVCs. They argued that global cities are dynamic spaces reflecting consumer shifts and orientations on commodities, which involve APS services to meet consumer demand by providing service inputs to producers. Thus, it is the interactions between APS firms and chained production firms that maintain the reciprocal relationship between GPN and ION.

They tried to illuminate this relationship in a two-way approach: GPN in ION and ION in GPN. In terms of GPN in ION, essentially, it is inter-city APS service connections that support the successful completion of the value-added production process from providing financial support for initiations to advertising services for consumption; while in terms of ION in GPN, inter-city connections are extended from the distribution segment of the production process that is supported by specialised APS services from different cities. It is a pioneer analysis complementing GPN and ION and addressing their limitations. However, even this approach becomes excessively sophisticated for application in empirical studies. It is not plausible to be able to explain the connections of less 'obvious' cities operating below the transnational scale, such as the connections within emerging city regions. Neither is it feasible to illustrate multi-directional complex flows due to the focus of the chained production process and readily quantifiable APS measures that reflect hierarchical (HQ to branch) office structures and that imply financialised capital and elite mobility. Since the Brown *et al* (2010) approach is a preliminary step towards the development of a robust analytical methodology, it lacks the present advantages and transparency in microeconomic empirical studies, which is the reason why it is not applied in this research.

5.3.3 The SNA Approach

This section reviews the framework of the SNA approach, focusing initially on its theoretical foundation. The empirical studies and specific methods will be elaborated in Chapter 7. The main arguments for the adoption of a basic SNA approach for this present research which is intended to shed light on network space is first, that it is a scale-free approach from an agency perspective, which is advantageous in analysing multidirectional interactions and complex structures in practice (Asheim and Gertler, 2005). Second, it is a quantitative method based on a node-node relation matrix which can illustrate the panorama of network interactions across territorial boundaries. Third, the main results derived from an SNA approach are presented by structural positions embedded in complex networks, which coincide with 'functional positionality' highlighted essentially by the calculative network capital discourse. Fourth, informed by consideration of the international literature in previous chapters, this research focuses on actual M&A relations instead of proxy data such as those used in the ION model. Although in common with GPN, the SNA approach omits the local embeddedness issue of network capital, Chapter 8 resolves this flaw by incorporating identified network capital from the SNA approach in a spatial regional growth model in order to examine the effects of network capital on the local economy.

The SNA approach is theoretically rooted in sociological enquiry that looks into the patterns of social actors' relationships and it underpinned development of the ION world city network analysis approach (Beaverstock *et al.*, 1999; Taylor, 2004; Derudder and Taylor, 2016). Moreno and Jennings (1938) established the cornerstone of SNA, introducing its principles and basic analytic methods in the 1930s. However, it was the advent of Barnes's (1979) work that contributed to the coherent paradigm of SNA, denoting patterns of network 'edges' and positions of nodes systematically. Associated with globalisation and the advent of the information age, myriad social participants are involved in relations interlinking them in complex and heterogeneous ways, which allows the realm of SNA to be extended to complex social systems at flexible scales, from the interpersonal to the international. A social network is comprised of nodes, edges, and subgroups (cliques), forming the metrics for the calculation of network capital (presented in detail in Chapter 7). Intertwined with the rapid development of computing technology, the visualization of networks becomes powerful in conveying complex information by using graph theory. Thus, SNA can quantify relations in matrices to shed light on complex relations of large nodes by assigning values to them according to specified metrics and research goals. In contrast to conventional statistical analysis, SNA observes real relations or actual actions of the population of interest rather than regarding observations as a sample of a larger population. In application, SNA adopts mathematical formulae to examine sampling variability in order to illuminate network patterns rather than statistical inference.

In SNA, network capital is attributed to the constraints and opportunities that arise from how they are positioned in networks; individuals may be 'outsiders'[22], 'sinkers'[23], or 'communicators'[24] in network space while subgroups have structural equivalence or heterogeneity to some extent (Wasserman and Faust, 1994). The Barabási–Albert model manifests that vertices with a higher degree have stronger ability to 'grab' edges added to the network (Albert and Barabási, 2002). Pursuing the same line, Huggins and Thompson

[22] Actors' outward ties outweigh inward ties.

[23] Actors' inward ties outweigh outward ties.

[24] Actors' inward ties equal outward ties.

(2015) also found that making connections to high growth cities is strategically beneficial to less developed cities to take advantage of developed cities' network capital. While Burt (2009) deemed that brokerage (structural holes), as one kind of capital, is important due to the fact that brokers establish relationships and translate codes between two groups which have both heterogeneity and opportunities. Therefore, brokers can obtain information and translation fees, and control advantages over others based on relationships connecting multiple clusters (Burt, 1993; Liefner and Hennemann, 2011). Neal (2011) also found the evidence that some cities play gateway or conduit roles in inter-city networks, making themselves become strategically advantageous. Lastly, Allen (2010) discerned that counting the ties that connect nodes is not the only way to calculate network capital, structural equivalence that compares the profile of ties is also very important to generate network capital and knowledge flows. In conclusion, conducting a rigorous exploitation of embedded positions in network patterns is a necessary starting point to understand a network and this analytic approach is adopted in Chapter 7.

Figure 8 illustrates how reference to a four-actor-network illustrates network relations employing limited metrics. In this simple example network, actor A and actor B have a positive friendship, so we assign their relation as one; and the positive friendship also exists between actor A and actor C, and actor A and actor D; while actor B is hostile to actor C, so we assign their relation as minus one. If either actor B or actor C want to know actor D, they have to ask actor A to introduce actor D to them. Thus, in terms of power centrality, actor A takes advantage of social capital, playing a broker or bridge role. Meanwhile, actor A may mediate the conflict between actor B and actor C. If actor A succeeds, actors A, B, and C will form a clique since they know each other. At this time, if any member in this clique knows an investment opportunity, they will bid for it as a team. If actor D knows this information, he may only look for actor A as a partner. However, if actor A failed in mediation and only actor A knows this opportunity, they are more likely to cooperate with actor D, because including either actor B or C will provoke hostility form the other. If any one of actors B, C, and D captures the opportunity, they will only cooperate with actor A. Thus, actor A is holding most network capital in this 'small network'. Lastly, in terms of connections, if actor A and actor C have kinship, then the whole pattern will change and actor B will be isolated. We can see that even for such a small network, a great amount of information can be exploited, such as relational strength, centrality degree, and clique options etc. Thus, when the number of actors increases and relations become intricate, the network will look more like that shown in Figure 9. This basic rationale is applied in a spatial sense in this research.

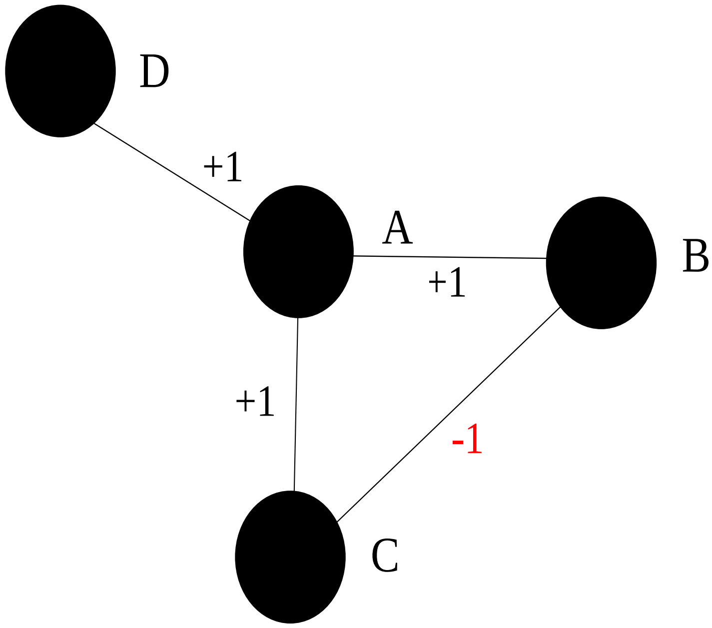

Figure 8 Four-Actor Network Pattern.

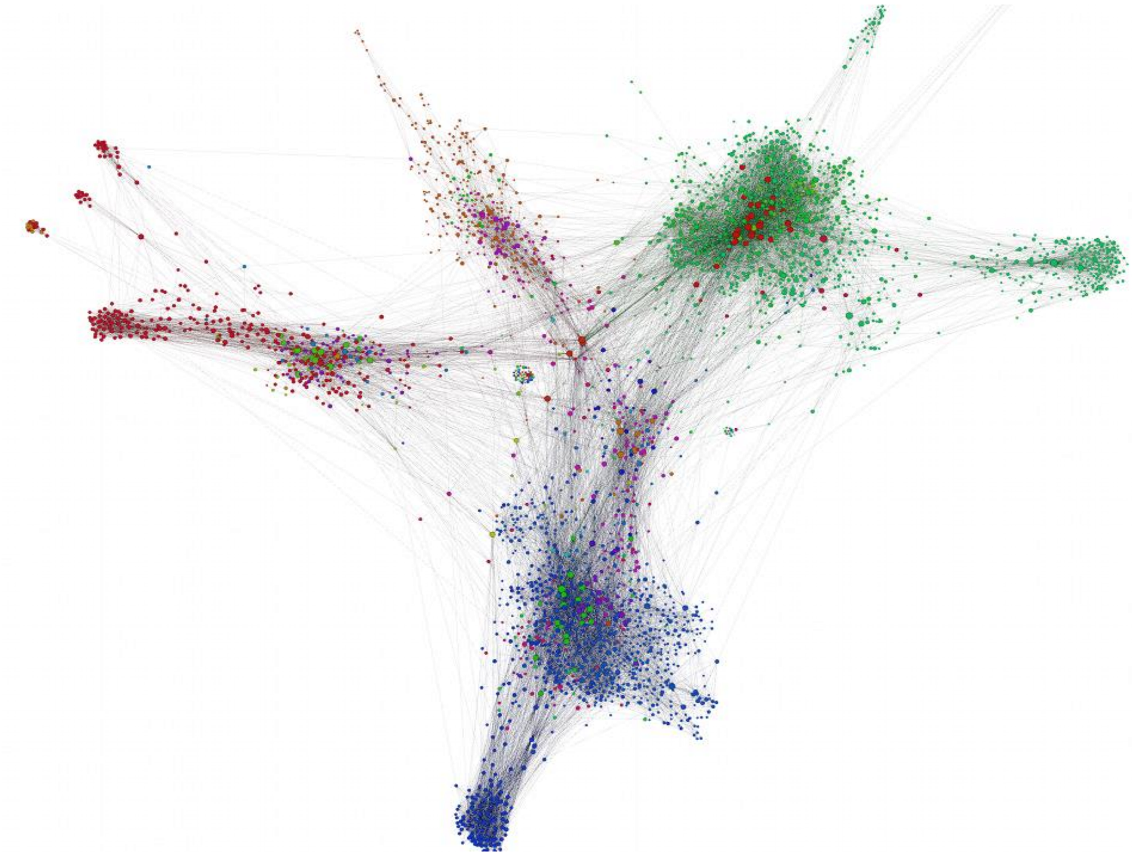

Figure 9 Multi-Actor Network Pattern (source: https://gephi.org/features/).

Hennemann and Derudder (2014) attempted to apply SNA innovatively in ION-based city network work by interpreting the headquarter-subsidiary office hierarchy through direct interactions between cities. They found that, in terms of real links other than proxy links, SNA is the preferred approach to estimate cities' positionality and complex structures over the ION model by means of randomization technique, which complements the epistemological paradigm of the world city network. In fact, these two methods are not controversial but complementary with regard to different situations (data availability, flow characteristics, industrial sectors, geographical scales etc.). However, this work only estimated 'Betweenness' to compare with the baseline model of ION, which requires more comprehensive SNA considerations in inter-city network analysis.

Lastly, in addition to the above three advanced methods, a gravity model is another popular proxy approach in the calculation of urban connectivity (Mátyás, 1997; Capello, 2000; Anderson, 2011; Liu *et al.*, 2012; Vasanen, 2012). It is based on the assumption that the strength of economic flows is determined by economic mass, mostly represented by GDP, population and urban size, and geographic distance (Mátyás, 1997). However, in contrast to GPN and SNA, the gravity model can be only used to proxy for connectivity by economic mass as opposed to investigating real flows, which may lead to biased results in estimating heterogeneous flows that are not highly correlated to urban mass. In contrast to SNA, a gravity model can only calculate tie strength other than structural positions where network capital is mostly embedded. In contrast to the ION model, it cannot mirror the significance of APS sectors in creating inter-urban connectivity. Last but not least, it is not available to identify the differentiation between cities with similar mass and distance. Thus, as for the GPN and ION approaches, the gravity model is not employed in the present research.

5.4 Research Design and Contribution

In order to take forward in the in-depth empirical research, relevant themes arising from the literature reviewed, this section concludes with the specification of the main research questions and corresponding hypotheses identified, highlighting also associated potential theoretical and practical contributions of the research.

As already discussed, the city region, popularly theorized in recent literature as the new motor driving the global economy, is conceived as the spatial focus of the research. The MYR city region which is comprised of 36 proximate cities in central China is the research object in the research due to its strategic policy relevance during China's economic transition and in the absence of previous relevant studies.

Four general research questions and linked hypotheses that emerge from the literature and empirical research scoping process, are specified next to inform empirical and theoretical understanding of the city region development process in the MYR city region case:

> Q1. What are the spatial economic patterns in the MYR city region? Correspondingly, it is hypothesized that *spatial association and heterogeneity co-exist in the MYR city region* (Hypothesis 1).
>
> Q2. What is the calculated network capital embedded in the MYR inter-city capital flows network? Correspondingly, it is hypothesized that *cities in the MYR city region hold different regional network space positions in conducting distinctive functions* (Hypothesis 2).
>
> Q3. What is the contribution of indigenous factors, productive flows and calculated network capital to the MYR city region development and how is spatial relationship in the process of city region development under the influence of these factors? Correspondingly, it is hypothesized that *urban growth across cities in the MYR city region is spatially interdependent, and indigenous factors, productive inter-city flows, and network positions not only contribute to city region development but also generate spatial spillovers* (Hypothesis 3).
>
> Q4. How should the spatial mechanism of the city region system be understood and what are the consequent policy implications? Correspondingly, it is hypothesized that *the city region is a complex adaptive system generating an emergent balanced urban configuration in a state of economic and spatial transition* (Hypothesis 4).

Question 1 will be addressed in Chapter 6, question 2 will be addressed in Chapter 7, question 3 will be addressed in Chapter 8, and question 4 will be addressed in Chapter 9.

In terms of the potential contributions of the empirical research, theoretically, first, calculative network theory is complemented in a spatial sense through investigating the inter-city flow network in the process of city region development. Meanwhile, the functionality issue emphasized in city region theory is developed in the context of the emerging city region. Generally, the research is designed to deepen city region development ‘space’ conceptualisation by incorporating the convergence of network capital and spatial spillovers. In addition, by drawing on the results and the CAS paradigm, the research contributes to an understanding of the complexity phenomenon in city region development systems. Empirically, the research fills the void in studies shedding light on the spatial patterns of MYR city region development studies in China. More importantly, it adjusts the standard growth model through incorporating distinctive flows and calculated network capital in spatial econometric specification, providing a new trajectory for regional practitioners to discover ‘new’ spillovers. Practically, the research also identifies implications for policy to facilitate regional coordinated development and economic transition which are highlighted in China’s planning scheme.

As discussed in Chapter 4 and Chapter 5, the research adopts spatial statistics techniques, an SNA approach, and a spatial econometric model in order to address research questions one, two, and three, respectively. In each empirical chapter, specific methods and functions are specified. In Chapter 6, a series of spatial techniques is applied to illustrate spatial economic patterns in the MYR region, including mean centre, Standard Directional Ellipse (SDE), grouping technique, spatial autocorrelation, and clustering technique. In Chapter 7, several SNA methods are applied to calculate network capital, including the Force Atlas algorithm, global centrality analysis and a nodal centrality analysis. In Chapter 8, a SAC model is adopted to explore spatial relationships in MYR city region development.

6. THE SPATIAL CHARACTERISTICS OF ECONOMIC PATTERNS

6.1 Introduction

As discussed in the literature review, there is no doubt that urbanisation and economic development are inseparable and mutually motivated. In addition to the concentration of population and resources in urban areas, Rugman (2005) and Peri (2005) found that the process of concentration is also associated with intensive inter-urban connections under the paradigm of spatial proximity. Zooming out and aggregating economic actors' inter-urban relations in a spatial sense, illustrates that, under deepening globalisation, metropolitan areas are growing and incorporating neighbouring cities due to the dual spatial dynamics of concentration and spreading-out of population, resources, and economic activities. These processes are interacting and overlapping, promoting the emergence of contiguous large and complex city regions. Thus, it is relevant to unveil the underlying spatial patterns of dynamically evolving city regions by investigating their underlying economic interactions.

Economic interactions are represented in this research by two forms in a geographic sense: spatial association in spatial proximity and direct linkages over spatial constraints. This chapter will focus on the spatial association, followed by the latter in Chapter 7. As already discussed in reviewing relevant literature, in addition to the contiguity of built areas, city regions are characterized by the spatial association of economic patterns that leads to coordinated regional development as an outcome. In city regions, cities can no longer be regarded as individual nodes, but must instead be understood as performing as a group based on their proximity and complementarity. The spatial association within city regions demands strategic thinking on the part of economic and policy actors seeking to direct investments efficiently and to relieve regional disparity respectively. Thus, the analysis explained in this chapter set out to explore the spatial characteristics of economic patterns in the MYR city region to build a spatial economic framework for the spatial growth model developed in Chapter 8 and facilitate the decision-making of economic and policy actors. It is noteworthy that due to the advances of spatial econometric tools, urban actors may neglect the importance of regional spatial characteristics and spatial economic patterns as underlying city region development processes (Ripley, 2005; Allard, 2013; Cressie, 2015).

As presented in Section 3.4, since the open door policy was introduced in the late 1970s, China has experienced an economic boom lasting three decades, making it the second biggest economy in the world. However, intertwined with uprising labour cost and rising competition from other emerging economies, China's status as a manufacturing centre has become challenged and is regarded as unsustainable. Therefore, the economic transition that is characterised by the combination of large-scale urbanisation and the development of service-oriented industries has been initiated in order to move beyond 'transactions of decline' (Pain, 2012: p. 90). During the economic transition, the Yangtze River Delta, Bohai Economic Rim and Pearl River Delta city regions have become the frontiers of development of knowledge economy and advanced services (APS) financial and linked business services with value-added. Therefore, China's national planning scheme, introduced in section 3.4, has identified the MYR city region as the strategic region to absorb manufacturing functions and surplus productivity from the coastal regions. However, while most Chinese city region studies have focused on these three developed city regions, the MYR city region has been neglected in research despite its strategic importance in economic transition for the national planning scheme. There has been a research 'vacuum' in investigating city regions in China's inland area and in the MYR city region.

As APS sectors have become significant in the globalisation of city regions (Castells, 1996; Sassen, 2000; Taylor, 2004), their rapid inward investment and local development in China has significantly changed the Chinese urban system (Derudder *et al.*, 2010; Yang and Yeh, 2013; Zhang, 2015). As "a new factor of regional differentiation" (Moyart, 2005, p. 214), APS are highlighted in the urban strategies of many Chinese cities regardless of their size and location. However, there is a gap in investigation of the spatial association between manufacturing which is China's pillar industry and the APS sectors upon which economic transition is dependent, particularly in the MYR city region given its intended strategic role in assisting national economic rebalancing. Thus, this chapter assists in filling this research gap by analysing the location of economic activities (including APS sectors and manufacturing) in the MYR city region.

The analysis is designed to address the general research question One: what are the spatial economic patterns in the MYR city region? This general question is divided into three specific questions in this chapter. First, how are economic activities distributed across cities, concentrated or balanced? Second, how is manufacturing correlated with APS sectors? Third, is the MYR city region pronounced in spatial heterogeneity and significant spatial association? Thus, this chapter not only describes the MYR city region spatial distribution of economic activities but also explores the underlying spatial association and heterogeneity to provide a relevant spatial framework for network capital analysis and spatial causality analysis in the following two chapters.

In terms of the chapter structure, after the introduction section, the second section reviews the necessity of investigating spatial association and heterogeneity as a relevant start in unveiling spatial economic patterns. Data and methodological functions are elaborated in the third section. The fourth section presents the results illustrating the underlying spatial patterns in the MYR city region, including the spatial distribution, concentration, heterogeneity and association across various indicators. The sequence of the results presentation is as follows: illustration of the general spatial distribution of economic activities (Section 6.4.1); illustration of the spatial patterns of manufacturing and APS sectors and an exploration of their correlations (Section 6.4.2); calculation of spatial attributes (Section 6.4.3); estimation of spatial heterogeneity (Section 6.4.4); exploration of spatial association and clustering across indicators (Section 6.4.5). Based on the results, the concluding section discusses the main findings from the spatial analysis of economic activities in the chapter.

6.2 Spatial Association and Heterogeneity: A Meaningful Start

As discussed in Chapter 4, the spatial mechanism of coordinated regional development is sourced from Tobler's first law in geography that highlights the importance of being *near* in spatial interactions. Since the 1990s, the rise of New Economic Geography enhanced the importance of spatial interactions in fuelling economic development and paid more attention to spatial heterogeneity across territories (Puga, 1999; Fujita *et al.*, 2001). Meanwhile, endogenous theorists argue that spatial interactions have become an endogenous variable in driving economic development (Aghion *et al.*, 1998; Aghion and Howitt, 1998). As Myint (2008) argued, inter-city spatial interactions are the premise to form completed urban system and the strength of spatial association is an important criterion to define a city region, particularly for circumscribing a city region functional boundary (Lang and Knox, 2009). In addition, for Scott (2001b), there is a concern that the spatial structure of city regions is not completely explained if the main focus is put on the dynamics within prime cities instead of on the associations between primary and other cities. The analysis in this chapter avoids an overemphasis on prime cities and instead pays attention to the global associations in the MYR city region. Thus, the detection of spatial association can aid understanding of the spatial underlying mechanism of human and economic interactions. The incorporation of the proximity concept also provides economic and social meaning (McCann, 2005). Meanwhile, as Anselin (1988) highlighted, spatial heterogeneity is another significant influence in the regional development process that is omitted in standard economic models. Spatial heterogeneity indicates that economic activities characterizing spatial patterns of economic development are not stable across territories (Le Gallo and Ertur, 2003). In conclusion, spatial associations and spatial heterogeneity coincide in regional space, shaping the economic patterns of city regions.

Accordingly, reflecting advances in computer science and GIS, several techniques are developed to detect spatial association that is based on spatial proximity relations (see Cliff and Ord, 1981; Getis and Ord, 1992; Ord and Getis, 1995; Anselin, 1995; Anselin *et al.*, 1996; Anselin, 2001; Anselin *et al.* 2004). Technically, spatial association is normally tested by detecting spatial autocorrelation and clustering patterns. As Anselin (2001) argued, spatial autocorrelation is defined as the coincidence of value similarity with locational similarity. Generally, the methods of spatial autocorrelation analysis are categorised into two kinds, namely a global autocorrelation test and a clustering test. The global autocorrelation test investigates all cities' spatial associations of attribute data, based on a Pearson correlation matrix in statistics. In practice, the global spatial autocorrelation test is usually measured by Moran's Index statistic (Cliff and Ord 1981; Upton and Fingletion, 1985). The Moran Index can identify whether cities are spatially associated (positive Moran Index) or spatially dispersed (negative Moran Index) at a global scale. However, it cannot detect whether cities are positively associated or negatively associated. Getis and Ord (1992) suggested the use of the Getis-Ord Gi statistic to distinguish clustering types. However, it should be noted that spatial association does not necessarily imply spatial causality in an underlying regional regime. It may be involved in a causal relationship or there may be other hidden variables that cause the association, such as data bias and mismatch between administrative division and natural economic area.

In terms of detecting spatial heterogeneity, identifying idiosyncratic places such as 'hotspots' and 'coldspots', normally by calculating the Getis-Ord Gi* statistic is a meaningful methodological approach (Getis and Ord, 1995). In addition, spatial gravity, SDE and subgrouping methods are also important ways to unveil structural heterogeneity in a spatial sense by investigating spatial concentration, orientation and similarities. However, it should be noted that spatial heterogeneity is rooted in many fields, including ecological systems, economic attributes, constitutional contexts and historic-cultural factors. Thus, the spatial heterogeneity hidden in actual processes cannot be fully revealed by the research focus on detecting the spatial economic heterogeneity derived from available datasets. Nevertheless, as Miller (2004) argued, investigating spatial association and heterogeneity is a meaningful starting point for further spatial analysis, for example, building advanced spatial econometric models (Rey and Montouri, 1999).

Empirically, Van Oort (2007) found the evidence of the spatial association of economic development in the Randstad region in the Netherlands. Li *et al.* (2015) also identified the spatial association of knowledge flows in China, as being mostly concentrated in high growth city regions. In addition, Rey and Montouri (1999) found that by considering spatial autocorrelation, the regional convergence in the US decelerated and was disturbed by regional heterogeneity, which demonstrates the necessity of detecting spatial association and heterogeneity in a regional growth model. They argued that regional development is normally overestimated due to ignoring underlying spatial association and heterogeneity, and they highlighted the significance of illustrating spatial patterns in explaining unbiased regional development. In conclusion, human interactions and economic activities across territories cannot be substituted by telecommunications but have in fact become more intense, generating spatial associations and drawing knowledge-intensive activities into city regions (Fujita and Thisse, 2013). Nevertheless, there are rare studies concerning the spatial association and spatial heterogeneity for emerging city regions such as the MYR city region. Therefore, this chapter addresses the research gap in illuminating the economic patterns of the MYR city region in a spatial sense.

Since there is no universal spatial pattern of city regions, more exploratory studies particularly for emerging city regions in developing countries are needed. In recent years, some Chinese scholars have started to investigate spatial patterns of the MYR city region. Wang *et al.* (2013) found that MYR city region is characterised by unbalanced spatial associations since the economic interactions between the Hubei sub-region and the Hunan sub-region are dense compared to those between other cities. Thus, coordinated development is mostly associated with these two urban areas. Based on these findings, Wang *et al.* (2016) further elaborated the spatial patterns of the MYR city region. They found that the MYR city region was characterised by a duopoly pattern in 1990 in which

Wuhan and Changsha were the only two connected high growth centres while others were relatively isolated. After 2000, they found that the spatial association between Wuhan and Changsha became more consolidated, while Nanchang started to be involved in coordinated development with increasing interactions with the other cities, establishing an emerging Wuhan-Changsha-Nanchang triad structure. After 2012, Nanchang upgraded its position to that of a primate city, reinforcing the triad structure. They argued in consequence that the MYR city region is going through a shift from a duopoly pattern to a polycentric pattern. However, their work was concentrated on the three triad cities and ignored the associations between the triad and other cities. In addition, as discussed in Section 5.3, the gravity model they adopted to estimate the strength of urban connectivity ignored spatial association based on spatial proximity and direct flows that have few spatial constraints. The analysis in this chapter addresses the omittance of spatial association and heterogeneity in order to investigate the panorama of spatial patterns in the MYR city region.

6.3 Data and Methodology

The attribute data and patent data for the MYR city region are extracted from the NBS and SIPO databases respectively as introduced in Section 1.4. The sample includes 36 cities in the Hubei, Hunan and Jiangxi sub-regions (provinces) in the year 2013 (35 cities at prefecture level and Wuhan at vice-provincial level[25]) across 13 economic indicators (see variable description in Table 2). Since this is preliminary step to unveil the underlying spatial mechanism of the MYR city region economy, more indicators are analysed in this chapter compared to the indicators adopted in the spatial growth model in Chapter 8. In addition, the main focus of the research is on the contribution of spatial factors and network capital to regional development, thus these indicators are reduced based on growth theories and multicollinearity testing in the Chapter 8 model specification. In this chapter, indicators are chosen to reflect aggregate economy, capital and knowledge stock, labour cost, market openness, manufacturing and advanced services[26], and infrastructure

[25] Vice-provincial cities were originally prefecture cities. Due to their outperformance in terms of economy and urban size, some cities are upgraded to a vice-provincial level. They are still under the administration of provincial government but are entitled greater economic policy flexibility and central government-funded resources.

[26] Among selected indicators, APS sectors are chosen to represent advanced services. Since there are mismatches in industrial classifications between European countries and China, there are some adjustments

configurations. These factors are commonly conceived as significant contributors, which will be discussed in detail in Chapter 8 (see Romer, 1986, 1990; Madariaga and Poncet, 2007; Liu, 2008). Since the concept of the MYR city region is a new planning scheme officially initiated in 2010, spatial analysis is based on cross-sectional data, the latest annual dataset (for the year 2013) is used.

Variables (logged)	Explanation	Observation	Mean	Deviation	Min	Max
GDP	Gross Domestic Product	36	7.23	0.64	5.90	9.11
GDP capita	Gross Domestic Product per capita	36	10.42	0.50	9.55	11.61
Capital Stock	Investment in Fixed Assets through construction and purchase.	36	6.79	0.61	5.14	8.52
Labour Cost	Total Wage/Number of Employees	36	10.53	0.15	10.26	10.94
Technological Advance	Number of Patents Authorised by SIPO	36	6.79	1.06	4.25	9.67
Foreign Investment	Utilized Capital from Abroad	36	10.52	1.05	8.81	13.17
Manufacturing	Number of Employees in Manufacturing	36	2.29	0.86	-0.80	3.97
Financial Services	Number of Employees in Banking and Insurance	36	0.03	0.71	-1.27	1.86
Real Estate	Number of Employees in Real Estate	36	-0.60	0.86	-2.21	1.53
Research Services	Number of Employees in Scientific Research Services	36	-0.77	1.01	-2.41	1.89
Logistics and Telecommunication	Number of Employees in Logistics and Telecommunication	36	0.19	0.75	-1.11	2.27

to select APS sectors for the MYR city region. As Sessen (1991) articulated, APS sectors are those advanced service sectors, providing value-added services to producers. According to this principle, the APS sectors in the MYR city region are chosen as Financial Services (including Banking and Insurance), Logistics and Telecommunication (L&T) (including Information Technology Services), Real Estate, and Research Services (including Technical Services).

Human Flows	Passenger Volume Transported with Various Means	36	9.18	0.70	7.58	10.58
Commodity Flows	Freight Volume Transported with Various Means	36	9.29	0.72	7.69	10.70

Table 2 Spatial Analysis Variables' Statistical Description (Source: NBS and SIPO).

In terms of methodology, a series of spatial analysis techniques are used to illuminate the spatial patterns in the MYR city region, including mean centre, SDE technique, grouping technique, spatial autocorrelation test, and clustering test. Geo-space is not flat or empty but is conditioned by geographic attributes (terrain, land cover, and traffic congestion etc.) and economic attributes (production, investment and knowledge etc.). This chapter uses these techniques to transform economic attributes into geo-space in order to discover the underlying spatial patterns of economic activities in the MYR city region.

Specifically, a mean centre technique is used to illustrate the geographic gravity points of economic activities. Spatial centres weighted by economic attributes can be used to provide a comparison with geographic centres, which is useful to investigate the economic gravities of distinctive economic activities. When weighted gravities are deviated to a certain direction from a geographic centre, it indicates the existence of concentration and the location of concentrations. In addition, the distance between weighted gravities and geographic gravity can show the extent of concentration. For example, when economic gravities are deviated to the northeast in a long distance, it indicates that the strength of certain economic activity is highly concentrated in northeastern cities. The mean centre is a point constructed from the average x and y values weighted by economic attribute data for the input cities' locations. The weighted mean centre is given as:

$$\bar{X} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}, \bar{Y} = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

Where x_i and y_i represent the coordinates for city i, and n is equal to the total number of cities, w_i is the weight (attribute data) at city i.

Secondly, SDE is an advanced technique compared to the mean centre. It is based not only on the mean centre method but it also calculates the standard deviation of the x-coordinates and y-coordinates from the mean centre to define the axes of the ellipse. Compared to the mean centre technique, SDE can detect not only the gravity movement but it can also illustrate the orientation between a concentrated area and a sparse area. The ideal geo ellipse is a 'roundness' when the distribution of cities has a perfect spatial normal distribution (meaning that they are densest in the centre and become increasingly less dense toward the periphery). When the ellipse weighted by economic attributes is elongated and rotated in a certain direction, it indicates that certain activities become disproportionately less dense from a concentrated area to a peripheral area, oriented in a certain direction. When weighed ellipses are compared to a geographic ellipse, the variance can indicate how differently these concentrated activities become less dense compared to local geographic features (city size and location). When the ellipse weighted by economic attributes is a similar shape to a geo ellipse, it indicates that certain concentrated activities become less dense in proportion to local geographic features. The orientation represents the rotation of the long axis measured clockwise from noon. The Standard Deviational Ellipse is given as:

$$SDE_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n}}, SDE_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n}} \quad (2)$$

Where x_i and y_i are the coordinates of city i, $\{\bar{X}, \bar{Y}\}$ is the coordinates of the Mean Centre of all cities, and n is equal to the total number of cities.

Then angle of rotation is calculated as:

$$\tan\theta = \frac{A+B}{C} \quad (3)$$

$$A = \left(\sum_{i=1}^{n} \tilde{x}_i^{\,2} - \sum_{i=1}^{n} \tilde{y}_i^{\,2}\right) \quad (4)$$

$$B = \sqrt{(\sum_{i=1}^{n} \tilde{x}_i^{\,2} - \sum_{i=1}^{n} \tilde{y}_i^{\,2})^2 + 4(\sum_{i=1}^{n} \tilde{x}_i \tilde{y}_i)^2} \quad (5)$$

$$C = 2\sum_{i=1}^{n} \tilde{x}_i \tilde{y}_i \quad (6)$$

Where $\tilde{x}_i$ and $\tilde{y}_i$ are the deviations of the (x, y) coordinates from the mean center.

Thirdly, a grouping technique[27] is used to analyse cities' heterogeneity and identify subgroups across territories. When the results are mapped, the spatial distribution of subgroups can be investigated to estimate spatial heterogeneity to some extent. The rationale of the grouping technique is to maximize the similarity within subgroups and the dissimilarity across groups by using a K means algorithm. The advantage of a K means algorithm is that it can include multiple indicators to identify subgroups. The K Means algorithm works by first identifying seed cities[28] used to grow each group and the number of seed cities are the number of groups. After seed cities are identified, other cities are assigned to the closest seed cities. Subsequently, for each group of cities, a mean centre is computed, and each city is reassigned to the closest mean centre. The process of computing a mean centre for each group and then reassigning cities to the closest mean centre will iterate until group membership stabilizes according to estimation of the effectiveness statistic. Grouping effectiveness is measured by using the Calinski-Harabasz pseudo F-statistic, which is a ratio reflecting within-group similarity and between-group difference, formally written as:

$$F = \frac{\left(\frac{R^2}{n_C - 1}\right)}{\left(\frac{1 - R^2}{n - n_C}\right)} \tag{7}$$

Where:

$$R^2 = \frac{SST - SSE}{SST} \tag{8}$$

$$\mathrm{SST} = \sum_{i=1}^{n_c} \sum_{j=1}^{n_i} \sum_{k=1}^{n_v} \left(V_{ij}^k - \overline{V^k}\right)^2 \tag{9}$$

$$\mathrm{SSE} = \sum_{i=1}^{n_c} \sum_{j=1}^{n_i} \sum_{k=1}^{n_v} \left(V_{ij}^k - \overline{V_i^k}\right)^2 \tag{10}$$

SST is the between-group dissimilarity and SSE is the within-group similarity; n represents the number of cities; n_i equals to the number of cities in group i; n_c equals to the number of groups; n_v equals to the number of variables; V_{ij}^k equals to the value of the Kth variable

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[27] Grouping techniques are some of the most widely used methods in machine learning. The Grouping Analysis tool utilizes unsupervised machine learning methods to determine natural groupings in the data.

[28] The first seed is selected randomly. The selection of remaining seeds applies a weighting that favours selection of subsequent seeds farthest in data space from the existing set of seed features (this part of the algorithm is called K Means).

of the j th city in the i th group; $\overline{V^k}$ is the mean value of the k[th] variable; $\overline{V_i^k}$ is the mean value of the k[th] variable in group i.

Fourthly, spatial autocorrelation and clustering analysis are carried out to illuminate spatial association across cities in the MYR city region. The Moran Index and Getis-Ord Gi are employed to evaluate global autocorrelation and clustering types. The null hypothesis of Moran's Index is that the cities with attributes are distributed randomly, whilst the null hypothesis of Getis-Ord Gi is that cities are not clustered. The Global Moran Index is given as:

$$I = \frac{n}{S_o} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \quad (11)$$

$$S_o = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} \quad (12)$$

Where z_i is the deviation of an attribute for city i for its mean$(x_i - \bar{X})$; $w_{i,j}$ is spatial weight (proximity) between city i and city j; n is the number of cities; and S_o is the aggregate of all the spatial weights.

z-score is computed as:

$$z_I = \frac{I - E[I]}{\sqrt{V[I]}} \quad (13)$$

Where:

$$E[I] = -1/(n-1)$$

$$V[I] = E[I^2] - E[I]^2 \quad (14)$$

At the presence of null hypothesis rejection, the Getis-Ord G statistic can distinguish high-value clustering (positive Getis-Ord G) and low-value clustering (negative Getis-Ord G). The Getis-Ord G statistic is given as:

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} x_i x_j}{\sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j}, \forall j \neq i \quad (15)$$

Where x_i and x_j are attribute values for city i and j, and $w_{i,j}$ is the spatial weight between city i and j . n is the number of cities.

The z_G-score is computed as:

$$z_G = \frac{G - E[G]}{\sqrt{V[G]}} \quad (16)$$

Where:

$$E[G] = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}}{n(n-1)}, \forall j \neq i \quad (17)$$

$$V[G] = E[G^2] - E[G]^2 \quad (18)$$

Lastly, in order to detect local instability (spatial heterogeneity), the Getis-Ord Gi* statistic is applied in identifying hotspots and coldspots in local neighbourhoods of cities (Getis and Ord, 1995). The statistically significant hotspots (or coldspots) should have a high value and should also be surrounded by neighbours with high values (or low values). The hotspots are identified statistically based on two conditions: the sum of local neighbourhood is disproportionate to the overall sum; the local sum is very different from the expected and the difference is large enough to reject a random distribution. The Getis-Ord Gi* statistic is computed as:

$$G^*_i = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \overline{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad (19)$$

$$\overline{X} = \frac{\sum_{j=1}^{n} x_i}{n} \quad (20)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2} \quad (21)$$

Where x_j is the attribute value for city j, $w_{i,j}$ is the spatial weight between city i and j, n is the number of cities.

Since W represents the spatial relations of observations and determines how we interpret the spatial association, it is important to specify W robustly according to data characteristics. Practically, there are two main categories of W widely used, namely a spatial contiguity matrix and an inverse distance matrix (and sometimes an exponential distance decay matrix) (Keller and Shiue, 2007; Elhorst, 2014). The spatial contiguity matrix is a binary matrix having several criteria defining neighbours, namely queen contiguity[29], rook contiguity[30] and k nearest neighbours[31]. The inverse distance matrix is a multi-valued matrix normally based on Euclidean distance and can insert a cutting-off point to decide the bandwidth of spatial effects. As Elhorst (2014) testified using a Monte-Carlo simulation method, the contiguity spatial matrix works best for use with small datasets. Thus, in this analysis, a contiguity matrix was selected to detect MYR city region spatial association. In fact, all MYR cities share a certain length of border with their neighbours with no islands. So there is no difference between queen contiguity and rook contiguity. Queen contiguity W is a binary matrix, written as:

$$W_{ij} = \begin{cases} 1, l_{ij} > 0 \\ 0, l_{ij} = 0 \end{cases} \tag{22}$$

Where l_{ij} is the length of shared boundary between City i and City j.

6.4 Results

6.4.1 Spatial Distribution of Economic Activities

Firstly, the economic performance of cities in the MYR city region is illustrated in Figure 10. The reason the data are illustrated in maps rather than in a descriptive statistics table is that in addition to numbers, the spatial distribution of economic activities can be observed to unveil spatial patterns. As shown in Figure 10, the economic performance of cities in the MYR city region is characterised by the salient core-periphery pattern. Specifically, Wuhan and Changsha, as capital cities of the Hubei and Hunan sub-regions respectively, are most developed in terms of GDP and GDP per capita. Nanchang and Yichang also outperformed other cities, just behind Wuhan and Changsha. In addition, Xiangyang and Yueyang are outperformed in GDP while Ezhou and Xinyu are outperformed in GDP per capita. Other less developed cities are mostly located in the geographically peripheral area of the city region except in the northwest. In terms of GDP composition, secondary industry still contributes to more than half of city region GDP. Notably, Wuhan is the

[29] Queen contiguity defines neighbours when they share a border or a vertex.

[30] Rook contiguity defines neighbours when they share a border of some length only.

[31] K nearest neighbours method identifies k neighbours based on distance to spatial units within a certain circular bandwidth. It is useful to include ports or islands in spatial relationship since contiguity matrix will ignore these places that can also be connected by waterways.

MYR services sector centre and the only city where tertiary industry contributes most to economic development.

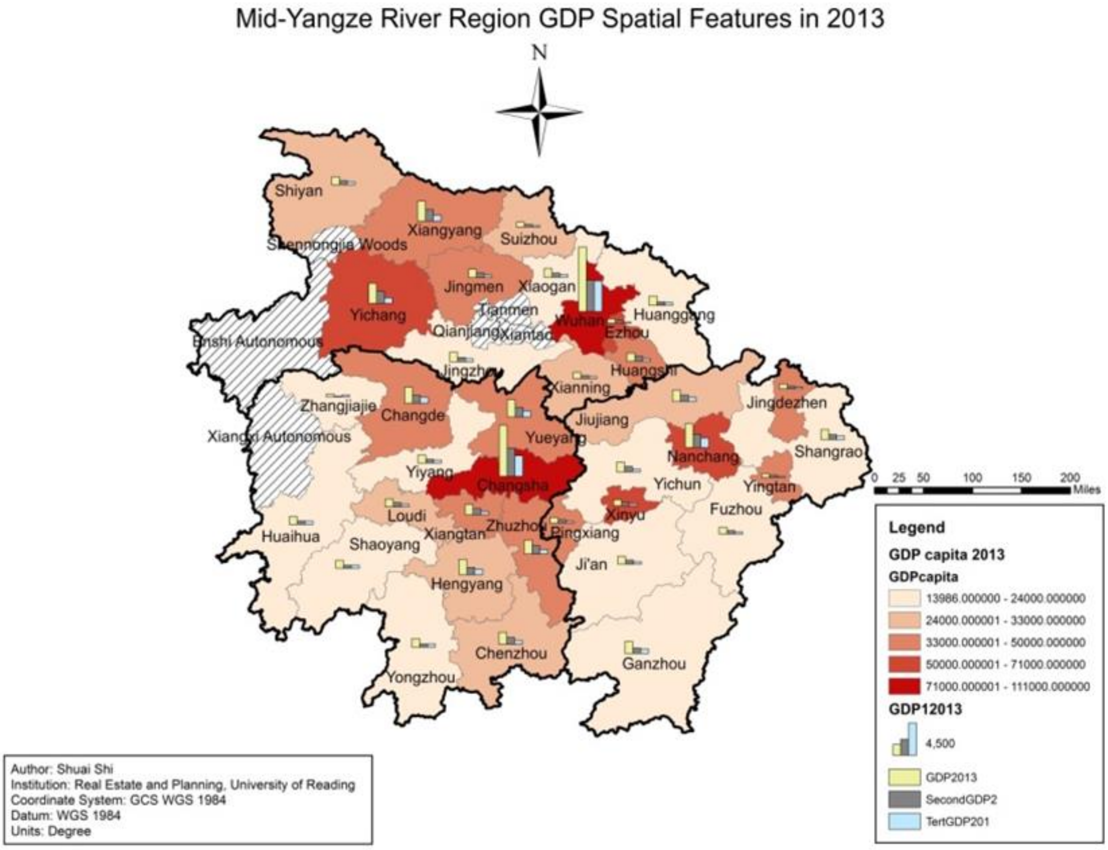

Figure 10 Economic Development Status in the MYR City Region (source: NBS).

Secondly, capital stock increase and labour cost are illustrated in Figure 11 and Figure 12 respectively due to their importance for economic development. It is found that the spatial distribution of capital stock is similar to that of GDP, which highlights the core city region positions of Wuhan and Changsha. In addition, Nanchang and Yichang also outperform other MYR cities capital stock increase and labour cost, as in GDP indicators. Xiangyang is a new 'semi-core[32]' city, indicating its relative strength in investments in fixed assets. Thus, it is postulated that capital stock increase is significant to economic development or has a close relationship with the local economy (this assumption is tested in the regional growth model in Chapter 8 and is found justified). However, in terms of labour cost, the distribution pattern illustrates an opposite pattern compared to GDP and capital stock

[32] In Word City System theory, semi-core cities are those that are upgraded from periphery cities but still have distinctive disparity to core cities, which makes them position between core and periphery cities. The semi-core cities are often geographically located between core and periphery cities.

increase, though Wuhan, Changsha and Nanchang maintain their triad positions. Thus, it is postulated that for the MYR city region whose pillar industry is manufacturing, increasing labour cost may jeopardise economic development in this economic transition phase (this assumption is also tested and found justified in Chapter 8), showing the negative effect of increasing labour cost on MYR city region development. Given the three cities' consistent outperformance, intertwined with the overwhelming concertation of APS sectors in these three cities (shown in Figure 18), it may be speculated that the higher incomes of employees in APS are associated with higher local labour costs.

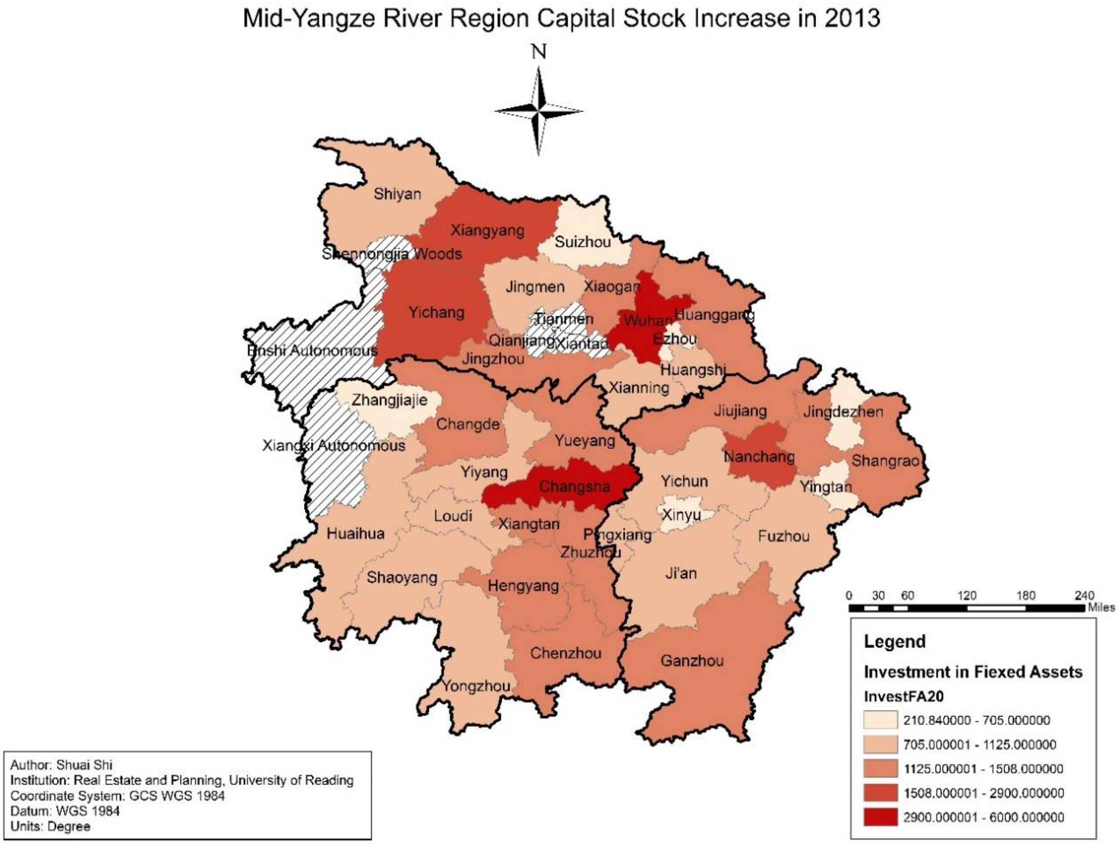

Figure 11 Urban Investment in Fixed Asset in the MYR City Region (source: NBS).

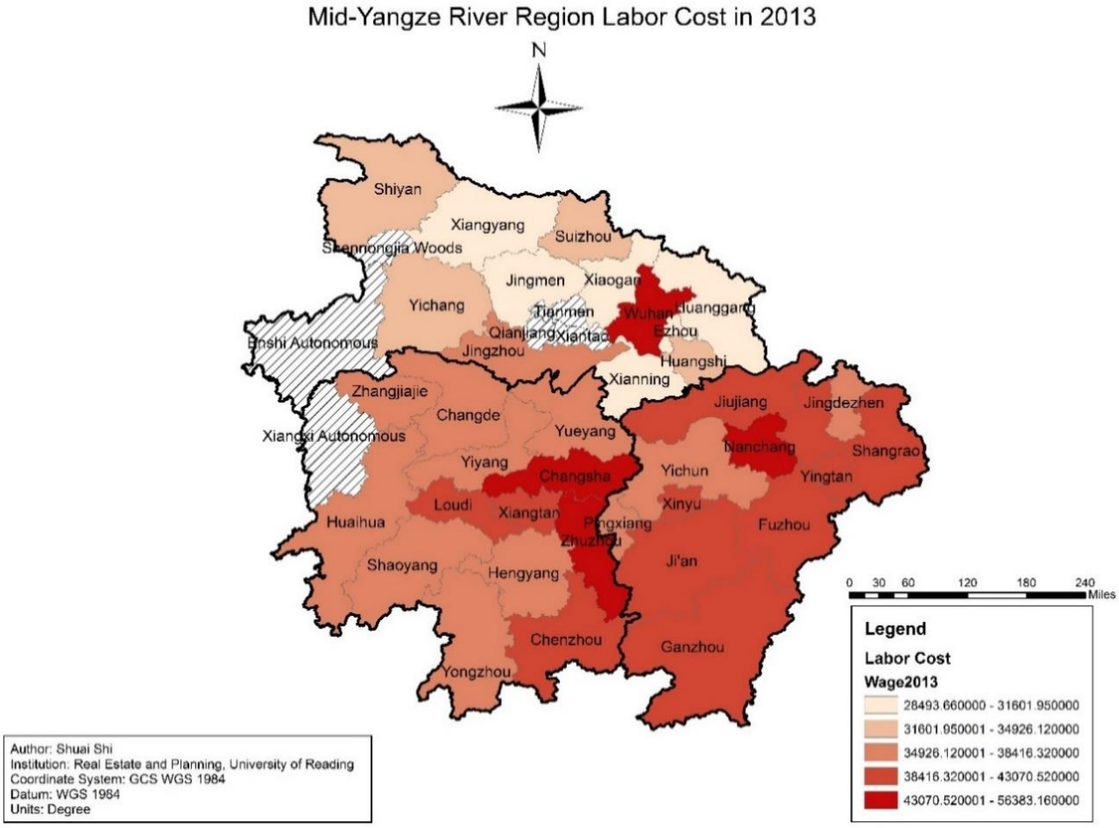

Figure 12 Labour Cost Status in the MYR City Region (source: NBS).

In addition, foreign investment is investigated to reflect urban attractiveness and openness to foreign capital, as illustrated in Figure 13. Foreign capital flows in China are the largest in the world and are regarded as an important for the dissemination of new technologies, knowledge, skills, information and so on, contributing to China’s economic development as an outcome (Madariaga and Poncet, 2007; Liu, 2008; UNCTAD, 2013). The Wuhan-Changsha-Nanchang triad cities are the most attractive area for foreign investment leaving Yichang, as the fourth developed MYR city behind, which indicates that it has less openness to the international market. However, it is interestingly that other MYR cities are becoming prominent in foreign investment, such as Jiujiang, Chenzhou and Ganzhou. In conclusion, the spatial distribution of foreign capital is generally resonant with the core-periphery pattern identified in GDP, while Wuhan has an enhanced leading position and, after the triad cities, Jiujiang has become prominent.

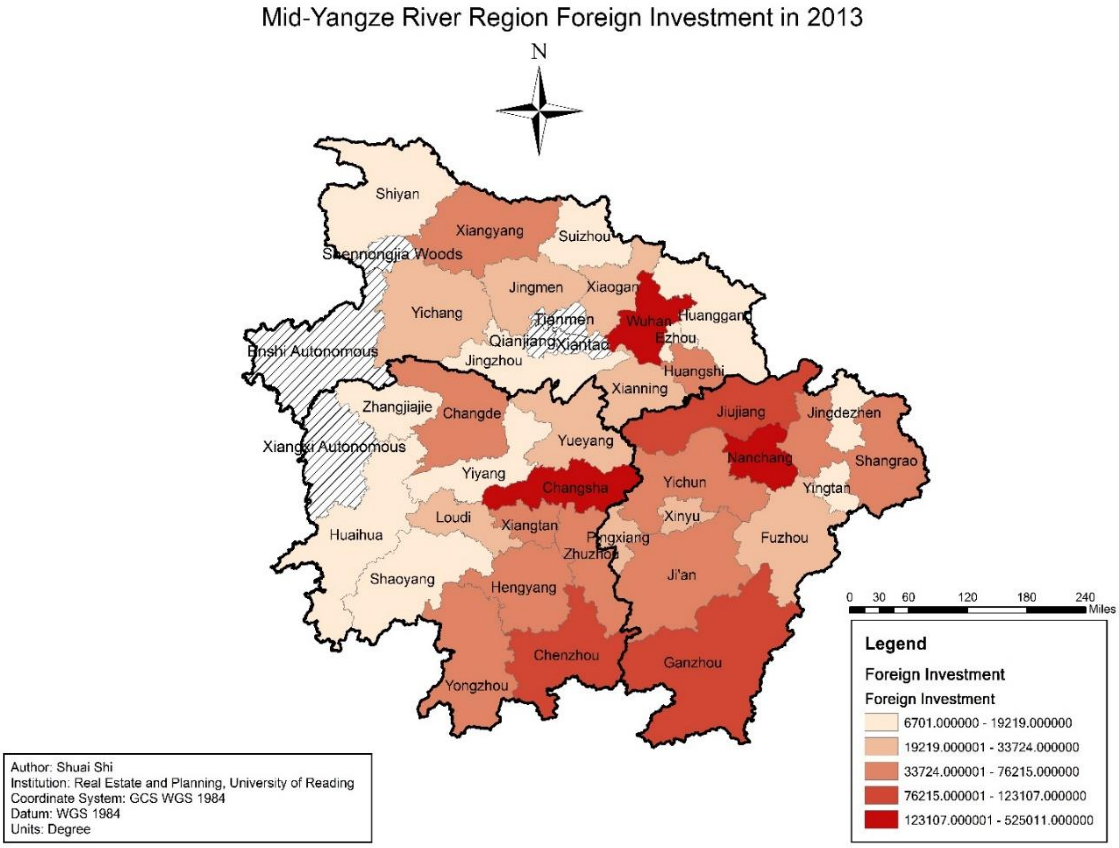

Figure 13 Foreign Investment Status in the MYR City Region (source: NBS).

In addition to economic indicators, the knowledge stock represented by authorised patents and transport connectivity represented by arteries, human and commodity flows are illustrated in Figure 14 and Figure 15 respectively. In endogenous growth theory, technological advances are fundamental to drive economic development (Romer, 1986, 1990). It is shown that technological advances are highly concentrated in Wuhan and Changsha, showing a duopoly pattern of knowledge stock in the MYR city region. Among others, Nanchang, Zhuzhou, Yichang and Xiangyang are also relatively strong, resonated with their strong economic performance, which suggests the potential relationship between knowledge stock and economic development (this assumption is also tested and found justified in the spatial growth model in Chapter 8).

In terms of transport connectivity, as shown in Figure 15, the MYR city region has the advantage of a central geographic location and proximity to the Yangtze River waterway, which is the busiest river in the world (NBS 2014). All cities in the MYR city region are connected by railway and highway. The triad cities (Wuhan, Changsha and Nanchang) are connected within two hours by high-speed train and can reach Shanghai, Guangzhou, Shenzhen and Hong Kong within six hours. Regarding civil aviation, Wuhan (No.6) and

Changsha (No.9) are two of the busiest airports in China (NBS 2014). In terms of commodity flows and human flows, Wuhan captures the MYR commodity trade centre position, while Changsha is attractive to human flows. In conclusion, the transportation network in the MYR city region is well-established and advantageous to facilitate regional integration (which is also tested and justified in Chapter 8).

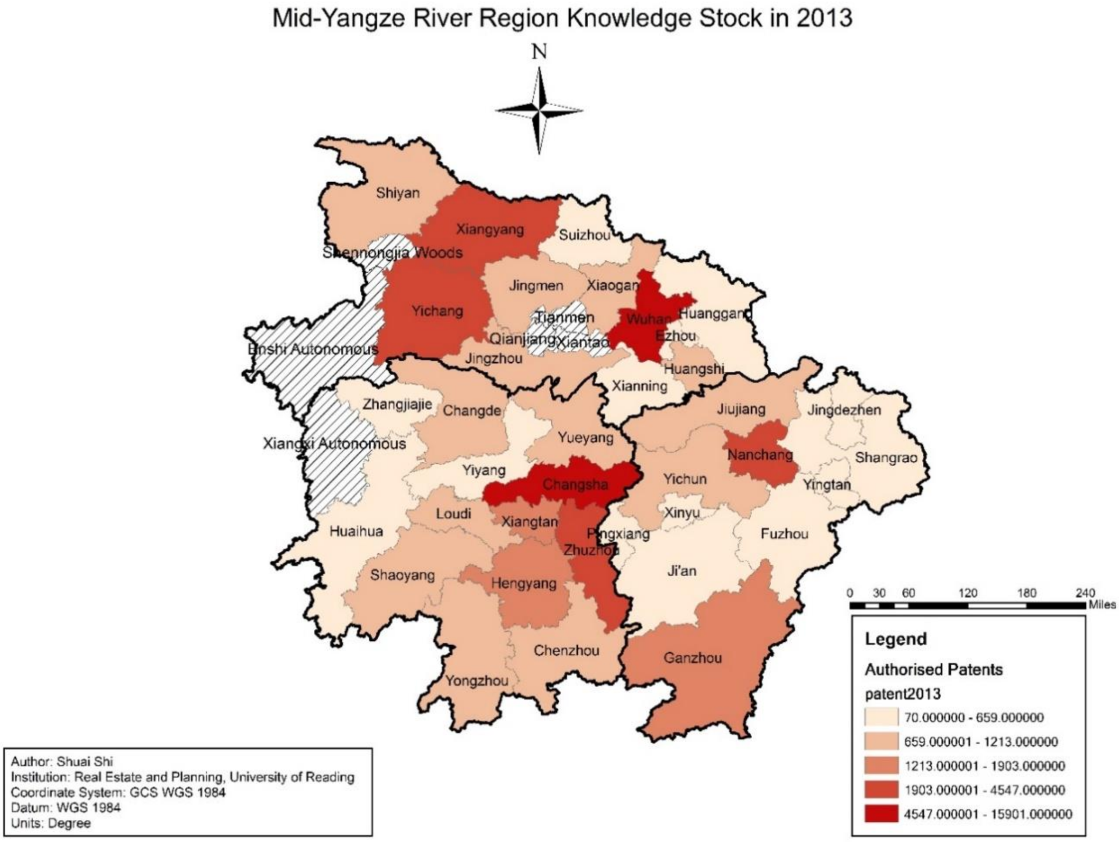

Figure 14 Knowledge Stock Status in the MYR City Region (source: SIPO).

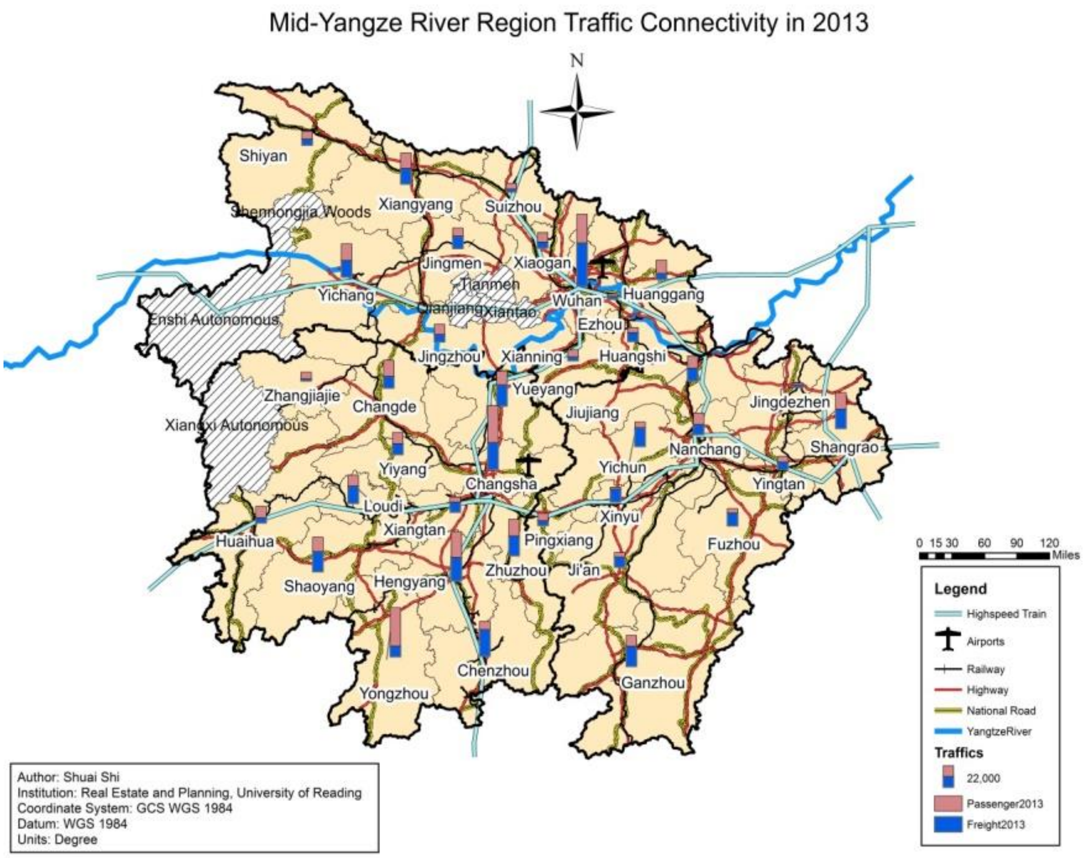

Figure 15 Transportation Network Status in the MYR City Region (source: NBS).

6.4.2 The Spatial Correlation between Manufacturing and APS sectors

Although the ION approach that is based on the office functions of APS firms was not adopted to estimate urban connectivity for the MYR city region in the research, there is no doubt that APS sectors are highly representative of the knowledge economy. Furthermore, as argued in the literature review, the reciprocal association of manufacturing and APS sectors is expected to be the key to accomplishing economic transition in China. In other words, APS sectors can provide specialised services to producers, which adds value to manufactured production; meanwhile manufacturing is the foundation market to facilitate APS sectors' development in China and the MYR city region. Therefore, APS spatial agglomeration patterns and correlation with manufacturing are investigated here in order to complement the investigation of spatial patterns in the MYR city region.

As shown in Table 3, the Pearson correlation matrix is used to investigate the correlation between manufacturing and APS sectors. It is found that manufacturing and APS sectors are highly correlated positively. In addition, principle component analysis (PCA) is carried out to reduce the number of APS sectors in order to investigate the general correlation between manufacturing and APS sectors. The first principle component[33] (PC1) is selected to represent APS sectors. As shown in Table 3, PC1 is also highly correlated with manufacturing at significance level. In addition, in order to observe the correlation between manufacturing and APS sectors across cities, the correlation fitted line is illustrated in Figure 16. We can see that most cities are clustered around the fitted line, indicating the positive association between manufacturing and APS sectors in the city region. However, Zhangjiajie and Huaihua are outlier cities, distant from the fitted line.

	Manufacturing	**L&T**	**Financial Services**	**Real Estate**	**Research**	**PC1**
Manufacturing	1.000					
L&T	0.818*	1.000				
Financial Services	0.752*	0.789*	1.000			
Real Estate	0.850*	0.805*	0.801*	1.000		
Research Services	0.773*	0.828*	0.803*	0.838*	1.000	
PC1	0.818*	0.934*	0.790*	0.805*	0.828*	1.000

Table 3 The Pearson Correlation Matrix of Manufacturing and APS Sectors (significance level at 0.05) (Source: Author calculations using NBS database).

[33] The eigenvalue of first principle component is 4.22 and explain 84 per cent of APS sectors' variation.

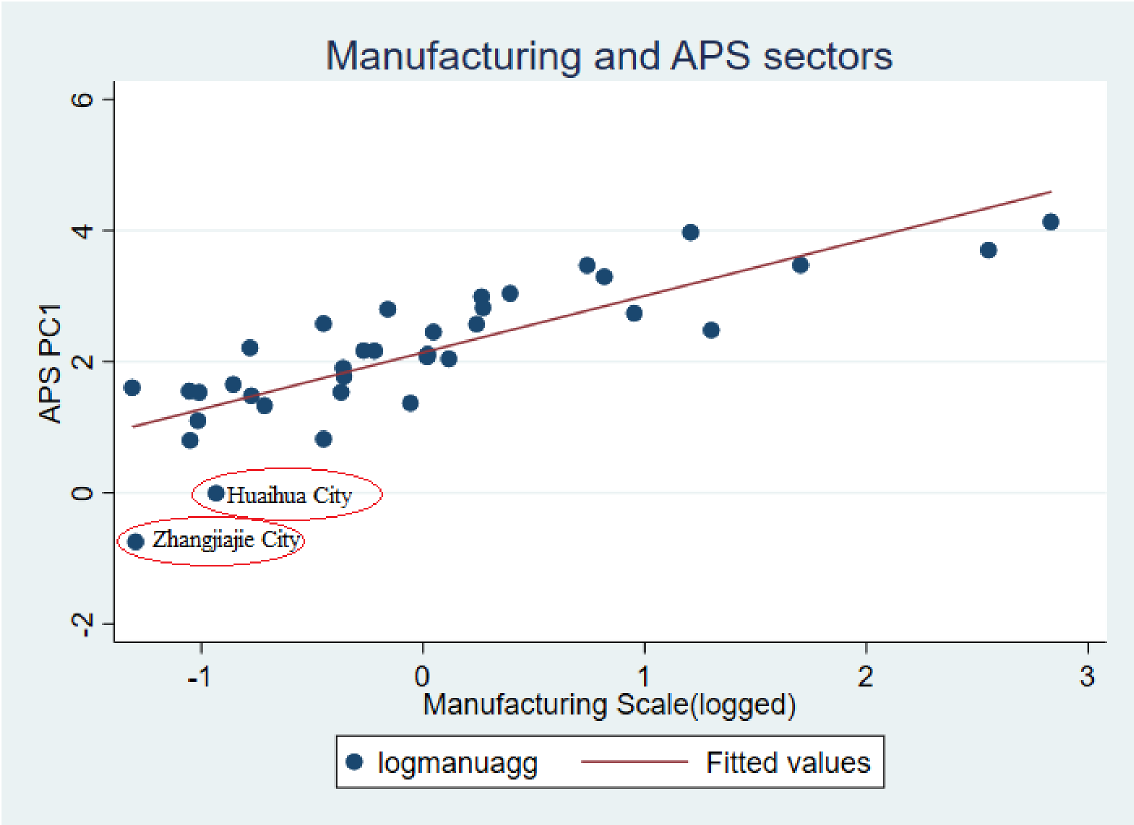

Figure 16 Correlation Fitted Line between Manufacturing and APS PC1 in the MYR City Region (Source: Author calculations using NBS database).

Lastly, in addition to the statistical correlation, the spatial agglomeration patterns of manufacturing and APS sectors are illustrated separately in order to investigate their spatial characteristics, and their spatial distributions are then compared in order to explore their associated patterns in a geographic sense (as shown in Figures 17 and 18). Due to the limited data availability, it is not possible to identify the geographical location of every firm in the different sectors. Consequently, the number of employees is used as a proxy and the dot density renderer[34] to represent the number of employees (every dot represents 2000 people). Given the spatial distribution of manufacturing, it is found that Wuhan is the densest area, indicating that it has the strongest manufacturing productivity in the city region, followed by Changsha and Nanchang. However, the spatial concentration of manufacturing in Wuhan transcends its boundary and extends to surrounding cities other than Changsha and Nanchang which are surrounded by relatively fewer dots. In addition, cities in the northwest are identified as outperformers in the geographical periphery area. Given the spatial distribution of APS sectors, it is found that the spatial pattern of APS

[34] The Dot Density renderer is used to represent quantitative values for an attribute variable as a series of pattern fills based on the attribute value for each city. Each city is filled with dots based on the attribute value. Each dot represents a certain value.

sectors generally overlaps with that of manufacturing, which reflects the high correlation; however, it is found that the spatial distribution of APS sectors is more concentrated in the triad cities.

Figure 17 The Spatial Agglomeration Pattern of Manufacturing in the MYR City Region (source: NBS).

Figure 18 The Spatial Agglomeration Pattern of APS Sectors in the MYR City Region (source: NBS).

6.4.3 The Spatial Concentration and Orientation

In this section the aggregate spatial patterns of economic activities in the MYR city region are illustrated by investigating weighted gravities and ellipses.

In terms of geo-centre results, as illustrated in Figure 19, in addition to the wage gravity which is overlapped with the geo centre (green node), all other gravities are deviated from the geo centre, which means that these activities are concentrated to different degrees. Among them, APS activities are the most concentrated. Specifically, the gravities of GDP, GDP capita and capital stock increase are overlapped and moved in a northern direction, which indicates that northern cities are relatively stronger in the aggregate economy and capital stock. This finding has resonance with their general spatial distribution patterns discussed in the previous section. In terms of attracting foreign capital (blue node), it is found that the gravity moved to the east, which shows the relative attractiveness of eastern cities. However, interestingly, foreign capital is flowing in the less developed east rather than the developed north. Similar to GDP-related gravities, knowledge stock increase (pink node) is also highly concentrated in northern cities, which again reinforces the higher development level and beneficial indigenous factors of the north. Given APS activities, due to clear mapping and the good fitness of PC1, PC1 (sky blue node) is used to represent aggregate of APS sectors. It is found that APS activities are highly concentrated in north-eastern cities. Associated with the general pattern shown in Figure 18, Wuhan city has a significant role, making the northeast prominent in APS activities. Lastly, in terms of commodity and human flows (grey and orange node), the south and southwest respectively are outperforming other areas.

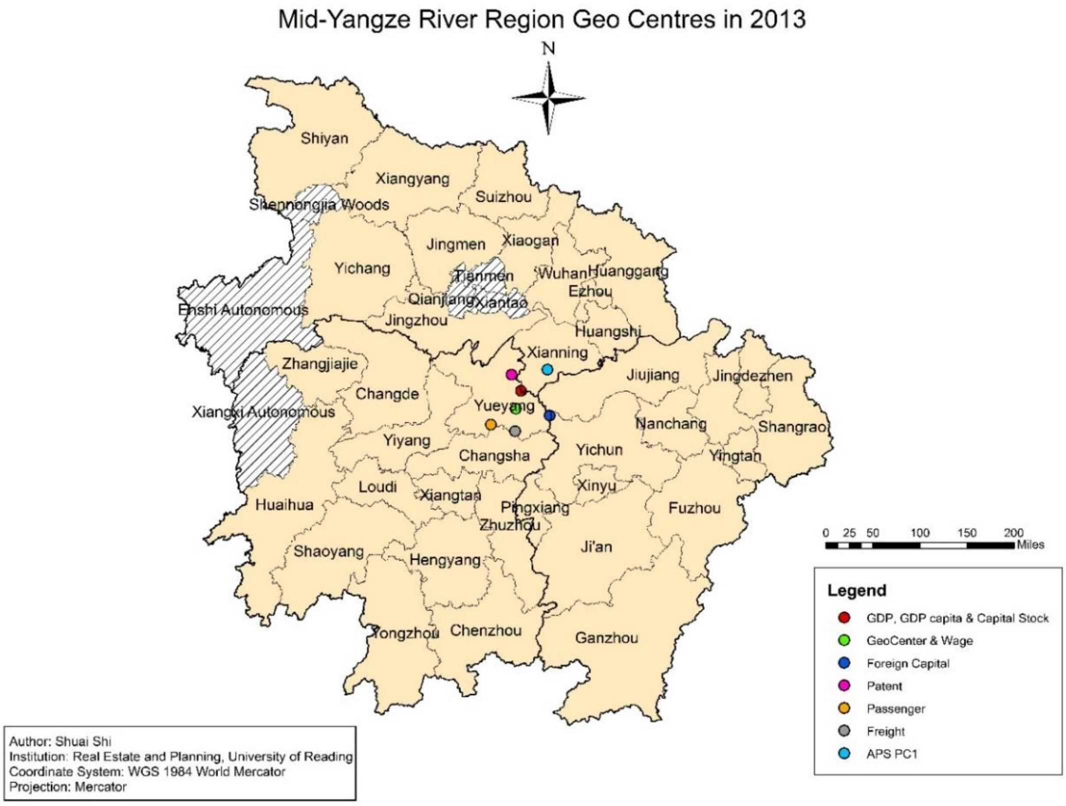

Figure 19 Economic Gravities in the MYR City Region (Source: Author calculations using NBS and SIPO databases).

Secondly, the SDE results manifest the spatial orientation of concentrated activities in the MYR city region. For clear mapping and comparison, the ellipses weighted by different indicators are presented separately. Firstly, it is seen that the geo ellipse is near to roundness, which means that generally there are more cities located in the geographic centre of the city region while less cities proportionately are located in the periphery. Secondly, as shown in Figures 20, 21 and 22, by comparing the geo ellipse to other weighted ellipses, it is found that the most different ellipses of selected activities are technological advances, foreign investment and APS activities. However, these three activities show different spatial patterns. In terms of the ellipse of APS activities, it is the smallest, but its shape is similar to the geo ellipse. This indicates that APS activities are the most concentrated activity and that their concentration becomes less dense proportionately following geographical features, which has resonance with the geo centre analysis finding. On the other hand, in terms of the elongated ellipses of technological advances and foreign investment, these are elongated in different directions. It is seen that technological advances and foreign investment are oriented respectively to the northwest and the northeast (albeit marginally), though northern cities and eastern cities have the strongest capability in technology and attraction to foreign investment respectively.

In conclusion, economic activities are strongly concentrated and direction-oriented to different degrees. Among them, knowledge stock increase and foreign investment are oriented to the northwest and the northeast respectively, while APS activities are more concentrated than others. Specifically, northern cities are characterised by a stronger economic development level and technological advances; foreign investments are more concentrated in the east; while transportation activities are more concentrated in the south.

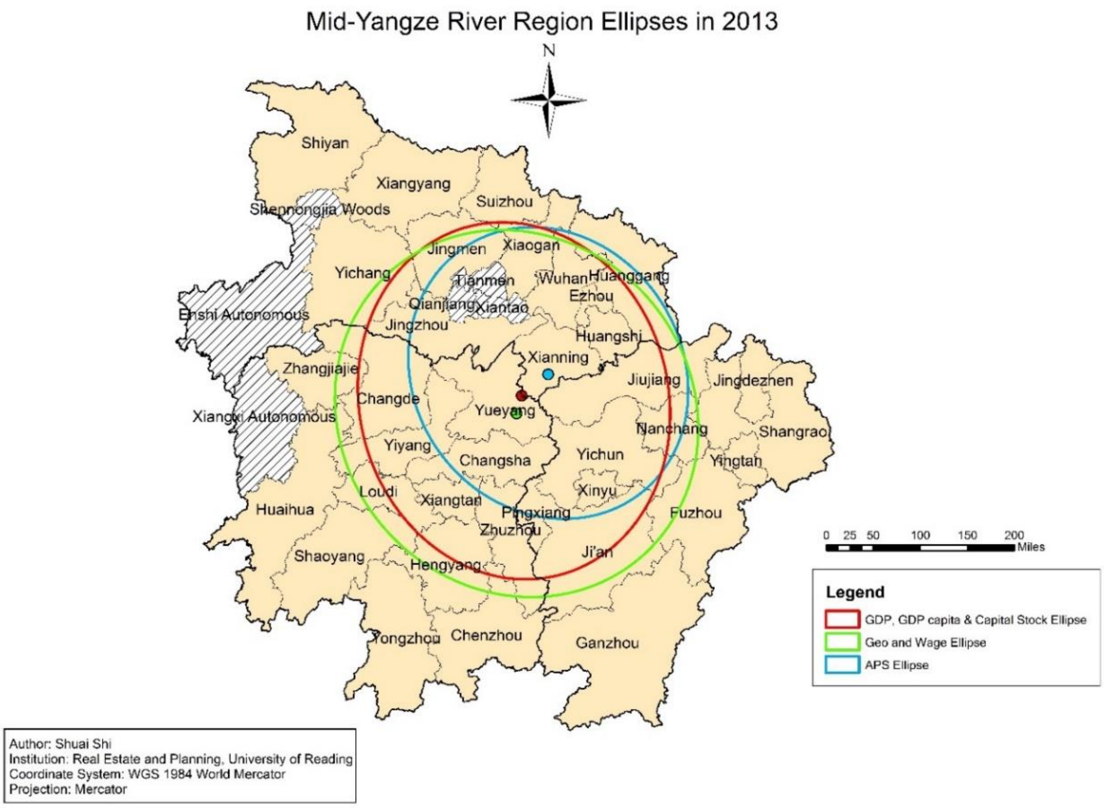

Figure 20 The SDE Map of Aggregate Economy and APS Sectors (Source: Author calculations using NBS database).

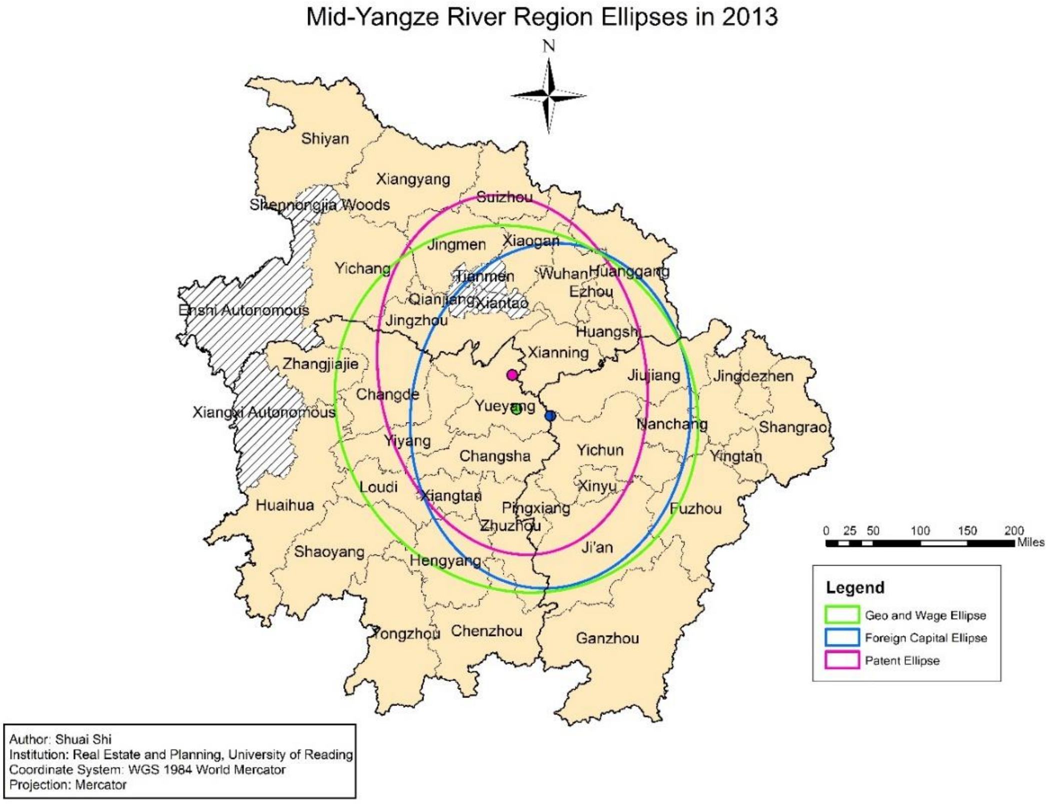

Figure 21 The SDE Map of Knowledge Stock and Foreign Capital (Source: Author calculations using NBS and SIPO databases).

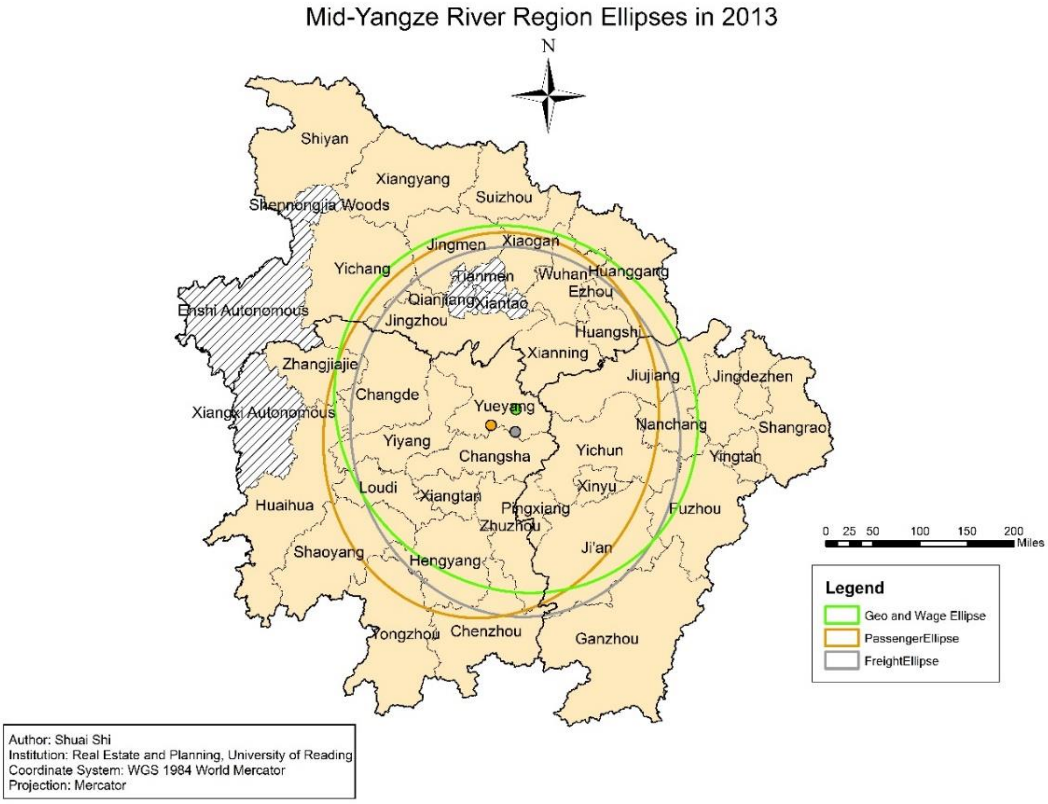

Figure 22 The SDE Map of Commodity and Human Flows (Source: Author calculations using NBS database).

6.4.4 Similarity and Dissimilarity across Cities

Having investigated the general spatial distribution and concentration patterns in the MYR city region, this section focuses on identifying city subgroups by investigating similarities and dissimilarities across cities in order to discover spatial heterogeneity to some degree.

Through sensitivity analysis, Figure 23 shows that the F-Statistic peaks at number three before declining. In other words, when the number of subgroups is three, group structure is the most stable with the maximum between-groups dissimilarity and within-groups similarity. As shown in the first map in Figure 24, Wuhan and Changsha are the most similar cities across economic performances. In the green group, it is interesting that Yichang, Xiangyang and Shiyan are not only similar but also contiguous to each other. In order to explore dissimilarities within the three subgroups, the number of groups is increased at the expense of effectiveness, as shown in the second and third maps in Figure 24. It is found that the triad cities are more heterogeneous than others, since they have separate established groups following the increased number of groups. Thus, given the three cities' consistent outperformance in economic activities, it may be speculated that big cities in MYR city region contribute more to spatial heterogeneity due to the spatial concentration of complex and intricate economic activities. In addition, the northwest group is the most cohesive contiguous area regardless of increasing the number of groups.

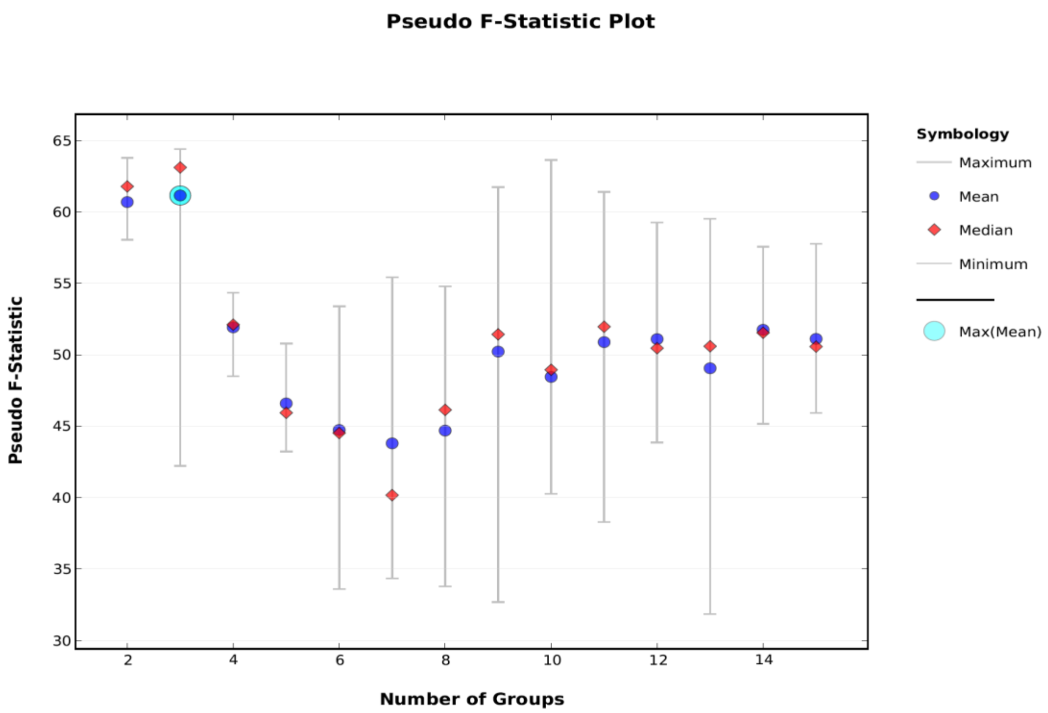

Figure 23 The F-statistic Sensibility in Different Group Numbers (Source: Author calculations using NBS and SIPO databases).

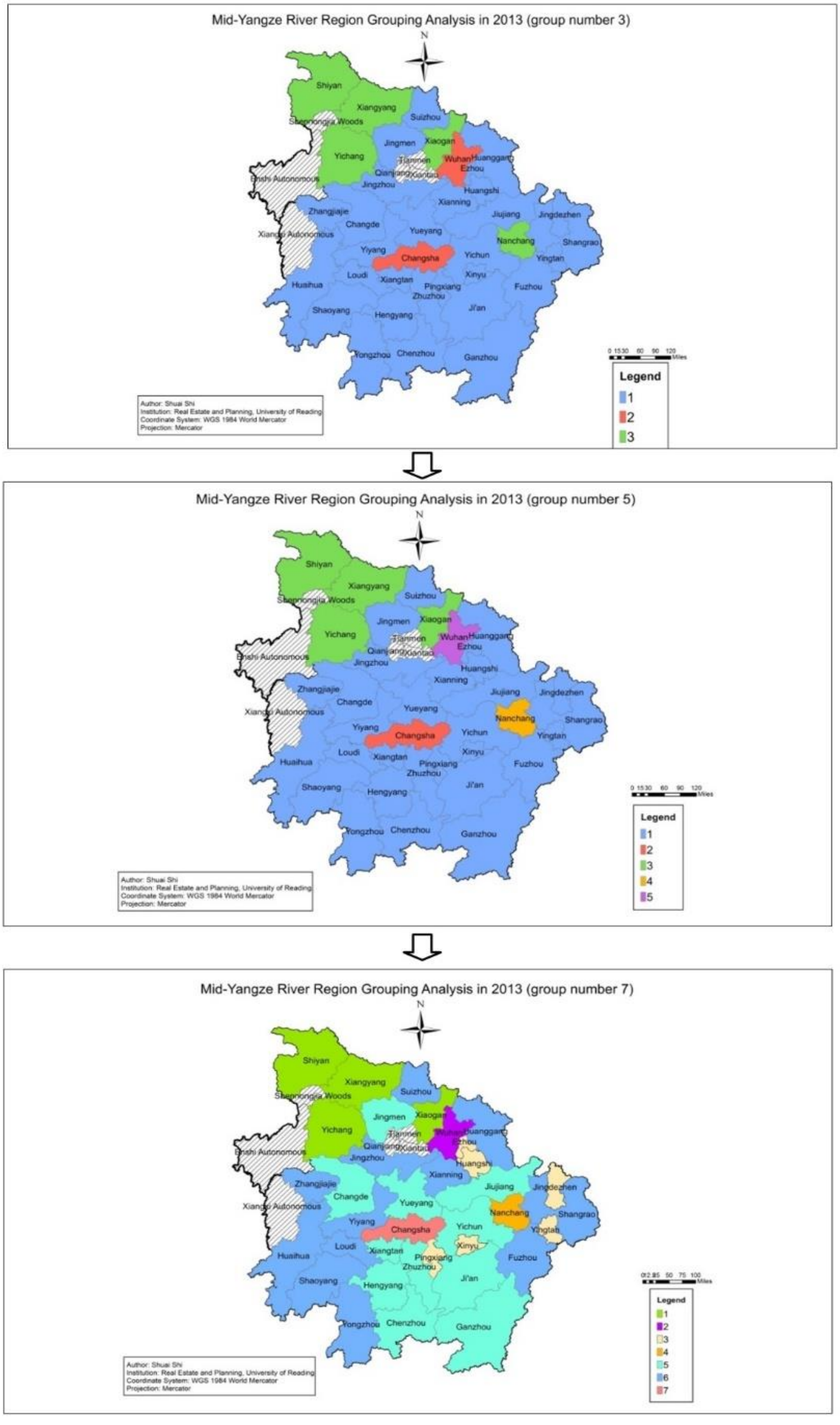

Figure 24 The Dynamic Maps of Grouping Analysis (Source: Author calculations using NBS and SIPO databases).

Lastly, Table 4 illustrates the contribution factors of various indicators to discover spatial dissimilarities across cities through increasing group numbers. It is found that real estate, knowledge stock increase and scientific research services consistently contribute most to distinguish subgroups. Among them, the importance of knowledge stock increase is enhanced, which has resonance with its identified disparity pattern. discussed in Section 6.4.3. On the other hand, real estate and scientific research activities become prominent among APS sectors in detecting spatial heterogeneity.

Variables (Logged)	R2 (3Groups)	R2 (5Groups)	R2 (7Groups)
GDP	0.625	0.647	0.821
GDP capita	0.648	0.703	0.747
Capital Stock	0.598	0.653	0.695
Labour Cost	0.469	0.488	0.534
Foreign Capital	0.733	0.919	0.956
Technological Advance	0.915	0.966	0.975
Manufacturing	0.847	0.871	0.925
Real Estate	0.937	0.950	0.964
Scientific Research	0.903	0.943	0.957
Financial Services	0.828	0.891	0.940
L&T	0.699	0.887	0.899
Commodity Flows	0.597	0.645	0.695
Human Flows	0.642	0.676	0.745
Pseudo F-Statistic	63.877	45.881	43.796

Table 4 The Contribution of Variables in Grouping Analysis (Source: Author calculations using NBS and SIPO databases).

In conclusion, based on the grouping results, similarities and dissimilarities coexist across cities in the MYR city region, which verifies the existence of spatial heterogeneity in the MYR city region economy. In addition, knowledge-related activities (patents and research services) and real estate activities contribute most to generating the spatial heterogeneity discovered. Thus, it is postulated that spatial heterogeneity affects the underlying spatial regime of the MYR city region economy significantly (this assumption will be tested in Chapter 8).

6.4.5 The Spatial Association, Clustering and Hotspots

This section aims to shed light on the spatial association across the MYR cities. Firstly, the Moran Index and the Getis-Ord G statistic are used to detect global autocorrelation and clustering type respectively in the city region. Then, the Getis-Ord Gi* statistic is used to estimate the spatial pattern in local neighbourhoods.[35] The difference between the analysis in this section and the previous subgrouping analysis is that the subgrouping technique takes all selected indicators into account to estimate aggregate spatial characteristics, while the techniques used in this section focus on individual indicators in an inferential sense.

Firstly, the Global Moran Index is used to test whether spatial autocorrelation exists globally in the city region. It is found that labour cost is the only variable that is globally clustered at significance level (see Table 5). It is manifest that cities that have high labour costs tend to cluster while cities that have low labour costs also tend to cluster (see spatial pattern example in Figure 25). Thus, it is postulated that if labour cost is significant to the local economy, its spatial association is likely to influence neighbour cities' economies (to be tested in Chapter 8). In addition, it should be noted that although GDP is not identified at 5 per cent significance level, it is identified negatively at 10 per cent significance level, which suggests a possible dispersal pattern. Given the small dataset (26 observations), due caution in interpretation is required however. It is postulated that there is an economically competitive relationship between neighbouring cities in the MYR city region (also tested in Chapter 8). However, the Moran Index cannot identify the spatial pattern where either high-value clustering or low-value clustering exists. Thus, the Getis-Ord G statistic is employed in the next analytical step.

[35] Local neighbourhood indicates the city group where cities are contiguous to each other at first order (neighbours' neighbour is not included).

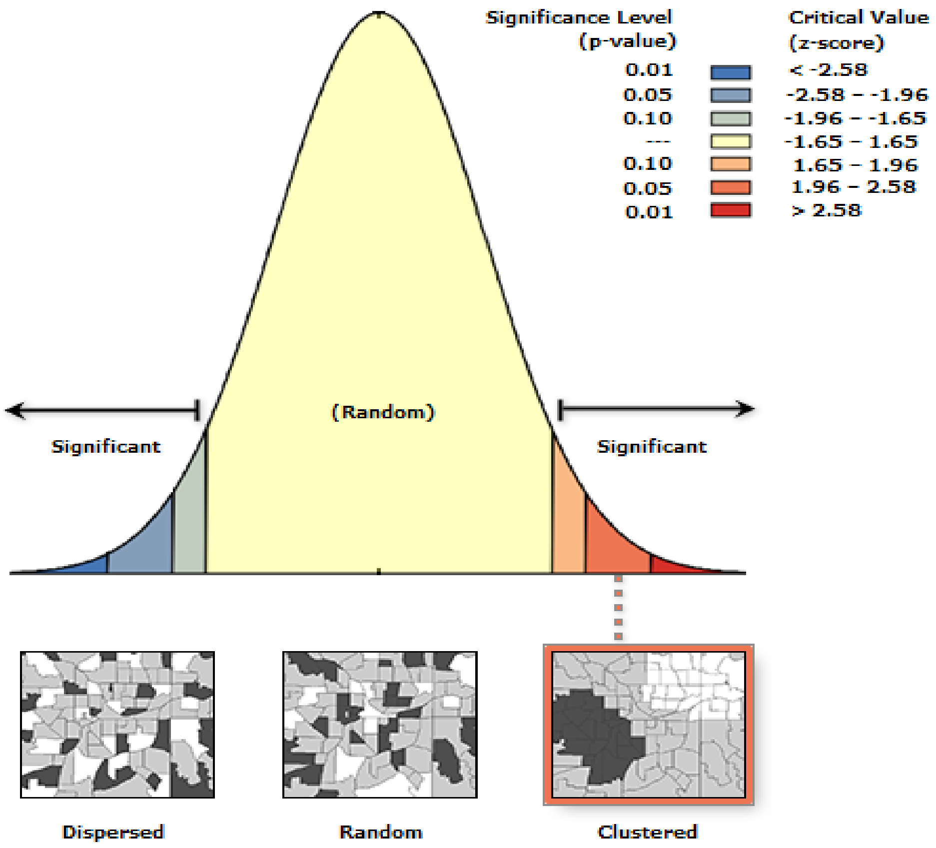

Figure 25 The Spatial Pattern Example Identified in Moran I Statistic at Significance Level.

The results of the Getis-Ord G statistic, find that foreign investments and manufacturing are identified significant positively, which indicates the high-value clustering pattern of these two economic activities (see spatial pattern example in Figure 26). It is therefore indicated that manufacturers and foreign investors tend to cluster in a spatial sense.

Lastly, based on the results of these two estimators, the Getis-Ord Gi* statistic is used to identify hotspot cities and coldspot cities, as shown in Table 5 and Figure 27. It is found that several cities are identified as either hotspots or coldspots, which indicates their spatial heterogeneity compared to others. Specifically, Wuhan and Changsha are the two most prominent hotspots across indicators, while Zhangjiajie shows a less developed status as a significant coldspot. In addition, Nanchang is behind Wuhan and Changsha, showing outperformance across certain indicators at significance level, while Yichang's hotspot status is limited to manufacturing and L&T activities. Generally, the spatial heterogeneity of triad cities detected in the Getis-Ord Gi* statistic resonates with the spatial subgrouping results.

In conclusion, the MYR city region is characterised by spatial association patterns at significance level across certain indicators, which verifies the existence of spatial association to some extent. Meanwhile, several hotspot cities and coldspot cities are identified as significant, which reflects spatial heterogeneity also to some extent.

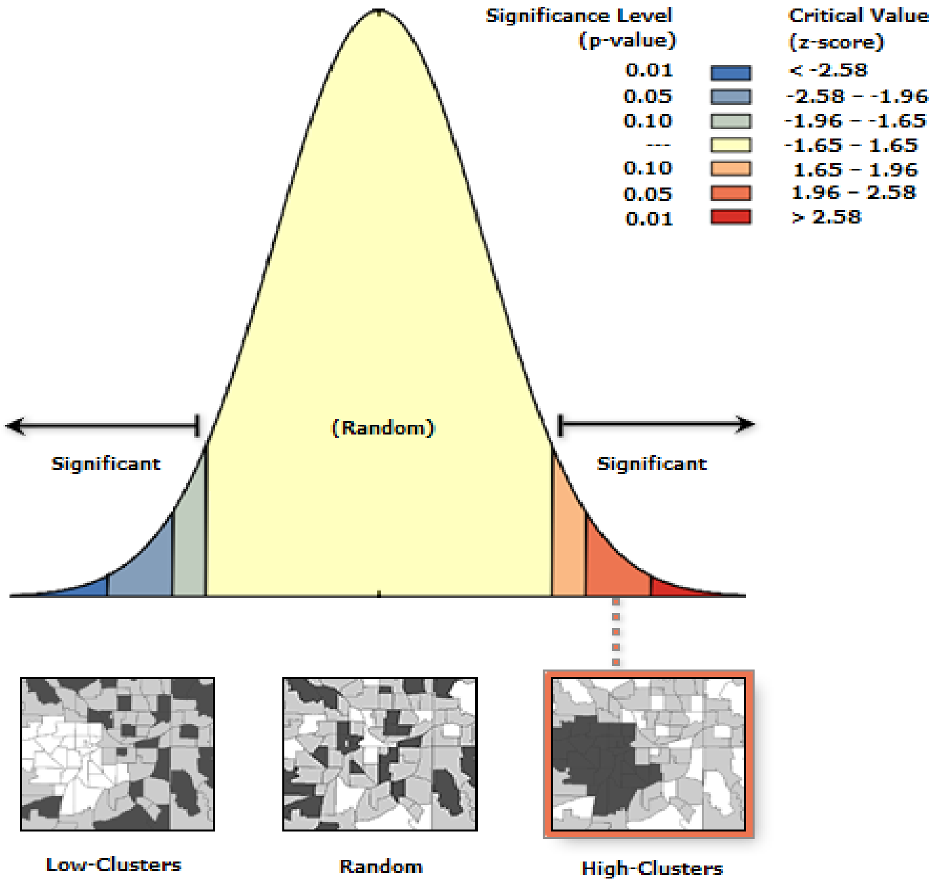

Figure 26 The Spatial Pattern Example Identified in Getis-Ord G Statistic at Significance Level.

Indicators (logged)	Global Moran's I	Getis-Ord General G[36]	Getis-Ord Gi* (hotspots)	Getis-Ord Gi* (coldspots)
GDP	-0.1737	0.02875	Wuhan*, Changsha*	Zhangjiajie*, Huaihua*
GDP capita	0.0692	0.02876	Wuhan*, Changsha*	Shaoyang
Capital Stock	-0.1327	0.02902	Wuhan*, Changsha*, Nanchang*	
Labour Cost	0.2771*	0.02857	Wuhan*, Changsha*	Xianning
Foreign Investment	0.0424	0.02891*	Wuhan*, Changsha*, Nanchang*	None
Technological Advance	-0.1843	0.02934	Wuhan*, Changsha	None
Manufacturing	0.1499	0.03030*	Wuhan*, Changsha, Xiangyang, Yichang	Zhangjiajie*

[36] Since observed General G is very small, decimal is increased by one to indicate number differences.

Financial Services	-0.0824	0.02861	Wuhan*, Changsha*, Nanchang*	None
Real Estate	-0.0252	0.02910	Wuhan*, Changsha*	None
Research Service	-0.0976	0.02899	Wuhan*, Changsha*	None
L&T	-0.0747	0.02850	Wuhan*, Changsha*, Nanchang*, Yichang	None
Human Flows	-0.0037	0.02862	Changsha*, Yongzhou*	Ezhou*, Xinyu*, Jingdezhen
Commodity Flows	-0.1231	0.02871	Wuhan*	Zhangjiajie, Ezhou*, Jingdezhen, Suizou

Table 5 The Results of Spatial Association Analysis (significance level at 0.05) (Source: Author calculations using NBS and SIPO databases).

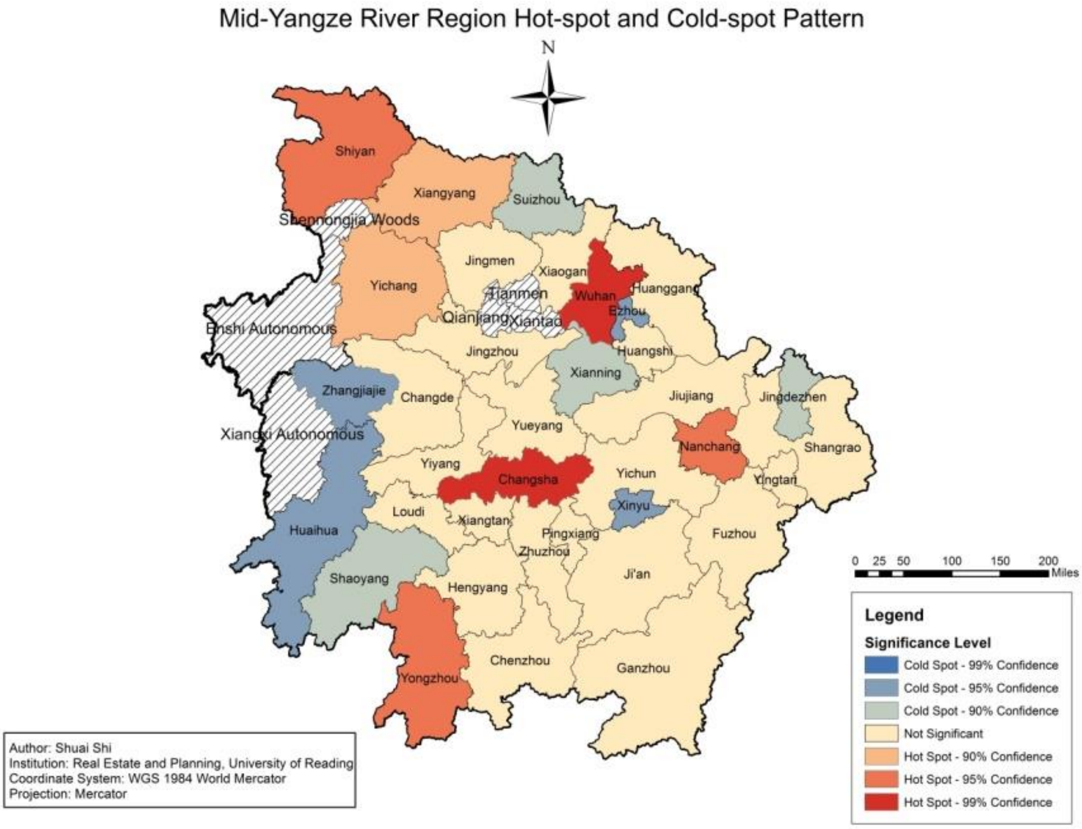

Figure 27 Identified Hotspot and Coldspot Cities across Indicators at Significance Level (Source: Author calculations using NBS and SIPO databases).

6.5 Conclusion and Discussion

This chapter set out to discover the spatial characteristics of the MYR city region economy. As reviewed in Section 3.4, during China's economic transition, the MYR city region has become a strategic region to absorb surplus productivity from the developed east region and to interconnect the developed east and the underdeveloped west in China's national planning policy. Thus, understanding the spatial characteristics of its economic patterns is an important starting point to unveil the underlying driving mechanism of the regional economy. In conclusion, there are two main findings from the chapter: the economic activities in the MYR city region are concentrated in high growth cities and oriented toward different directions to different degrees; spatial association and heterogeneity coexists in the economic patterns identified. These two findings justify the necessity of incorporating spatial factors in the regional growth model in Chapter 8.

Here the specific research questions posed in this chapter are returned to and the research results developed from the general research question 1 presented in Section 5.4 are discussed. The empirical results from the analysis in this chapter only are discussed here, while discussion based on all of the empirical findings is presented in Chapter 9.

First, how are economic activities distributed across cities, concentrated or balanced? In conclusion, the MYR city region is characterised by an unbalanced spatial pattern exhibiting concentration, disparity and orientation, which justifies a salient core-periphery pattern in the city region. It is manifest that economic activities are highly concentrated in the Wuhan-Changsha-Nanchang triad cities, while Yichang is catching up, particularly in manufacturing. Consideration of Gravities, illustrates that economic activities, technological activities and transportation flows are all concentrated in specific MYR areas to different degrees. Specifically, northern cities are generally more developed than others, as is their knowledge stock. Eastern cities are more attractive to foreign investment, while they are less developed in terms of the aggregate economy. This finding could be attributed to the fact that some foreign investors may prefer to target less developed regions where, with few competitors, they can capture market share quickly. Southern cities have a transportation hub function which is important for physical flows. Western cities represent the least developed area of the city region, performing weakly across all indicators. In addition, it is found that knowledge stock, foreign investment and APS are more concentrated geographically than other activities.

Second, how is manufacturing correlated with APS sectors? It is found that manufacturing still has a major part in economic output across the whole city region, while APS sectors are highly concentrated in primate cities, namely Wuhan, Changsha and Nanchang. This finding resonates with Yang and Yeh's (2013) empirical work in which they found that in contrast to manufacturing activities, APS firms are more concentrated in high-tier cities. In addition, they found that manufacturing and APS sectors are not spatially associated in China. They attributed this finding to the internalization of the supply of producer services which are only found in big cities due to their availability of essential resources such as specialised labour, information and knowledge, and a developed financial market. However, manufacturing and APS are highly correlated in the MYR city region, albeit mostly in primate cities. As noted in the literature review, the positive association between APS and manufacturing is expected to be the key to upgrade the industrial base and economic growth of the MYR city region, thus, this finding is a positive signal for MYR city region economic transition and its potential role in wider Chinese economic rebalancing. On the other hand, given the high concentration of APS in the triad cities, policies should recognize the development of APS sectors in MYR and investigate the potential for their emergence in other MYR and Chinese manufacturing cities.

Third, is the MYR city region pronounced in spatial heterogeneity and spatial association significantly? Through grouping analysis, it is found that MYR cities display the coexistence of similarity and dissimilarity at aggregate level. Specifically, the triad cities (Wuhan, Changsha and Nanchang) are more spatially heterogeneous, while similar northwest cities (Yichang, Xiangyang and Shiyan) have potential to form a homogeneous market. However, a concern is that the similarities of cities' economic structures could prompt intercity competition, while the prevalence of spatial heterogeneity could lead to market fragmentation that would be detrimental to regional development. Thus, it can be concluded that policy makers should be encouraged to put forward policies to promote cooperative coordination projects to facilitate market integration for similar contiguous cities and to generate synergy effects for dissimilar cities. In practice, in order to achieve coordinated development, an authorised organization or committee with financial support to promote strategic policy for sub-regional administrative divisions should be established to replace quangos supporting ad hoc cooperative ventures. Lastly, several hotspot and coldspot cities are identified across several indicators, which reinforces the spatial heterogeneity of these cities in their neighbourhoods. In addition, knowledge-related activities (patents and research services) and real estate activities are the most important contributors to spatial heterogeneity, which should therefore draw attention in the policymaking process.

In terms of spatial association, it is found that clustering patterns across certain indicators are pervasive in the MYR city region. Specifically, labour cost, foreign investment and manufacturing are significantly pronounced in spatial association, which indicates their clustering tendency and possibly the spatial relationship between neighbouring cities. In other words, manufacturers and foreign investors have potential to take advantage of positive spillovers if they locate their operations in or near to corresponding high growth cities, such as the triad cities and Yichang. Given the importance of manufacturing and foreign investment for China's economy, policies to upgrade the business atmosphere and infrastructure in these high growth cities to enhance their attractiveness both to manufacturers and foreign investors, may be important for the achievement potential associated added value. Furthermore, economic actors located near to these high growth cities could take advantage of associated potential positive spillovers. For example, Yueyang is not only host to geo-gravity and several weighted gravities (see Figure 18) but is also contiguous to Changsha, which indicates that economic actors in Yueyang could invest in proximate cities to benefit from positive spillovers from high growth in Changsha simultaneously. Thus, for economic actors, Yueyang stands out as a potentially outstanding location for logistics, trade and back offices *ceteris paribus*. Local government upgrading of related infrastructures in Yueyang to provide an attractive business environment could potentially attract economic actors with this interest in mind. On the other hand, the western cities (Zhangjiajie, Huaihhua and Shaoyang) in the least developed MYR area may have a high likelhood of experiencing negative spillover effects. Local governments in these western cities would be advised to incorporate network thinking in creating policies to counter such effects by encouraging trans-boundary interactions with high growth or hub MYR cities. In general, the findings support the need to explore inter-city network relations without spatial constraints, which is the focus of analysis in the next chapter.

In conclusion, by addressing the specific questions posed in this chapter, the findings verify general Hypothesis 1 presented in Chapter 5 '*spatial association and heterogeneity co-exist in the MYR city region*, and justify the necessity of incorporating spatial factors in a regional growth model in Chapter 8. Furthermore, the findings shed light on the spatial complexity of the MYR city region economy, which is a reason to borrow from the CAS paradigm to develop in depth understanding of the MYR city region system in Chapter 9. However, it should be noted that the coexistence of spatial heterogeneity and association cannot guarantee actual causal effects influencing underlying economic-spatial processes or spatial causality relationships. This limitation is one of the main research motives to build the spatial growth model in chapter 8, however, the findings from this chapter provide some preliminary insights for economic actors and policy makers, and can contribute to the interpretation of the results of the spatial growth model.

Summary Points:

1. The MYR city region is characterised by an unbalanced spatial pattern with concentration, disparity and orientation.
2. The spatial patterns of manufacturing and APS sectors are spatially correlated regardless of the highly concentration of APS sectors in primate MYR cities.
3. The coexistence of spatial association and spatial heterogeneity is verified in the spatial regime of the MYR city region.
4. It is postulated that spatial effects are affecting the underlying spatial regime of the MYR city region economy.

7. NETWORK CAPITAL IN REGIONAL DEVELOPMENT

7.1 Introduction

The ‘network’ concept is associated with the rise of the ‘information age’ and ‘network society’ in late twentieth century at different scopes and geographical scales (Castells, 1989, 1996). Under conditions of globalisation and the advance of telecommunication technologies, ties between individuals, economic actors, companies and institutions become unprecedentedly intense and intricate, leading to the formation of complex networks between spatial units at different scales, such as cities, regions, countries and trans-nationally. Consequently, in the contemporary era of world urbanisation, major centres of population and economic activities are frequently identified in research literature in terms of their roles and positions in cross-territorial relational networks. As discussed in Chapter 5, extensive city regions that are strongly connected to global networks by various actors and institutional relations have become seen as the new engines of the global economy (Scott, 2001a, 2001b). More importantly, the network concept is not only about the underlying patterns or structures that denote the panorama of actors’ strategic positions, but also about the feedback effects on the opportunities and constraints of actors’ behaviours. Strategic but generally intangible ‘network capital’ unintentionally generated by such actors and institutional relations, which is a feature of inter-city networks, is therefore commonly perceived as boosting the economic competitiveness of cities, regions and countries (Mahroum *et al.*, 2008; Pain *et al.*, 2016). However, mainstream network capital studies have commonly focused on individual actors or organizations (see Light, 1984; Zimmer and Aldrich, 1987; Bates, 1997; Singh *et al.*, 1999; Hoang and Antoncic, 2003; Huggins, 2010; Huggins and Johnston, 2010; Kimino *et al.*, 2014). Few studies have explored the concept of network capital in a spatial or territorial context. This chapter attempts to fill this gap in network capital studies in relation to urban and regional spatial economy dynamics in the MYR city region.

Since network capital comes into being gradually through the accumulation of human and institutional interactions over time, there is no simple capital network input-output equation to aid city region analysis. Therefore, in order to shed light on the city region economy associated with network capital, the analysis in this chapter focuses on cities as the ‘nodes’ in networks and finance capital mobility as generating the ties that construct network space. According to the framework of calculative network capital reviewed in Chapter 5, Mergers & Acquisitions (M&A) financial deals are selected to represent capital mobility between cities based on four distinctive M&A characteristics:

- M&A deals per se concern large financial capital flows with few spatial constraints, which resonates with space of flows theory.
- In contrast to one-off trade deals, M&A deals are characterized by control transfer and long-term interactions associated with the cumulative process of network capital development.
- M&A activity is characterized by intensive interactions and valuable spillovers such as information exchange, technique sharing, elite communications and management learning (Freeman, 2004), which underpins the significance of network capital.
- M&A deals not only operate between target and acquirer companies but are also associated with APS, including financial services, accountancy, law, consultancy etc., which contribute to and add value to network capital (Sassen, 1991). As discussed in Chapter 5, APS firms also have an important role in the generation of network relations between cities (Castells, 1996).

However, despite the advantages of M&A deals as a metric that can represent significant inter-city ties associated with capital flows, most M&A studies focus on the operation of deals and their effects on the financial performance of firms. At the same time, network capital analysis is generally limited to the study of dyadic relationships between acquirers and targets. In consequence, the focus of this chapter is on M&A deals as network ties and cities as network nodes in order to shed light on a multi-directional inter-city network.

China is of particular interest with regard to city network capital due to its extraordinary economic growth rate accompanying its major urbanisation during the past three decades. Krugman (2011) noted the contrast between the emerging location patterns in advanced economies of the world and those of China where ongoing high manufacturing production, per capita GDP and regional differentiation are ‘a clear cousin to the emergence of the U.S. manufacturing belt in the 19th century’ (p. 6). Nevertheless, under open door policy, China’s development has undergone dynamic changes, characterized in the twenty first century by pioneering entrepreneurship, supported by strong governance and strategic planning (He, 2009). Even so, a slow-down in China’s growth rate since 2010, rising labour costs, and strong competition from other emerging economies, require national economic structural adjustment and transition from China’s traditional manufacturing base to a high-value advanced manufacturing and services economy. As reviewed in Chapters 3 and discussed in Chapter 6, a series of national strategic plans introduced, aims to transfer traditional manufacturing and surplus productivity in the east of China to the MYR city region in order to maximize growth and reduce national economic risk. Researching the phenomenon of network capital formation in the MYR city region is of interest in considering emerging network patterns associated with city region transition from an emerging to an advanced economy.

In conclusion, this chapter is designed to address general research question 2: What is the calculated network capital embedded in the MYR inter-city capital flows network? The general research question is divided into four specific questions in this chapter. Specifically, how is the MYR inter-city network established through cumulative capital flows? What are the overall patterns and subgroups of the MYR inter-city network? How is network capital distributed across cities through network positions? How do economic actors take advantage of network capital to distribute their resources and extend their influence practically? In terms of the chapter structure, the first section explains the rationale of calculative network capital and its association with M&A projects. The second section presents the data source and the calculation methods of network capital. The third section illustrates the results concerning the network dynamics, overall structure and cities’ individual network capital. The concluding section discusses the findings and suggests how they can inform the strategies of governments and institutional actors.

7.2 Calculative Network Capital in M&A Projects

As discussed in Chapter 5, markets stem intrinsically from networks in which ideas, thoughts, innovations and learning are generated and shared (Powell *et al.*, 1996; Glückler, 2007), whilst building collaboration networks across territories is a significant pipeline to upgrade knowledge stock, driving regional development as an outcome (Powell et.al., 1996; Nicolini *et al.*, 2003; Bathelt *et al.*, 2004, Mahroum *et al.*, 2008; Huggins and Thompson, 2015). In addition, Rodriguez-Pose (1999) articulated that network capital exists in established economic networks through cumulative interactions instead of temporal partnership contracts. Thus, investigating established networks across territories is meaningful to shed light on spatial-economic dynamics.

However, estimating network capital is generally limited to illuminating social capital by the investigation of social interactions and personal contacts. As Huggins (2010) argued, focusing on firms' social capital may easily distort real economic expectations of networked firms and fails to unveil underlying network capital. An overemphasis on social capital studies can wrongly imply that network capital is fully explained by social capital in inter-city networks, ignoring more formal and reliable flows (such as M&A deals) and flow network characteristics (multi-directionality and indirect-connectedness). As discussed in Chapter 5, in order to fill this analytical gap, the notion of calculative network capital under economic globalisation and capital financialization is proposed in order to highlight the network positions of cities that are determined by dynamic, multidirectional, and borderless inter-city flows and their attributes (Huggins, 2010; Huggins and Johnston, 2010; Kramer *et al.*, 2011; Kramer and Diez, 2012; Smith *et al.*, 2012). In terms of methodology, as argued in Section 5.3, SNA is employed to dig into city network positions and network patterns in this chapter which puts attention on the multi-directionality of linkages and the structural positions of (city) nodes. When SNA methods are applied in a spatial sense, it is possible to investigate how cities, as active nodes, operate in the network of cities where cities are interconnected via various economic ties in the era of globalisation.

As discussed in the previous section, M&A flows are selected to construct the inter-city network due to their resonance with the calculative network capital discourse. Associated with deepening globalisation and the rise of the knowledge economy, M&A projects across territories are not only launched for traditional reasons e.g. asset reallocation, market expansion, business diversification, production synergies and R&D upgrading (Harford, 2005), but are also launched to leverage soft assets, such as knowledge stock, human resources, core technologies and privileged information (Lee and Lieberman, 2010; Stettner and Lavie, 2014). In network space, compared to greenfield investments[37] that lack information and technology exchange with external entities and financial investments

[37] Greenfield investments are those investments in which parent companies start up entirely new ventures in new places beyond headquarters by developing new operational facilities from the ground up.

that lack engagement with daily operations, M&A projects more explicitly reflect capital mobility across territories and underlying long-term elite interactions, technology sharing, production and management mode learning etc., which add increased value to calculated network capital.

However, most M&A related studies have concentrated on the operations of M&A deals themselves and bilateral relationships at the organizational level, such as deal evaluation, integration, managerial shift, HR management, synergy operations, monitoring, post output, and local drivers to attract M&A deals, but ignore their aggregate mobility across territories. Havila and Salmi (2000) argued that M&A deals could change the pattern of business networks, and they found that M&A deals have interlocking effects on third parties and distant actors, transcending solely acquirer-target bilateral relationships. Although their work inspired cross-territorial thinking in M&A studies, the interlocking effect they emphasized is essentially derived from the chained value-added process in GPN but lacks network capital thinking which is based on multi-directional flows across territories. As Böckerman and Lehto (2006) argued, in addition to organizational factors, spatial factors are also significant to influence the quality of M&A projects in value evaluation, monitoring, sharing assets and synergy operations. Furthermore, Rodríguez-Pose and Zademach (2003) looked at the spatial pattern of German M&A deals, and found that M&A deals were highly concentrated in leading city regions, driving local economies as an outcome. In addition, in the process of M&A concentration, they found that spatial proximity still plays a significant role in the choice of target companies especially within the same city regions, interlinking cities within these city regions. In conclusion, M&A projects not only represent capital mobility across organizations but also generate aggregate capital flows and spillovers in a spatial sense, and the network capital derived from these flows is relatively concentrated within a city region.

Compared to developed economies, M&A studies on developing countries and their city regions are still deficient. China, as the biggest emerging economy, is upgrading from a ‘brain drain’ to a ‘brain circulation’ economy through trans-boundary interactions, such as trade, investments, knowledge exchange and learning, information exchange, elite communications etc. (Saxenian, 2005). Empirically, the network capital in the urban system is identified in China through analysing formal partnerships at an organizational level (Luo and Shen, 2009), APS office connectivity (Derudder *et al.*, 2013), and professional and personal contacts (Wong and Salaff, 1998; Tung and Worm, 2001).

However, there is a lack of studies concerning aggregate capital flows across territories using network thinking at a city region scale. Therefore, this chapter aims to complement both network capital discourse and city region research, and may provide helpful guidance for economic actors and urban planners to facilitate city region development.

Based on the literature reviewed, the conceptual framework of the network research in this chapter is illustrated in Figure 28.

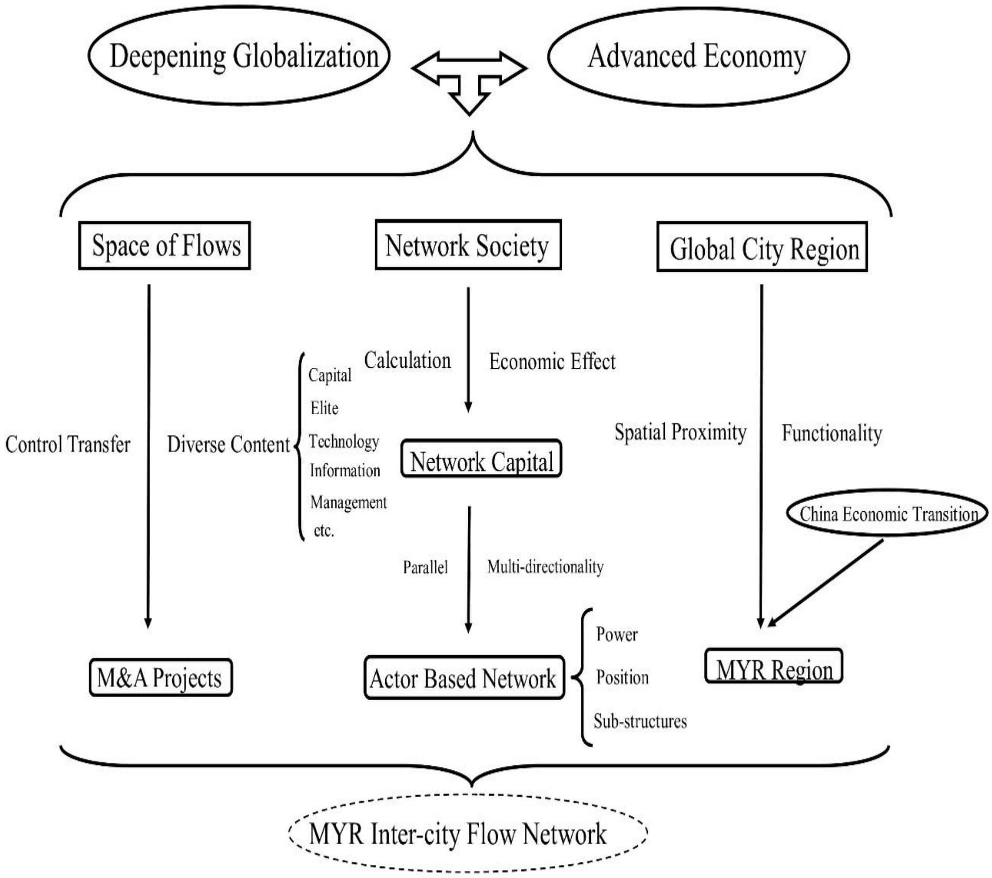

Figure 28 The Conceptual Framework of Network Capital Analysis in the MYR City Region.

7.3 Data and Methodology

M&A data are derived from the Zephyr database, supported by Bureau von Dijk, which includes the most comprehensive worldwide M&A deals and is updated hourly. Given data availability, data from 2003 to 2014 are selected for the present analysis to establish the inter-city network, including source and target companies, source and target cities, deal types and values,[38] and industrial classifications. Since the chapter examines the inter-city network within the MYR city region, M&A deals transcending the geographical scale of the region are excluded. Specifically, 1238 M&A deals from 2003 to 2014 involved 42 cities[39] in the region, forming a city-by-city one-mode network. All deals are valued above 1 million Chinese Yen. Deal types include mergers,[40] acquisitions, minority stake (>2 per cent), and capital increase. The key criterion for inclusion of deals in the analysis is that they involve the transfer of a business and operations in the M&A process. Geocoding provides the locations of target and source companies respectively, which identifies the source and target cities of M&A deals. In terms of sectoral distribution, as shown in Graph 7 and Graph 8, the top ten sectors are fixed in terms of both target and acquirer companies. The top ten sectors are from industrial manufacturing (*Industrial, Electric & Electronic Machinery, Metals & Metal Products,* and *Chemicals, Petroleum, Rubber & Plastic*), APS sectors (*Property Services*, *Banking*, and *Insurance & Financial Services),* and *Life Sciences* and *Wholesaling & Retailing*.

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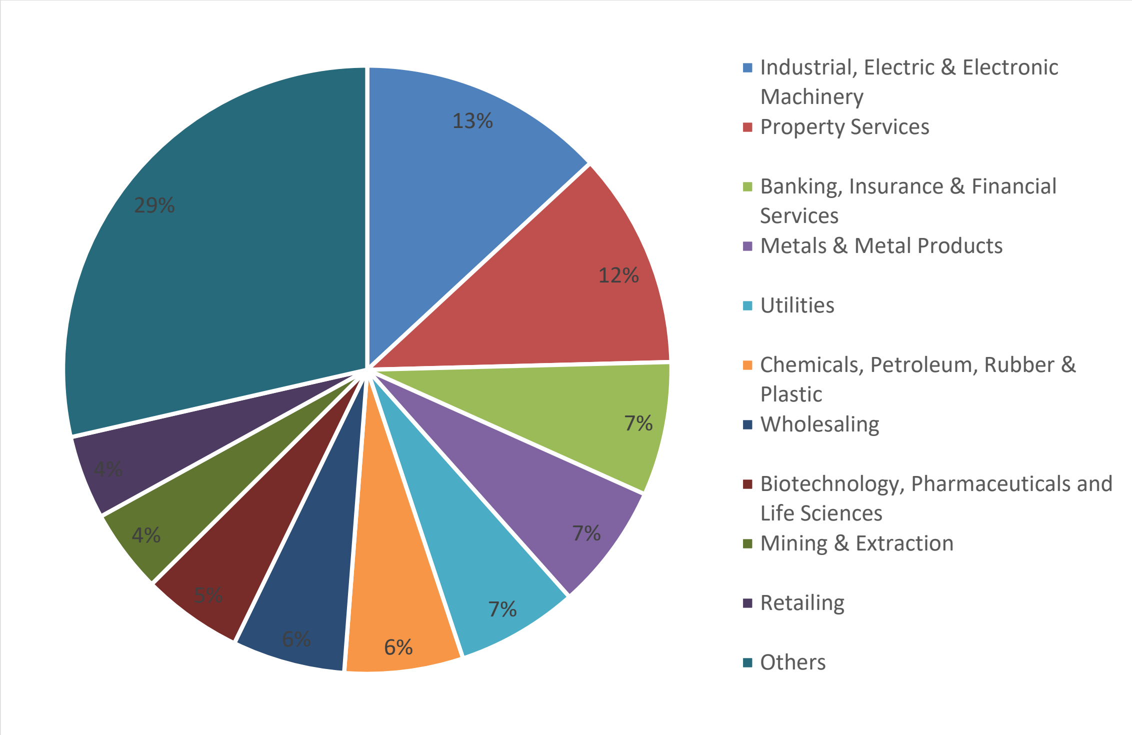
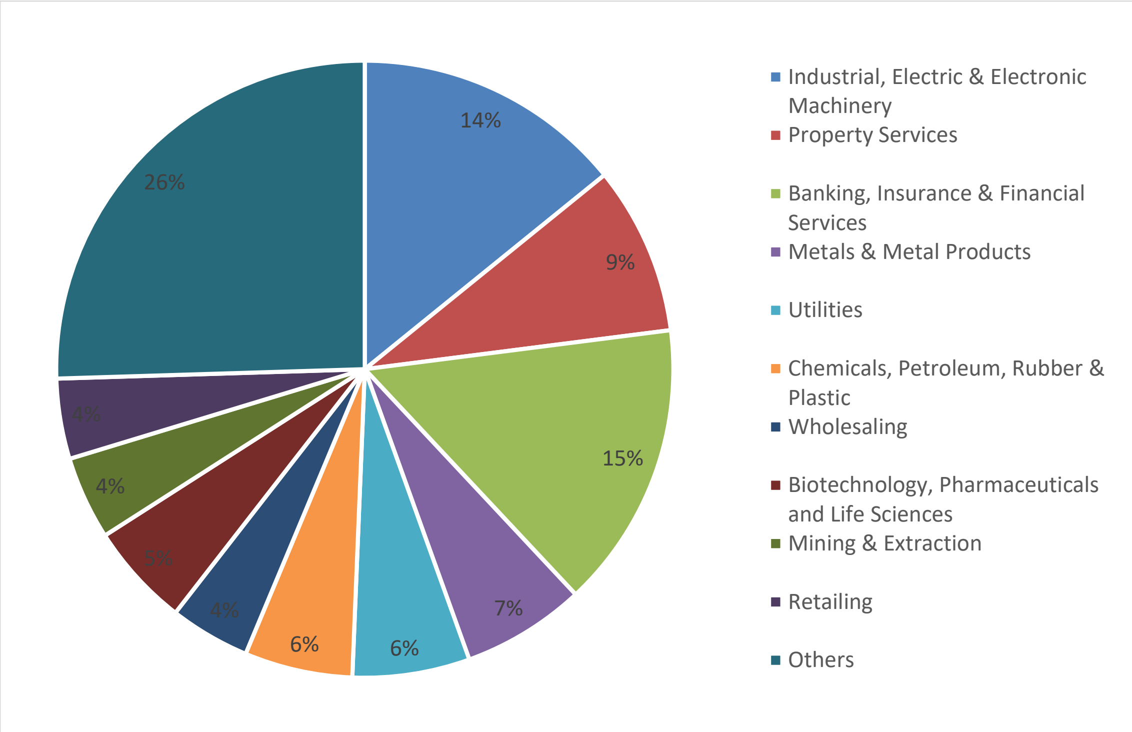
[38] Since M&A projects have several attachments besides capital, M&A deal value is not used as the strength of linkage.

[39] Six cities that are missing in the NBS dataset are available in this dataset, including Xiangxi autonomous city, Enshi autonomous city, Shennongjia woods area, Qianjiang city, Tianmen city and Xiantao city.

[40] In this chapter, the alleged merger deals that are not one-for-one share swap are counted as acquisition deals.



Graph 7 Sectoral Distribution of M&A Target Companies (source: Zephyr).



Graph 8 Sectoral Distribution of M&A Acquirer Companies (source: Zephyr).

In terms of SNA methodology, first, the Force Atlas algorithm (see Jacomy *et al.*, 2014) is used to create a dynamic map to shed light on the evolving process of city region network development. As Noack (2009) argued, the position of a node cannot be interpreted on its own but instead has to be compared with others. The Force Atlas algorithm simulates a physical system where nodes repulse each other and ties attract their nodes in order to spatialise a network. It uses the repulsion formula of electrically charged particles and the attraction formula of springs to calculate the relative distance between nodes. In the force-directed layout[41] calculated by the Force Atlas algorithm, nodal mass creates a repulsive force, ties create an attractive force, and gravity attracts nodes to the centre of the spatialisation space in case isolated nodes drift away (see Noack, 2009). In the end, these three forces converge to place every node in a relative position and turn structural proximities into visual proximities. Formally, it is written as:

$$F_r(n_1, n_2) = k_r \frac{(\deg(n_1)+1)(\deg(n_2)+1)}{d(n_1, n_2)} \quad (1)$$

$$F_a(n_1, n_2) = \log(1 + d(n_1, n_2)) \quad (2)$$

$$F_g(n) = k_g(\deg(n) + 1)d(n) \quad (3)$$

Where F_r is the repulsive force; F_a is the attractive force; F_g is the gravity force; k_r is the constant which adjusts the scaling to provide clear mapping; k_g is the gravity constant attracting nodes to the centre. The balanced state is approached through a stepwise simulation of the forces. The force atlas algorithm tackles the temperature problem[42] by calculating each node's oscillations and global oscillation, and computing an optimal step length[43]allowing a certain amount of oscillations. As argued by Jacomy *et al.* (2014) in relation to sensitivity analysis, the tolerance for oscillations is set as 0.01 to obtain optimal performance.

Second, in order to address the question how cities are embedded in network space and generate network capital, SNA centrality analysis is employed to estimate the global structural characteristics of the network and the positions of cities. Thus, the SNA centrality analysis in this chapter is comprised of global centrality analysis and nodal

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[41] The force-directed layout is the visual layout of the nodes that are placed depending on the ties between nodes in order to denote structural densities, regardless of nodes' attributes (Noack, 2009).

[42] In the process of the simulation, some nodes are unable to find a stable position and start oscillating around their balancing position, which causes high 'temperature' problem and defers the convergence.

[43] The nodes with different linkages have different frequencies in oscillation. Highly connected nodes tend to oscillate quickly, and require more steps to converge, and vice versa.

centrality analysis. Global centrality algorithms, including Average Path Length[44], Density[45], Modularity[46], Multi-dimensional Scaling (MDS)[47], and Average Clustering Coefficient[48], are adopted to estimate global centrality, which determines the global network structure, as formally specified below.

Modularity is the fraction of the edges that fall within the given groups minus the expected fraction if edges were distributed randomly (see Newman (2008) and Blondel *et al.* (2008)). More formally, in a network of L edges and N nodes, the modularity M are formulated as:

$$M = \sum_{i=1}^{c} \left(e_{ij} - a_i^2\right) \tag{4}$$

$$e_{ij} = \sum_{vw} \frac{A_{vw}}{l_n} l_{v\in c_i} l_{w\in c_i} \tag{5}$$

$$a_i = \frac{k_i}{l_n} = \sum_j e_{ij} \tag{6}$$

Where e_{ij} is the fraction of the edges whose two nodes belong to subgroup i and subgroup j separately, and a_i is the ratio of the edges of subgroup k_i to the total edges l_n, and A_{vw} is the adjacency matrix of node v and node w.

MDS is an explorative method used to unveil the underlying network patterns under conditions of fewer observations, dimensions, and cognitive interpretation. Distinct from Principle Component Analysis (PCA) which is more suited to the analysis of attribute datasets, MDS does not require correlations but only similarity or distance. In addition, distinct from the subgrouping method (modularity) which uses eigenvalue as the grouping criterion, MDS does not have a predefined group number but focuses only on cognitive/perceived differences. In particular, the subgrouping method may put a high-

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[44] The average of the sum of geodesic paths in a network. Average distance C(D) is the total distance of geodesic paths D divided by the sum of all pairs of vertices,
$C(D) = \frac{D}{n^*(n-1)}, D = \sum_{s\neq t\in V} d_{st}$.

[45] A ratio of all actual ties to all possible ties in a network. Fully saturated network is the term that describe the statement that all logically possible ties are present in a network.

[46] The modularity algorithm is an unbiased measure, proposed by Newman (2006), to identify subgroups where internal linkages are denser than external linkages.

[47] MDS evaluates cities' structural equivalence based on the functional distance matrix.

[48] Average clustering coefficient is the average of the sum of all nodes' clustering coefficient in order to investigate global cohesion.

dimensional sample into a one-dimensional spectrum/pattern division, which results in an over-simplification or bias in data analysis. MDS aims to put high-dimensional observations into a lower dimensional space in the sense of approximation, in order to find an optimal clustering pattern. In the MDS layout, the structural similarity of nodes determines the relative distance between nodes using a Stress Minimization algorithm to improve the precision of results (a lower stress score indicates higher accuracy of clustering results). Since a higher-dimension is difficult to interpret, a two-dimension-scaling space is normally used for optimizing the node's locations in a scatterplot (Borg and Groenen, 2005). In terms of the reliability of results, therefore, the stress St is formulated in two dimensions as:

$$St = \sqrt{\frac{\sum\sum\left(f(x_{ij})\text{-}d_{ij}\right)^2}{2}} \tag{7}$$

Where d_{ij} is the Euclidean distance between node i and node d, $f\left(x_{ij}\right)$ is the function of input data to keep stress value between 0 and 1. The optimal stress is zero when the MDS map perfectly reproduces input data. However, the distance between nodes within clusters cannot be trusted since the exact placement of nodes within a tight cluster has little effect on overall stress, and so may be quite arbitrary.

After investigating global network patterns, the positions of nodes are examined by calculating their degree,[49] Betweenness, closeness, clustering coefficient, PageRank (PR), and Hyperlink-Induced Topic Search (HITS). In terms of degree**,** nodes with a high in-degree are prestigious in a network, while nodes with a high out-degree are generally regarded as influential nodes.

Betweenness is an advanced algorithm used to investigate the structural positions of cities by measuring how frequently a node (city) appears on the geodesic paths between other nodes (cities) in the network. It represents the 'brokerage' or gateway position of a node (city) in the network. More formally,

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}} \tag{8}$$

[49] Degree index calculates the number of the linkages that nodes connect. In a directed network, in-degree calculates the number of the linkages that nodes receive, while out-degree calculates the number of the linkages that nodes originate.

where σ_{st} is the total number of geodesic paths from node s to node t and $\sigma_{st}(v)$ is the number of shortest paths passing through node v.

Closeness indicates the reciprocal of the sum of a node's functional distances from all other nodes. It serves as a gauge for how closely related nodes (cities) are in a network, and it is therefore an indicator of functional 'clustering'. In addition, compared to the clustering coefficient which investigates the neighbourhood of nodes, closeness is an estimation of the global clustering of nodes. More formally,

$$C(x) = \frac{1}{\sum_y d(y,x)} \tag{9}$$

Where $d(y, x)$ is the shortest functional distance between node x and all other nodes y.

Calculating the clustering coefficient is a bottom-up method, investigating the clustering degree of each node's local neighbourhoods. In node i's neighbourhood, if its neighbours also have links with each other, then the clustering coefficient is one, which denotes the perfect complete network. The high clustering score indicates good signal of neighbourhood cohesion. However, on the other hand, if node i has many neighbours, but its clustering coefficient is low, that means node i is a star node in its ego network. It is formulated as:

$$C_i = \frac{2e_i}{k_i(k_i\text{-}1)} \tag{10}$$

Where e_i is the number of the edges between node i's neighbours and k_i is the number of i's neighbors. The average of the nodes clustering coefficient is used to estimate the global clustering for the whole network.

The HITS algorithm developed by Kleinberg (1999) and originally used in Internet Web page rank evaluation is applied in the present city region analysis to explore the hub and authority positions of cities. The HITS metric determines two values for a node: its authority and hub values. The rationale is that some Web pages are portals that direct users to other pages, denoting a hub function, while some web pages like authoritative sites are directed by many hubs, which denotes their higher authority. Nodes with few linkages may also be authoritative if their linkages are from significantly important hubs, and vice versa. The reasoning applied in the case of Internet Web page links has relevance for the analysis of inter-city network flows. In the inter-city MYR network analysis, a high hub score indicates the advantages of cities in transmitting investment information and circulating capital etc., while a high authority score indicates a city's individual value or attractiveness to hub cities.

Authority and hub values are computed through iterative mutual recursion to the convergence between hub and authority weights (the stopping criterion used is 0.0001). Thus, in the HITS algorithm, there are no cities with overlapping roles signifying outperformance in both hub and authority. Use of the algorithm thereby illustrates the different relative network positions of cities. However, in comparison with the PR algorithm, the HITS algorithm focuses on only a subgraph consisting of the most relevant city nodes and the linkages between them as opposed to all nodes. Therefore, in the MYR network, only Fuzhou is left out of the subgraph since the city has no ties or only a self-loop. Formally, the authority score i_k and the hub score j_k are formulated in equation (11) as:

$$\begin{cases} i_k = (A^t \cdot A) \cdot i_{k-1} \\ j_k = (A \cdot A^t) \cdot j_{k-1} \end{cases} \tag{11}$$

$$\text{where } i = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}, j = \begin{bmatrix} h_1 \\ h_2 \\ \vdots \\ h_n \end{bmatrix},$$

so the initial weight matrix is:

$$i_0 = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix} \text{and } j_0 = A^t \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}$$

Iterations are updated as:

$$\begin{cases} i = A^t \cdot j \\ j = A \cdot i \end{cases} \tag{12}$$

Where i is the authority weight vector and *j* is the hub weight vector. A is the adjacency matrix of focused subgraph G, A^t is the transpose of A. k is the number of steps to reach convergence.

PR is a variant of eigenvalue centrality[50] developed by Brin and Page (2012) and used by Google Search to rank websites. PR counts the number and quality of links to a Web page to determine a rough estimate of how important a website is, and therefore its attractiveness to Internet users in capturing information. Unlike HITS which produces two separate scores, PR is an advanced algorithm estimating how likely it is that a particular page will be clicked on by users randomly, indicating general attractiveness. Analogously, in the MYR network, the PR algorithm can estimate the likelihood of cities being interconnected by random investors via M&A deals, which expresses their urban attractiveness to investors. Google has ceased to use the algorithm due to the development of new advertisement applications that diminish its accuracy, however the MYR city region has a much smaller population size and M&A data are based on actual deals safeguarding measurement accuracy in the calculation of urban network capital by using PR.

In applying the PR algorithm, nodes are first assigned the same initial likelihood ratio, or the inverse of the number of nodes. When there are no ties in the network, the likelihood of each city in the MYR city region receiving an M&A deal is therefore 2.38 per cent. This is formulated in equation (13) as:

$$\mathrm{P(i)} = \sum_{\mathrm{j} \in \mathrm{B_i}} \frac{\mathrm{P(j)}}{\mathrm{L(j)}} \tag{13}$$

Where $\mathrm{P(i)}$ is the likelihood of node i being connected, B is the set of nodes that have outbound links into i, $L(j)$ is the number of node j's outbound links. However, in reality, investors may not continue to make investments through a connected path to the end, so they are assumed to stop investing within a certain number of steps. Therefore, a damping factor is used to simulate the likelihood of investors continuing to invest via the cities they have already invested in. Due to related empirics (Brin and Page, 2012), the damping factor is generally set as 85 per cent in Web page analysis, which means that users have an 85 per cent possibility of entering the next page via the hyperlink of the last page. Since this damping factor is based on analysis of low cost hyperlink clicking, for analysis of high cost M&A deals, the damping factor d is adjusted to 50 per cent. Further empirical studies

[50] Eigenvector centrality is a measure of the influence of a node in a network. It assigns relative scores to all nodes in the network based on the concept that connections to high-scoring nodes contribute more to the score of the node than equal connections to low-scoring nodes.

are better equipped to conduct sensitivity analysis for deciding the damping factor. However, the willingness of investors to continue an investment is hardly ever estimated and more qualitative research is needed. The formula of the likelihood of reaching node i is developed in equation (14) as:

$$P(i) = \frac{1\text{-}d}{n} + d\left(\sum_{j \in B_i} \frac{P(j)}{L(j)}\right) \tag{14}$$

Through subsequent iterations, the PR computation converges after k steps when the likelihood of reaching node i at step k+1 is approximate to the likelihood of reaching node i at step k within criterion statistic ε, as formulated in equation (15). When the difference between the likelihood of reaching node i at step k+1 and the likelihood of reaching node i at step k is less than ε, the iterations stop and PR is converged (see equation (17)). Here ε is set as 0.001. Therefore, the likelihood of reaching node i at step k+1 is formulated in equation (15) as:

$$P(i, k+1) = \frac{1\text{-}d}{n} + d\left(\sum_{j \in B_i} \frac{P(j,k)}{L(j)}\right) \tag{15}$$

Since PR is a dominant right eigenvector of the modified adjacency matrix, in matrix notation, this is formulated in equation (16) as:

$$P(k+1) = dM_{ij}P(k) \cdot \frac{1\text{-}k}{N} \cdot 1 \tag{16}$$

$$\text{where matrix } M_{ij} = \begin{cases} \frac{1}{L(j)}, & \text{if j links to i} \\ 0, & \text{otherwise} \end{cases}, P(k) = \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_k \end{bmatrix}$$

Iterations converge until:

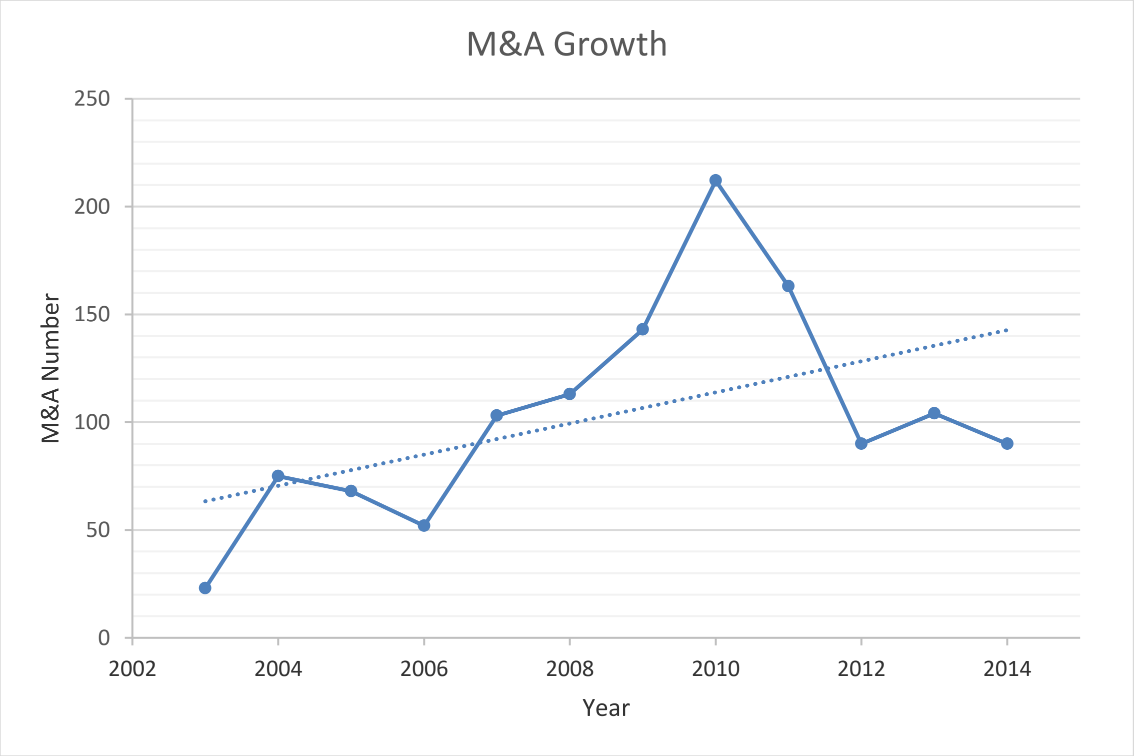
$$|P(k+1)\text{-}P(k)| < \varepsilon \tag{17}$$

Use of the PR algorithm also has value in city region economic analysis since cities with high PR scores can be expected to attract the attention of investors. Unlike simple indegree, which indicates current prestige, PR can therefore potentially reveal the likelihood of a city receiving investments based on the simulation of capital mobility across territories. In addition, the PR method reflects the interlocking effect of M&A flows by continuing investments (indirect-connectedness characteristic of the inter-city network), which reinforces its implications for shedding light on network capital in the MYR city region.

7.4 Results

7.4.1 Network Evolution Atlas

Firstly, as shown in Graph 9, it can be seen that M&A deals have grown continuously since the year 2003, peaking in 2010 and followed by a recession period until 2014. However, the M&A growth line does not reveal the relative strength of cities and the interactions between them that are the focus of this chapter.



Graph 9 M&A Projects Growth over 2003-2014 in the MYR City Region (source: Zephyr).

Associated with the characteristics of M&A deals and their long-term effects such as capital movement, R&D synergy, technology sharing, and HR communication, the development of the network as a cumulative process is examined. The Force Atlas is mapped to illustrate the cumulative process and the interaction of cities driven by repulsive and attractive forces in order to capture the underlying pattern of the MYR network development (see Figures 29 to 31 and video in the dissertation supplementary materials).

Generally, it can be seen that there are two distinctive phases in the process of MYR network development: an endogenous phase and an interactive phase. The first phase is characterized by endogenous reinforcement and limited inter-city ties, while the second phase is characterized by the simultaneous process of both reinforcing subgroups and rising distant ties across subgroups. As shown in Figures 29 to 31, the network patterns in 2006, 2010, and 2014 represent distinctive phases during the network evolution process. In the endogenous phase, most ties originate from core cities (Wuhan, Changsha, Nanchang) and most trans-boundary ties are in the same sub-regions (as shown in Figure 29), which is characterized by a star network pattern. There are few ties among medium size cities[51] especially across sub-regions and there are several isolated cities in the city region periphery. During the first phase, the ties between medium size cities are increasing and isolated cities are decreasing, but this process is confined within the sub-regional boundary and is evolving slowly, which illustrates a gradual reinforcement of sub-regional networks. In the interactive phase, the reinforcement of the sub-regional network continues while the ties between medium size cities rapidly become more intense, which indicates the transition from a star network to a centralized network, with most resonance in the year 2010. Although the incremental volume of M&A decreased after 2010, M&A deals have a more trans-boundary tendency and are in the main no longer limited to prime cities (as shown in Figure 30). Lastly, Figure 31 illustrates the final pattern of the MYR network in the year 2014 and shows that regardless of cohesive sub-regional networks, the whole MYR network has become more integrated than before, which is characterized by the ongoing transition from a centralized network to a balanced network.

In terms of the Wuhan-Changsha-Nanchang triad, each city has dominating power in its sub-regional network; however, the interactions between the three cities are time-lagged. Wuhan built up ties with Changsha early in 2005, Nanchang built up ties with Changsha in 2007, while Wuhan and Nanchang were not directly interconnected until 2010. In addition, Wuhan's power in the network was extended in 2011, illustrating its potential to play a control/headquarters role in the MYR city region. Lastly, Fuzhou became the only isolated node in the network after 2010, indicating its exclusive disadvantaged network position.

[51] According to the classification of city size by NBS (2014), small size cities are the cities whose population is less than 500,000; medium size cities are the cities whose population is between 500,000 and 1,000,000; big cities are the cities whose population is between 1,000,000 and 5,000,000; metro cities are the cities whose population is between 5,000,000 and 10,000,000; mega cities are the cities whose population is above 10,000,000. In 2016, Wuhan has become a mega city and the only city in central China exceeding 10 million population.

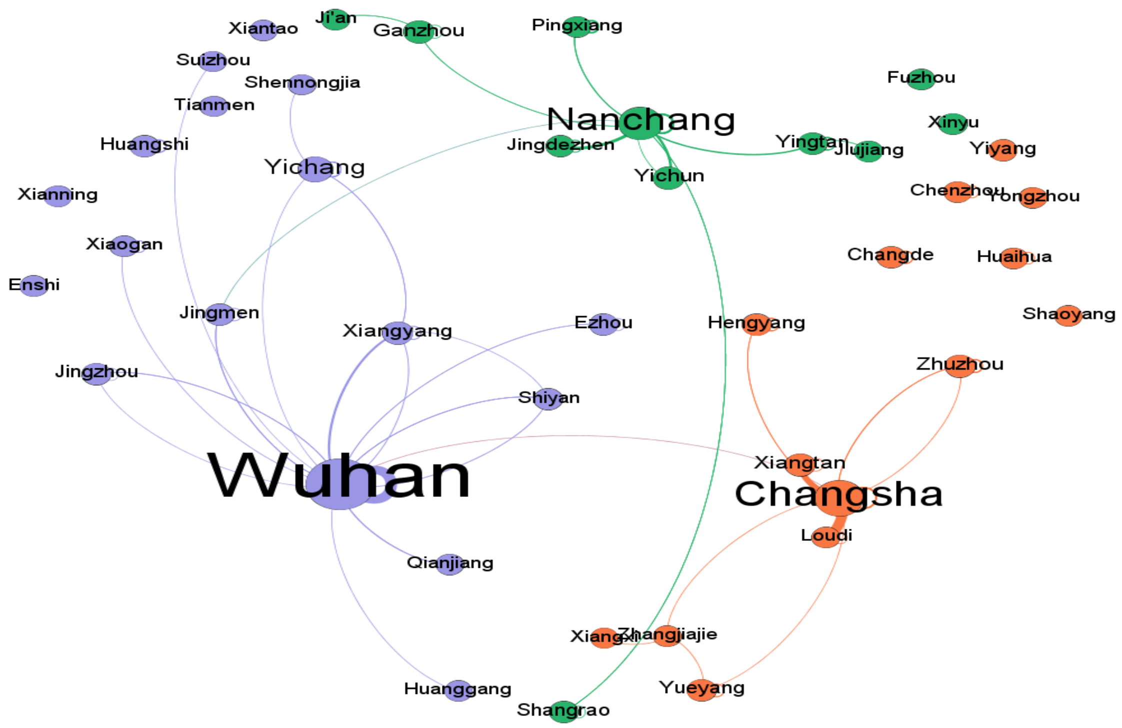


Figure 29 The MYR Inter-city Network in 2006 (weight=1, tolerance=0.01, gravity=1.2) (Purple denotes cities in Hubei, Orange denotes cities in Hunan, Green denotes cities in Jiangxi) (Source: Zephyr database).

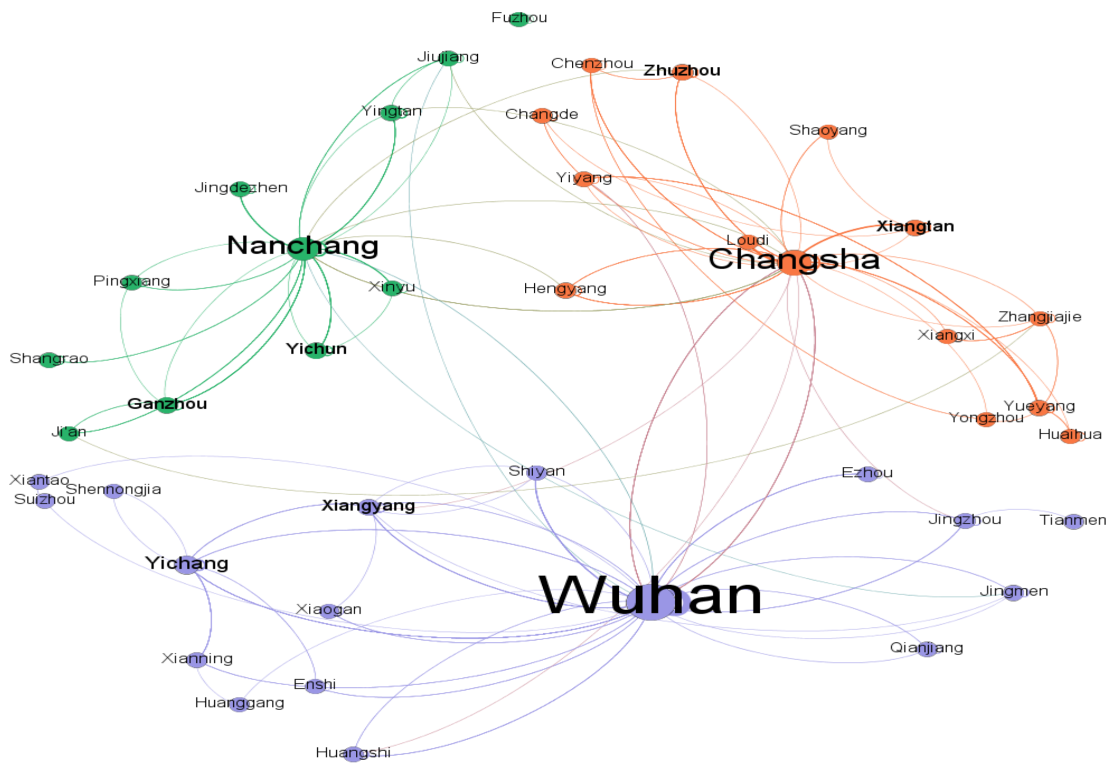


Figure 30 The MYR Inter-city Network in 2010 (weight=1, tolerance=0.01, gravity=1.2) (Purple denotes cities in Hubei, Orange denotes cities in Hunan, Green denotes cities in Jiangxi) (Source: Zephyr database).

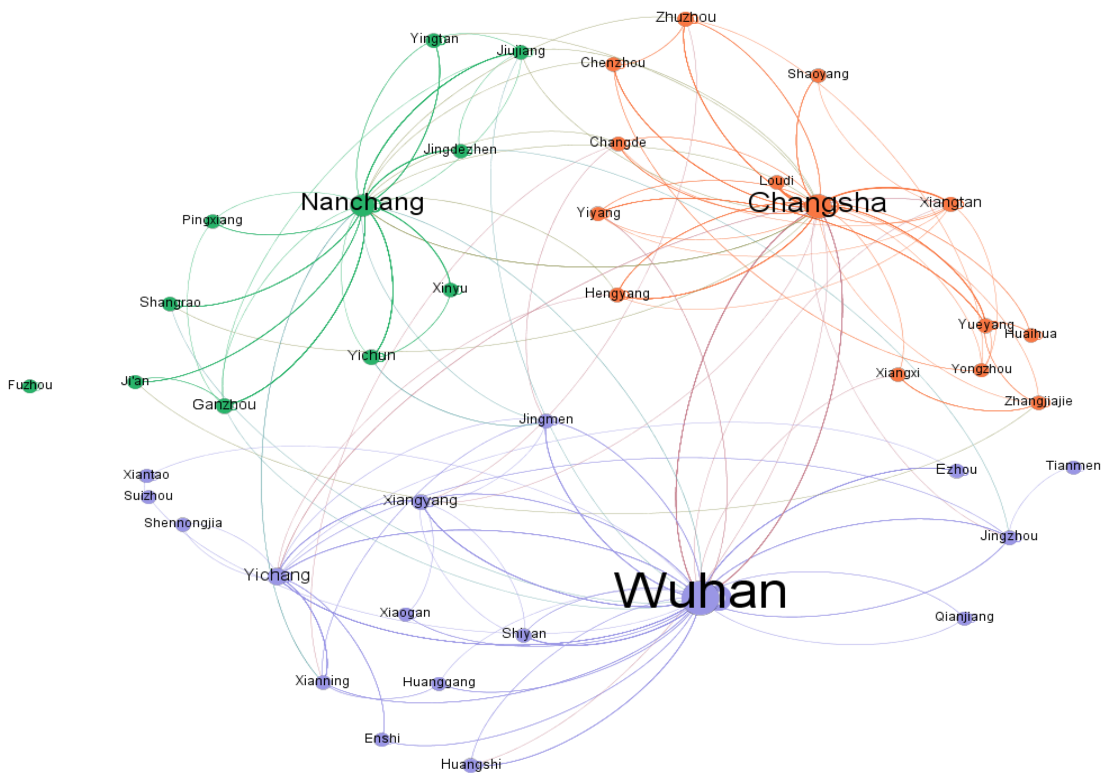


Figure 31 The MYR Inter-city Network in 2014 (weight=1, tolerance=0.01, gravity=1.2) (Purple denotes cities in Hubei, Orange denotes cities in Hunan, Green denotes cities in Jiangxi) (Source: Zephyr database).

7.4.2 Global Centrality Results

After the dynamic investigation of the MYR inter-city network, centrality analysis is conducted next in order to explore other network characteristics ranging from global network characteristics to individual city network attributes. Firstly, global network type is tested. As Watts and Strogatz' model (1998) defined, a small world network[52] is a network where the typical distance L between two randomly chosen nodes (i.e. the number of steps required) grows proportionally to the logarithm of the number of nodes N in the network, that is: $L \propto \log N$ under the condition of a high clustering coefficient. Therefore, the MYR network is not a small world network since its average path length (2.515) is not approximate to LogN (1.6232) under the condition of a low clustering coefficient (0.388). In addition, due to its high density (0.718), the MYR network is not only a fairly dense but also a centralized network regardless of tie strength and directions.

[52] In a small world network, the majority of nodes are not connected directly but can be approached within a small number of steps.

In terms of modularity results, as shown in Figure 32 (in which cities are geographically coordinated), six subgroups are identified at a high modularity score[53] (4.61): three large groups and three small groups. In addition, it is found that the division of subgroups is generally overlapped with the division of sub-regions, especially for the three big subgroups, indicating that administrative divisions still have an effect on the launching of M&A deals regardless of the increase in trans-regional ties. Nevertheless, it is of interest that Hengyang in the Hunan sub-region is the only city that belongs to the subgroup of the Jiangxi sub-region. Combined with its contiguity with the Jiangxi sub-region, Hengyang has an advantageous geographical location for network membership and the generation of network capital. This indicates it's potential to become an MYR gateway city between the Hunan and Jiangxi sub-regions, reflecting also its high scores in hub and clustering coefficients (see Table 8). Other small subgroups are all located around the boundary of sub-regions, such as Suizhou and Xiantao (dark green subgroup) at the boundary of the Hubei sub-region, Yueyang, Zhangjiajie, Huaihua and Yongzhou (orange subgroup) at the boundary of the Hunan sub-region, and Fuzhou (pink subgroup) at the boundary of the Jiangxi sub-region.

[53] High modularity score indicates that identified subgroups are all well-connected subgroups.

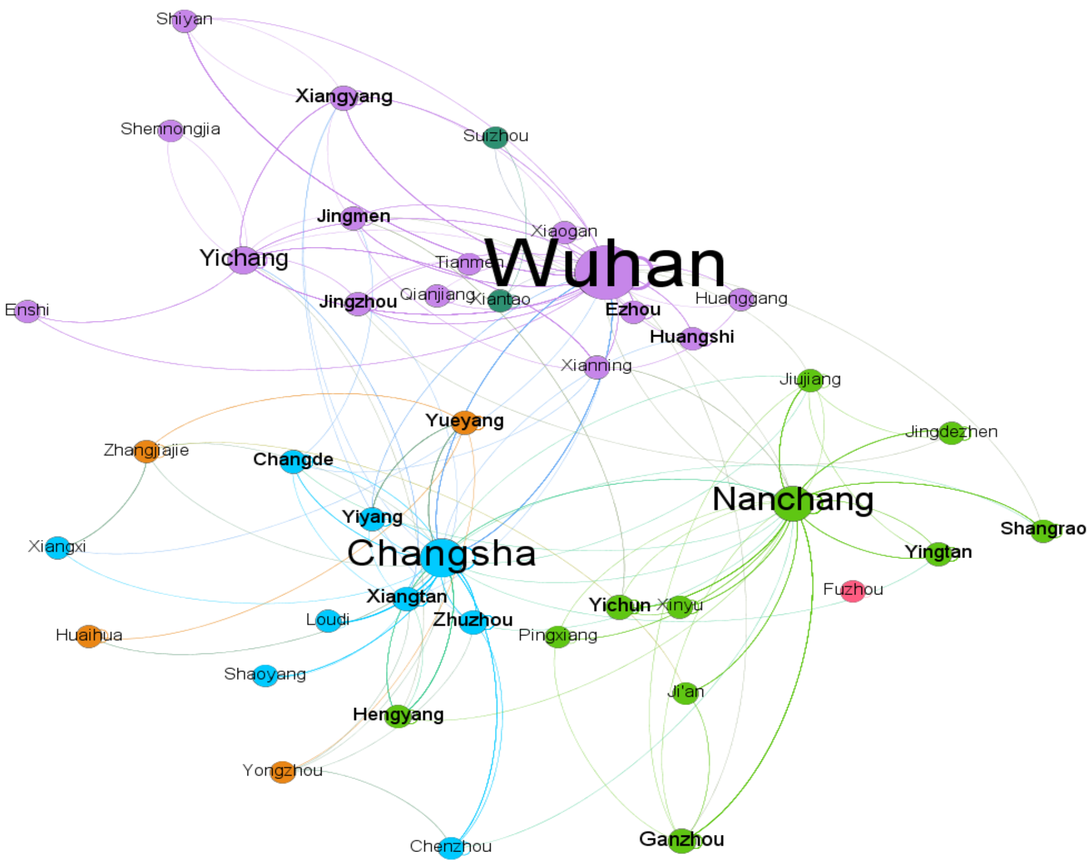


Figure 32 The MYR Inter-city Network Subgroups in Geo Layout (Modularity=-4.61, Mercator Coordinate System) (Source: Author calculations using Zephyr database).

Secondly, in order to explore the association between top-down subgroupings by modularity calculation and bottom-up structural similarity by MDS calculation, the identified subgroups are distributed by MDS results instead of by geographic location (see Figure 33). It is found that there are more clusters based on similarity than identified subgroups at low stress (0.0854[54]), allowing for limited insufficient dimensionality, while most cluster members are from the same subgroups. Specifically, the cities from small sub-groups tend to be clustered, while the cities in big sub-groups have more dissimilarities. This finding indicates that being similar is not required to initiate interactions between cities, albeit similar cities tend to join the same subgroup membership particularly small subgroups. In addition, it is also found that medium size cities are more likely to be clustered than big cities. It can be seen that the triad cities (Wuhan-Changsha-Nanchang) are more idiosyncratic and located in the network core separately. Wuhan and Changsha, with intensive ties, captures central positions in the MDS layout, and creates a vacuum in

[54] Any stress score under 0.1 is excellent. However, as long as there is non-zero stress, it means some of the distances are, to some degree, distorted. Generally, longer distances have fewer tendencies to be distorted than shorter distances since the stress function accentuates discrepancies in the larger distances.

the surrounding space, which indicates their heterogeneity in the whole network. On the other hand, Nanchang is clustered with Jiujiang, and Yichang is clustered with Xiangyang. Lastly, in general, among the three sub-regions, Hubei sub-region is the most centralized with a wider range in its layout since the disparity between Wuhan and others stretches its spatial scope. In addition, there are more small clusters in the Hubei sub-region, such as Jingmen-Xianning, Suizhou-Xiantao, Ezhou-Xiaogan-Enshi-Shiyan, and Yichang-Xiangyang. This finding reveals that big cities are more heterogeneous than others in the inter-city network.

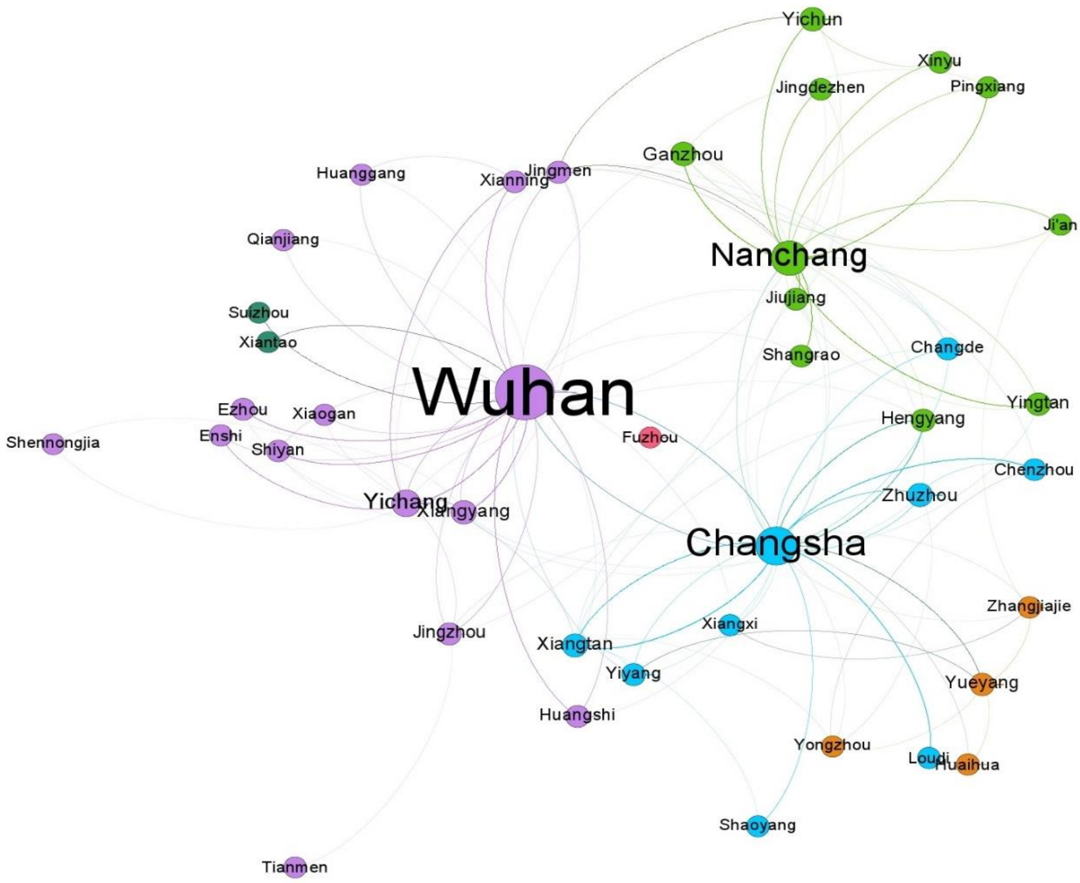


Figure 33 The MYR Inter-city Network Subgroups in MDS Layout (Modularity=-4.61, Stress=0.0854) (Source: Author calculations using Zephyr database).

In conclusion, the MYR network is not a typical small world network, but is instead a centralized network with cohesive subgroups and a clustering tendency of similar cities.

7.4.3 Node Centrality Results

Given individual cities' network performance, it is found that degree-related estimators and gateway function estimators (Betweenness and hub) are more deviational[55] and right-tailed[56] than the rest, as shown in Table 6, which indicates the severe disparity between outperforming cities and the rest in capturing extending power and gateway positions. On the other hand, functional proximity estimators (Closeness and Clustering) show a relatively normal distribution pattern. In conclusion, the power and gateway positions of individual cities varies substantially, which means that network capital expressed by advantageous prestige, control and gateway positions are rather unequally distributed in the network, though cities are functionally proximate and have several cohesive neighbourhoods.

	Mean	**Standard Deviation**	**Kurtosis**	**Skewness**	**Minimum**	**Maximum**	**Count**
Indegree	29.429	63.98	21.657	4.431	1	374	42
Outdegree	29.429	76.932	18.922	4.184	0	429	42
Degree	58.857	140.667	20.255	4.309	2	803	42
Closeness	0.327	0.233	0.459	0.175	0	1	42
Betweenness	41.976	120.940	12.802	3.634	0	581.628	42
Authority	0.105	0.114	1.856	1.557	0	0.428	42
Hub	0.051	0.148	28.293	5.070	0	0.901	42
PR	0.024	0.010	4.559	1.710	0.012	0.062	42
Clustering	0.388	0.137	1.895	-1.101	0	0.65	42

Table 6 The Statistical Description of Nodes' Centrality Attributes (Source: Zephyr database).

Secondly, the correlation between these network attributes is explored and illustrated in Table 7. Apparently, degree, outdegree and indegree are, as direct counting estimators, highly correlated significantly, which indicates that cities with high outbound ties are highly associated with inbound ties and vice versa. The Betweenness and Hub attributes are also highly correlated with degree-related attributes, which indicates that cities with more direct ties are more likely to be positioned in other cities' geodesic paths and to direct others to authoritative cities. Therefore, in the MYR inter-city network, power, prestige

[55] The deviational degree is estimated by standard deviation and kurtosis here. If kurtosis is greater than 3, there are more outliers than normal distribution.

[56] If skewness is greater than 1 or less than -1, the distribution is skewed. The right-tailed skewness indicates more cities are having lower score than mean.

and hub positions are normally combined in the same cities. In addition, the significant correlation between PR and the above correlated attributes demonstrates that the cities with a high degree and an outperforming hub position are more likely to attract random investors.

	Indegree	**Outdegree**	**Degree**	**Closeness**	**Betweenness**	**Authority**	**Hub**	**PR**	**Clustering**
Indegree	1								
Outdegree	0.993*	1							
Degree	0.998*	0.998*	1						
Closeness	0.351*	0.366*	0.360*	1					
Betweenness	0.957*	0.971*	0.966*	0.371*	1				
Authority	0.241	0.210	0.225	0.159	0.229	1			
Hub	0.946*	0.948*	0.949*	0.332*	0.861*	0.149	1		
PR	0.785*	0.760*	0.772*	0.084	0.743*	0.180	0.689*	1	
Clustering	-0.059	-0.073	-0.067	0.105	-0.067	0.033	-0.090	0.101	1

Table 7 The Pearson Correlation Matrix of Network Estimators (significance level at 0.05) (Source: Author calculations using Zephyr database).

Regarding the individual attributes of cities, the best performing cities are shown in Table 8. It can be seen that the Wuhan-Changsha-Nanchang triad, and also Yichang, are outperformers in the MYR inter-city network. In particular, Wuhan is dominating in both the highest inward degree and outward degree, followed by Changsha and Nanchang, then Yichang. A common feature is that their outward ties outweigh counterparts, capturing outsider positions in the network. Other cities have a small proportion of linkages and their inbound ties outweigh outbound ties, except in the case of Yiyang, capturing sinker positions in the network. Given closeness, cities have less disparity, while it is interesting that Yueyang is the best performer regardless of its relatively low degree ranking (no.10). It is seen that Yueyang is not only connected to Changsha which has intensive ties but also to the peripheral cities that are not easily approached by other cities, indicating its advantageous position in approaching all other cities (see Figures 34 and 35).

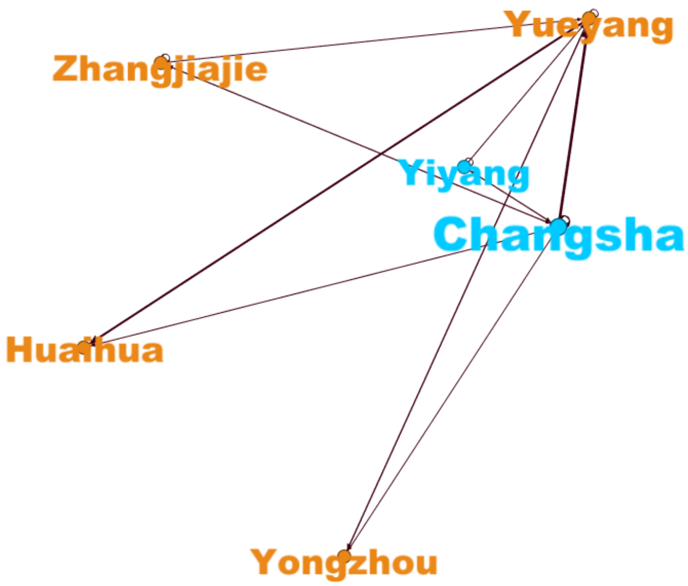


Figure 34 Yueyang's Ego Network in One Step (Source: Zephyr database).

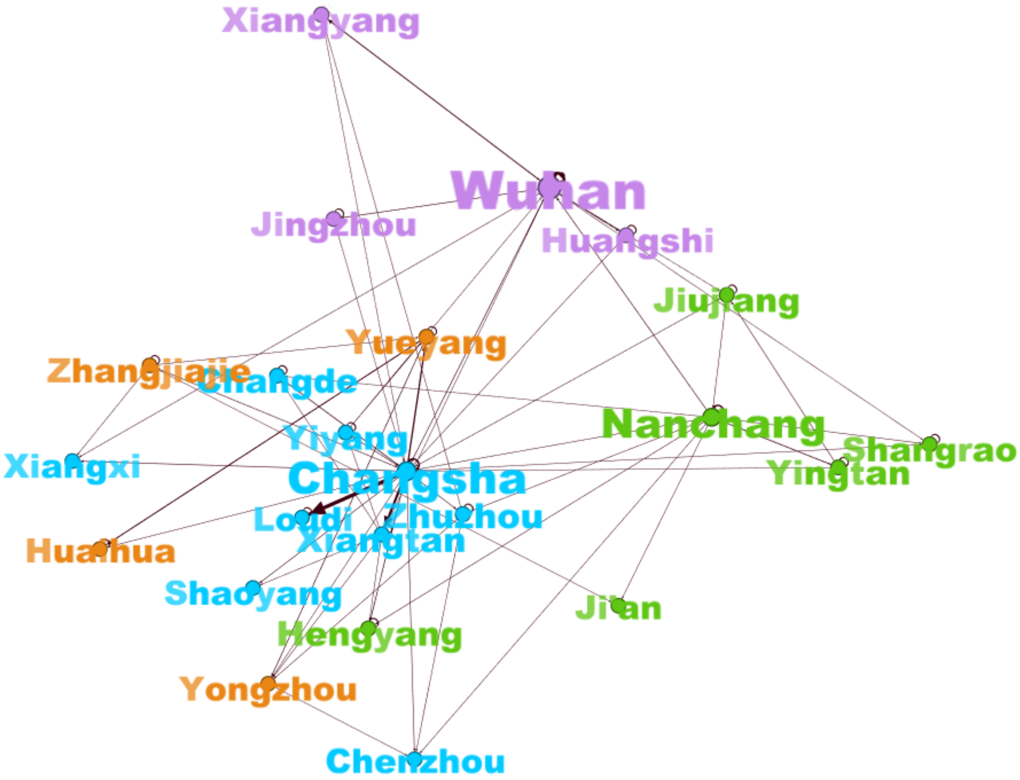


Figure 35 Yueyang's Ego Network in Two Steps (Source: Zephyr database).

In relation to Betweenness, city rankings are generally associated with degree ranking. For the four largest cities, Changsha is catching up while Yichang remains further behind. For medium size cities, Jingzhou, Jingmen and Xianning outperformed given their degree ranking, indicating the presence of network capital as a consequence of their advantageous positions. However, Betweenness cannot detect the relative roles of cities themselves in the network and it ignores the directionality of ties. For example, although Changsha is outperformed in Betweenness only behind Wuhan, it is more likely to be connected by other hub cities based on the HITS algorithm, indicating its authority status in the network. In addition, Yichang is the most authoritative city, while Wuhan and Nanchang play a relatively hub role in the network. Among medium size cities, Xiangyang outperformed in terms of authority ranking only behind Yichang and Changsha, indicating its attractiveness to hub cities (see Figure 36). Intertwined with the same subgroup membership and physical proximity, Xiangyang and Yichang have become a contiguous authority area with high attractiveness in the northwest of the city region.

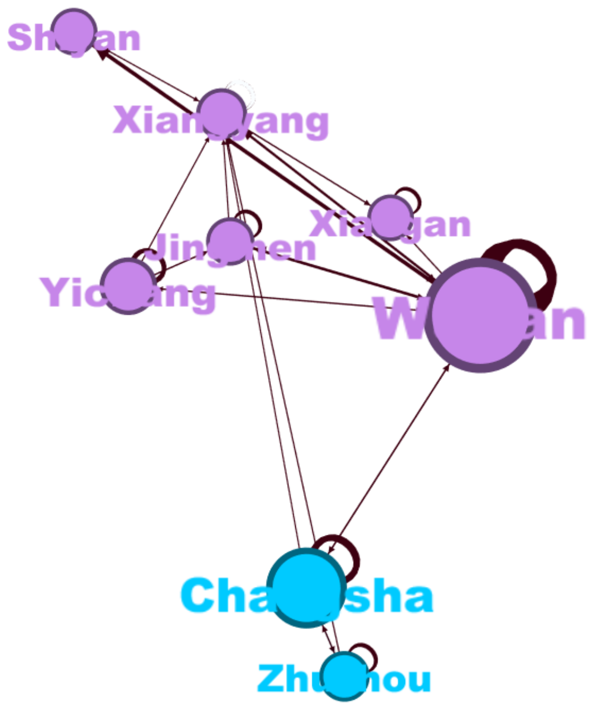


Figure 36 Xiangyang's Ego Network in One Step (Source: Zephyr database).

Given the PR results, for the top four cities, Wuhan still dominates at a 6.23 per cent likelihood of attracting investors from a random city, followed by Changsha at 4.11 per cent and Nanchang at 4.05 per cent, then Yichang at 2.72 per cent. Given the clustering coefficient, the cities with low scores have a star network tendency, which is normally associated with top regional cities and peripheral cities. On the other hand, medium size cities are more likely to have cohesive neighbourhoods. Among the top four cities, Yichang has the most cohesive neighbourhood where neighbours tend to have investments in each other (see Yichang's ego network illustrated in Figure 37). Medium size cities, Ganzhou, Hengyang, Jingzhou and Jiujiang are also outperformed in neighbourhood clustering. In conclusion, although the top cities have different hub or authority positions, they are still overwhelmingly dominating in prestige, power, bridging and the likeliness of investment attraction. On the other hand, the medium size cities that are functionally closer to other cities and hold relative hub positions also have advantages in terms of their potential to generate network capital.

Id	**Province**	**In-degree**	**Out-degree**	**Degree**	**Close-ness**	**Between-ness**	**Authority**	**Hub**	**PR**	**Cluster ing**
Wuhan	Hubei	374	429	803	0.615	581.628	0.118	0.901	0.062	0.290
Changsha	Hunan	183	222	405	0.625	455.190	0.368	0.160	0.041	0.352
Nanchang	Jiangxi	132	186	318	0.588	335.652	0.025	0.303	0.041	0.405
Yichang	Hubei	58	77	135	0.488	67.101	0.427	0.228	0.027	0.405
Ganzhou	Jiangxi	38	24	62	0.381	47.528	0.188	0.008	0.037	0.508
Yichun	Jiangxi	37	24	61	0.374	39	0.113	0.001	0.033	0.444
Xiangyang	Hubei	36	24	60	0.392	5.305	0.322	0.036	0.028	0.499
Zhuzhou	Hunan	27	27	54	0.408	3.609	0.046	0.056	0.021	0.409
Xiangtan	Hunan	27	24	51	0.408	9.396	0.090	0.032	0.021	0.455
Yingtan	Jiangxi	16	21	37	0.426	0.000	0.022	0.024	0.030	0.452
Yueyang	Hunan	25	12	37	0.750	2.581	0.049	0.001	0.019	0.413
Hengyang	Hunan	20	14	34	0.388	1.122	0.067	0.067	0.020	0.537
Jingzhou	Hubei	16	13	29	0.471	51.072	0.181	0.026	0.021	0.490
Jingmen	Hubei	14	14	28	0.471	27.514	0.173	0.035	0.021	0.453
Huangshi	Hubei	15	11	26	0.385	0.000	0.170	0.009	0.022	0.519
Yiyang	Hunan	8	17	25	0.465	2.124	0.007	0.048	0.026	0.366
Changde	Hunan	15	10	25	0.388	4.906	0.032	0.027	0.026	0.452
Ezhou	Hubei	17	8	25	0.000	0.000	0.271	0.000	0.016	0.324
Shangrao	Jiangxi	16	7	23	0.000	0.000	0.116	0.000	0.026	0.358
Jiujiang	Jiangxi	19	4	23	0.421	24.883	0.173	0.014	0.022	0.468
Xianning	Hubei	16	5	21	0.392	28.271	0.216	0.016	0.018	0.352

Table 8 City Rankings in Network Estimators (Source: Author calculations using Zephyr database).

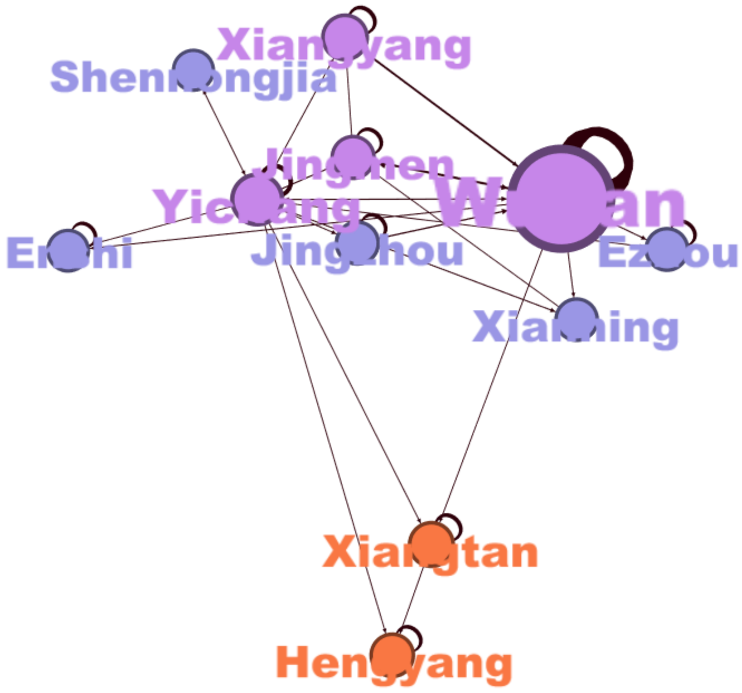
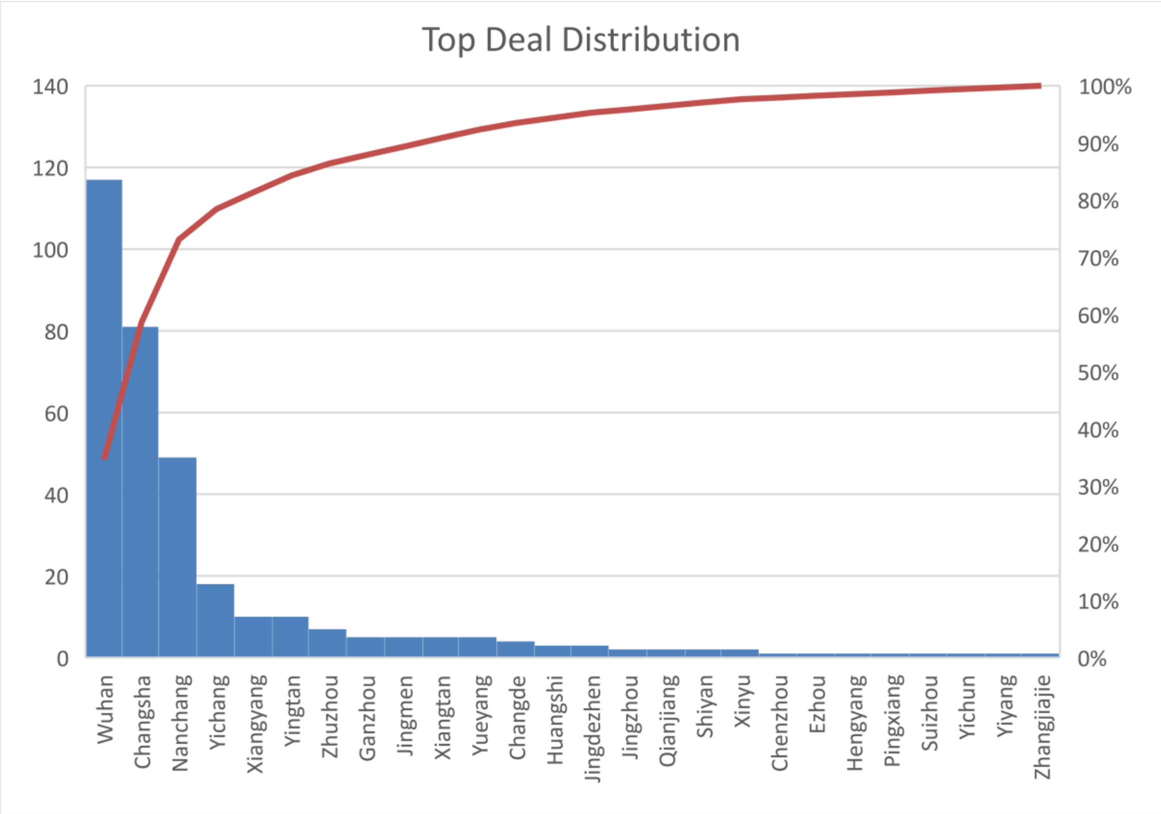


Figure 37 Yichang's Ego Network in One Step.

7.4.4 The Triad + 1 in the MYR Inter-city Network

It is notable that the inter-city network in the MYR city region is a centralized network with functional clusters and subgroups where most network capital is held by big cities, namely Wuhan, Changsha, Nanchang and Yichang. Especially in terms of big projects, about 80 per cent of the projects valued above 10 million Chinese yen are concentrated in these four cities, as shown in Graph 10. The four cities therefore form a core group in the network, called the triad +1 in this analysis (see Figure 38). Next, the network performance and sectoral preference of the triad + 1 cities are compared to shed light on their network capital in terms of both positions and business sectors.



Graph 10 Top M&A Deals' Distribution over 2003-2014 in the MYR City Region (source: Zephyr).

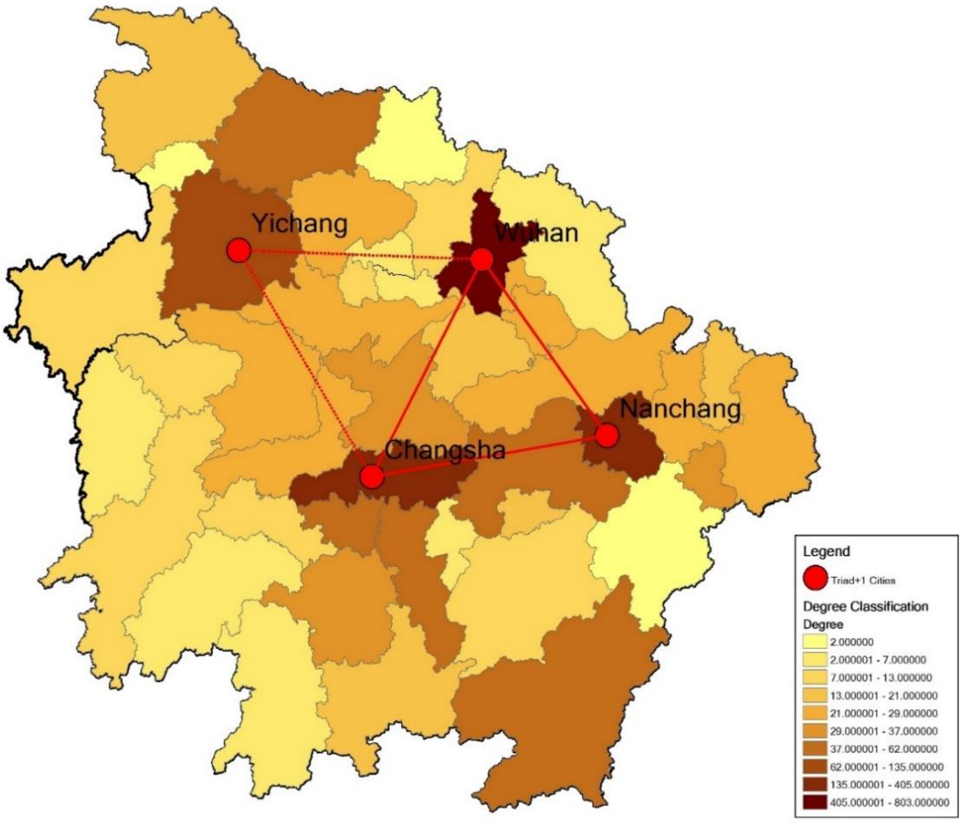
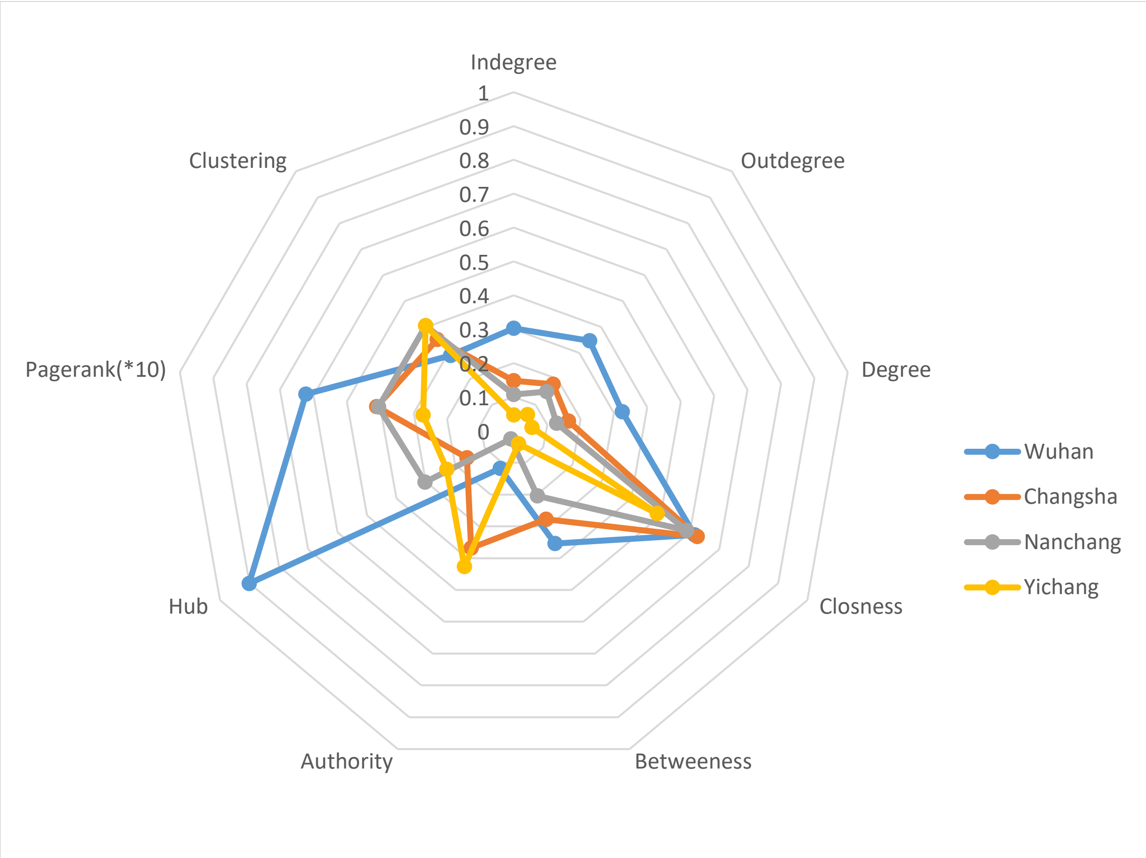


Figure 38 The Triad +1 Cities Based on Network Degrees (Source: Zephyr database).

As shown in Graph 11, the triad + 1 cities show distinctive performance in the network estimators. Wuhan is characterized by the strongest bridging capacity and an overwhelming magnitude of linkages, which indicates its headquarters and gateway position in the network. Changsha and Nanchang, as two sub-regional prime cities, are more similar in their network positions. Changsha is an authority city with more functional linkages to other hub cities, which indicates its authority prestige in the whole network, while Nanchang is the sub-regional headquarters with a control function that is relatively circumscribed within the Jiangxi boundary. However, combined with the spatial association in the industrial northwest of the region, Yichang is a representative authority city in the northwest associated with a relatively compact and cohesive neighbourhood.



Graph 11 The Network Attributes Radar Chart of the Tiad+1 Cities (Source: Author calculations using Zephyr database).

Secondly, the sectoral distribution of the triad + 1 cities is illustrated in Table 9 and Table 10 to show their individual preferences. It shows that Wuhan, Changsha and Nanchang, as both target and acquirer cities, are generally following the pattern of overall sectoral distribution which highlights the outperformance of manufacturing such as *Industrial, Electric & Electronic Machinery*, and advanced services such as *Property, Banking, Insurance & Financial Services.* Among the latter three sectors, *Banking, Insurance &*

Financial Services is more capable of launching acquisitions while the other sectors are more attractive to receiving projects. In addition, Wuhan has a higher representation of *Wholesaling & Retailing*, which reinforces its position as a trade centre (identified in Chapter 6 also). Changsha has a higher representation of *Computer, IT* and *Internet services*, which indicates its specialisation in ICT industries. Nanchang has a higher representation of *Biotechnology, Pharmaceuticals* and *Life Sciences*, which indicates its specialisation in life science industries. However, Yichang is the idiosyncratic city which specialises in heavy industry, such as *Chemicals, Petroleum, Rubber & Plastic*.

City/Target Sectors	No.1	No.2	No.3	No.4	No.5
Wuhan	Property Services	Industrial, Electric & Electronic Machinery	Wholesaling	Retailing	Banking, Insurance & Financial Services
Changsha	Industrial, Electric & Electronic Machinery	Property Services	Personal, Leisure & Business Services	Banking, Insurance & Financial Services	Computer, IT and Internet services
Nanchang	Industrial, Electric & Electronic Machinery	Banking, Insurance & Financial Services	Wholesaling	Property Services	Biotechnology, Pharmaceuticals and Life Sciences
Yichang	Chemicals, Petroleum, Rubber & Plastic	Transport, Freight, Storage & Travel Services	Utilities	Mining & Extraction	Banking, Insurance & Financial Services

Table 9 The Top Five Target Sectors Metric of Triad + 1 Cities (Source: Zephyr database).

City/Acquirer Sectors	No.1	No.2	No.3	No.4	No.5
Wuhan	Banking, Insurance & Financial Services	Property Services	Industrial, Electric & Electronic Machinery	Retailing	Wholesaling
Changsha	Banking, Insurance & Financial Services	Industrial, Electric & Electronic Machinery	Property Services	Metals & Metal Products	Computer, IT and Internet services

Nanchang	Industrial, Electric & Electronic Machinery	Biotechnology, Pharmaceuticals and Life Sciences	Banking, Insurance & Financial Services	Transport Manufacturing	Food & Tobacco Manufacturing
Yichang	Chemicals, Petroleum, Rubber & Plastic	Transport, Freight, Storage & Travel Services	Utilities	Property Services	Construction

Table 10 The Top Five Acquirer Sectors Metric of Triad + 1 Cities (Source: Zephyr database).

In conclusion, the triad + 1 cities have different sectoral characteristics that define their network position and capture of deal value, which increases the heterogeneity of the core group of cities in the centralised MYR network. Specifically, Wuhan is the gateway city and trade centre, circulating and possessing the most network capital; Changsha is the authority city and ICT centre, possessing the second highest network capital; Nanchang is the sub-regional hub city which is specialised in life science sectors; Yichang is the representative authority city in the northwest which is located in the cohesive neighbourhood and which specializes in heavy industry sectors.

7.5 Conclusion and Policy Implications

The analysis in this chapter set out to fill a gap in the investigation of the network capital embedded in the capital flows network in the process of MYR city region development. In contrast to transportation hubs that are based on visible traffic flows, borderless flows like financial capital mobility, knowledge exchange and information sharing are significant virtual ties interconnecting cities dynamically, contributing to regional development under globalisation. It is shown from the analysis that MYR city region development is deepening with growing trans-boundary capital flows, evolving gradually from a star network pattern to a centralised network pattern. The multi-directionality of intensive inter-city flows in the process of network evolution should be given due attention, as this gives rise to an emphasis on structural positions in a complex urban space rather than in a hierarchical urban system. Meanwhile, investigating the indirect ties interconnecting cities is also found beneficial in the investigation of network capital. In conclusion, it is found that dynamic, borderless, multidirectional, and indirect capital flows converge in regional space, generating distinctive network space positions, which forms network capital as an outcome. Next the specific research questions posed in this chapter (developed from general research question 2 in Section 5.4) is addressed and general findings are discussed.

Firstly, how is the MYR inter-city network established through cumulative capital flows and how do economic actors respond to the process of network evolution in order to distribute their resources and extend their influence practically? As Hakansson and Snehota (1995) argued, network development rests on changes through gradual and incremental steps as network actors interact and adapt to each other. Investigating networks in a dynamic vision is therefore significant for delving into network capital. It is seen that the number of M&A deals is increasing and interconnecting cities gradually. However, although Hakansson and Snehota (1995) have noted that network development depends on increasing linkages and actors' adaption, the phases of network development are not yet clarified. Through investigating the force atlas, it is found that MYR inter-city network development resembles the process of cell fission to some extent, dividing into an 'interphase' and a 'mitotic phase'. The gradual changes are not constantly incremental as in a linear pathway but may lead to dramatic change at a certain time, such as in the case of the transition from a star network to a centralized network in the year 2010. However, unlike cell fission in which one cell splits into two cells, in the MYR inter-city network, the number of cities is relatively fixed. Therefore, network development is more reasonably divided into the endogenous phase in which cities focus on self-growth, and the interactive phase in which the relative strength of the attractive force and repulsive force derived from increasing cross-territorial ties, determines reshaping and regrouping exercises. In contrast to isolated self-growth, the interactive phase is characterised by multidimensionality and multi-complexity (Asheim and Gertler, 2005). Therefore, capturing the transition period is also important for network actors to access and magnify network capital (Hoang and Antoncic, 2003). Furthermore, along with the evolution of the network and the change of scale, the positions and roles of network actors are also changing and have a high possibility of taking concurrent positions. For example, Changsha is an indigenous hub for the Hunan sub-region in the first phase but became an authority city for the whole MYR city region in the second phase, intertwined with more connections to hub cities in other sub-regions. Thus, the patterns of centrality shift in inter-city networks reflecting 'when and at what particular relations we look' (Timberlake, 2010, p.2).

Secondly, how are the overall patterns and subgroups of the MYR inter-city network formed, and how do economic actors respond to network patterns and subgroups in order to distribute their resources and extend their influence practically? As Hoang and Antoncic (2003) argued, horizontal interactions have more resonance with developmental patterns than vertical linkages in GPN and ION. Therefore, regarding cities as horizontal nodes in a complex regional network constructed by multi-directional flows is beneficial for illuminating the global patterns of network capital. Specifically, in a city-based network, the degree of centralization becomes important to network actors developing network strategies. In the analysis, the MYR inter-city network is identified as a centralized, but not a small world, network, which means that disproportional network capital is concentrated in limited core cities and information transmission is inefficient except in core cities. If economic actors are seeking information, technology, and advanced services rather than control functions, core cities will be priority destinations since they have high stocks of network capital allowing them to access knowledge and information efficiently (Huggins and Thompson, 2015). In particular for launching M&A deals, Hitt *et al.* (2001) articulated that the hurdle for acquirers attempting to identify an appropriate target with synergy effects is the information asymmetry between acquirers and targets. Therefore, locating in core cities with advantageous positions is beneficial to dissimilate information asymmetry, especially the information asymmetry caused by spatial distance (Huggins and Thompson, 2015).

However, there is no optimal pattern generating maximum network capital, ranging from a star network to a complete network, since network space is dynamic, heterogeneous and complex in nature (Baum *et al.*, 2000). Therefore, further research concerning the relation between network capital and regional development in different case studies is needed. Essentially, network capital is generated in an incomplete network where heterogeneous structures and positions intersect. Uzzi (1996) provided evidence that networks with both strong ties and weak ties are more valuable for firms' survival than homogenous networks. Furthermore, ties from different sectors make the network more heterogeneous. Intertwined with the rise of APS sectors in a globalized economy and the qualified industrial base in the MYR city region, the interface between APS sectors and advanced manufacturing become the most promising engine for generating heterogeneous network capital for the city region. Under the condition of general heterogeneity, as shown in the MDS map, the cities that are structurally similar to other cities but belong to different subgroups may capture network capital to become gateways between two heterogeneous groups. Therefore, allocating operations in heterogeneous gateway cities across subgroups is an advantageous strategy for economic actors to capture a broker role and earn a translation fee in circulating heterogeneous flows, e.g. capital, knowledge and information.

In addition, compared to the subgrouping results in Chapter 6 which highlight the spatial heterogeneity of the triad cities and spatial cohesion of northwest cities, the subgrouping (Modularity) in the inter-city network is more pronounced in sub-region divisions and heterogeneous peripheral cities (see Figures 22 and 30). This may be attributed to the importance of familiarity and the path-dependence of investment decision-making (Huberman, 2001; Collins *et al.*, 2009). The difference between the spatial pattern of the aggregate economy and that of capital flows reinforces the complexity of the spatial regime in the MYR city region.

Thirdly, how is network capital distributed across cities through network positions in the MYR inter-city network and how do economic actors respond to individual cities' network capital in order to distribute their resources and extend their influence practically? In the 'network society' (Castells, 1996), structural position is a significant way of estimating cities' network capital. Capturing an advantageous position, such as prestige, control, hub, authority and functional proximity positions, is significant for network actors. For economic actors located in core cities, in order to maintain their network capital, they need to develop their control position within the city region and extend their connections to national and international authority cities in order to access regional gateways. For economic actors in medium and small size cities, in addition to connecting to regional hub cities, they also need to capture control positions in their neighbourhoods and in peripheral cities/towns. Meanwhile, breaking boundary constraints and connecting to national hubs is also important to have less restricted activity than in regional core cities, since the network capital in advantageous positions within the same region may be counteracted when the predictability issue is considered. The behaviours of economic actors in core cities and isolated cites are both predictable and constrained with regard to strategic decisions, while economic actors in medium size cities are more flexible and unpredictable in investing in network capital. Economic actors in medium size cities need to cooperate with each other for synergy effects. Specifically, Yueyang is a good example for medium size cities, connecting prime cities with hub functions and extending influence on peripheral cities simultaneously. Economic actors are not isolated but are embedded in a dynamic complex network space full of heterogeneous flows. Building a flow tracking system and a cooperation mechanism to share information could therefore assist the strategy-making of economic actors.

In conclusion, through addressing these specific questions in this chapter, general Hypothesis 2 '*cities in the MYR city region hold different network space positions in conducting distinctive functions*' is proved. Thus, in addition to the spatial association and heterogeneity based on contiguity in Chapter 6, cities are also performing different functions according to their positions in distance-free networks. The interaction of contiguous patterns and network patterns shapes the spatial regime in the MYR city region.

Lastly, since network data are representative of an actor-to-actor matrix, they cannot be used to explore causality between network attributes and regional development. Therefore, exploring the contribution of network capital to the regional economy can assist further studies, and this is the motive for the analysis in the next chapter. In addition, although M&A deals incorporate spillovers, the network capital derived from M&A inter-city flows is limited to capital mobility and their attached interactions, and is unable to unveil the overall interactions in the MYR city region. This is the reason why commodity and human flows are incorporated into the regional growth model in Chapter 8.

Summary Points:

1. The MYR inter-city capital flows network has transited from a star network pattern to a centralized network pattern.
2. The MYR inter-city capital flows network is a centralized network with functional clusters and subgroups.
3. Network capital is highly concentrated in primate cities, namely Wuhan, Changsha, Nanchang and Yichang, although they hold different roles in terms of prestige, power, bridging and the likeliness of investment attraction and they have sectoral preferences.
4. On the other hand, medium size cities also have opportunities to capture network capital by making efficient linkages.

8. THE RESONANCE OF SPATIAL PROXIMITY AND NETWORK CAPITAL IN REGIONAL DEVELOPMENT

8.1 Introduction

As discussed in Chapter 4, according to standard economic theories especially endogenous growth theories, local growth is heavily driven by indigenous input factors such as capital stock, labour pool, natural resources and technological level etc., whilst observations are independent in local growth models. However, economic actors benefit not only from local assets embedded in geographic configurations, but also from functional positionality derived in connected networks through intense economic interactions with few spatial constraints (Agnew, 2001; Bathelt *et al.*, 2004). According to the results in Chapter 6, spatial association and heterogeneity coexist in the MYR city region. Spatial association occurs in many ways including through capital spillovers, knowledge transfers, labour and commodity mobility, and other types of spatial interactions. In addition, Chapter 6 and Chapter 7 found that both economic activities and network capital are disproportionally concentrated in particular cities, suggesting that there is a 'spiky' city region geography (Florida, 2005). However, there are few studies exploring the underlying drivers of the regional economy under the convergence of geo-space and network space mechanisms, especially at a city region scale. Thus, based on the results from Chapter 6 and Chapter7, the analysis in this chapter considers both *near* and *distant* spatial interactions by incorporating indigenous factors, flow factors and network capital factors into a spatial growth model and examining their contribution to the regional economy at a city region scale.

Castells' (1996) space of flows theory is used to complement the indigenous growth theory, since it argues that in a digital society, cities are an open dynamic space full of distinctive virtual and physical flows, such as labour, commodities, information, knowledge and capital etc., rather than a locale that is limited by administrative boundaries and territorial contiguity. In particular, capital mobility is deeply financialised, free from spatial constraints, and does not follow the proximate order (from *near* to *distant* as discussed in Chapter 4) to target investment destinations. As Castells (1996) argued, these exogenous flows communicate in complex ways in contributing to economic associations across territories. Thus, the second aim of the analysis in this chapter is to clarify the effects of transboundary flows on regional development observed by using a network lens. As reviewed in Chapter 3, the MYR city region, as an emerging strategic city region during China's economic transition, is a valuable laboratory to investigate the dynamic resonance of spatial effects and network thinking in the space of flows yet it has rarely drawn research attention, especially from an international perspective. In conclusion, combining spatial effects and networking thinking can address above research voids to shed light on a regional growth model in the space of flows for MYR city region.

Generally, this chapter addresses general research question 3: What is the contribution of indigenous factors, productive flows and calculated network capital to the MYR city region development and how is the spatial relationship in the process of city region development under the influence of these factors? The research question is divided into four specific sub-questions in this chapter. Specifically, first, how does the indigenous growth model including capital stock, labour pool and technology explain MYR city region development? Second, how do distinctive flows including human flows, commodity flows and capital flows improve the indigenous growth model and contribute to MYR city region development? Third, can calculative network capital (based on network positions) facilitate regional development? Fourth, is economic development in the MYR city region affected by spatial interdependence and, if any, how much? Last, what are corresponding policy implications to facilitate MYR city region development? Accordingly, the first section of the chapter discusses the relationship of indigenous growth theories, spatial econometric studies, and calculative network capital discourse. In the second section, the data process is presented and the spatial regional growth model is specified. The third section illustrates the results of the spatial regional growth model. Lastly, based on the results, identified contributors to regional development are discussed and the policy implications for MYR city region development are proposed.

8.2 Spatial Economy Drivers: Indigenous Factors or Transboundary Flows?

Although various regional growth models exist, the main focus consistently focuses on indigenous factors and the endogenous mechanism (Capello and Nijkamp, 2009; Stimson *et al.*, 2011). As Bathelt and Taylor (2002) emphasized, economic development is largely dependent on the exploitation of indigenous resources even in the context of globalisation and transboundary activities. Krugman (1991) also articulated that it is the accumulation of indigenous input factors such as labour pool, capital stock and knowledge stock that leads to circular causation effects associated with urban growth. However, in practice, most regional growth models are based on the Cobb-Douglas Production Function which explains production output by capital stock, labour pool and materials (Cobb and Douglas, 1928). Subsequently, the Cobb-Douglas Production Function is mainly complemented by considering inputs factors' elasticity and incorporating material substitution, natural resources and technological advances etc. (Solow, 1957; Arrow *et al.*, 1961; Uzawa, 1962; Solow and Stiglitz, 1968; Dixit and Stiglitz, 1977; Lucas, 1988; Romer, 1986, 1990; Capello and Nijkamp, 2009; Stimson *et al.*, 2011). In particular, the effects of technology are emphasized and regarded as a significant endogenous factor influencing the proportional contribution of overall right-hand inputs to final output in long-run development (Romer, 1986; Capello and Nijkamp, 2009; Stimson *et al.*, 2011). Ha and Howitt (2007) proposed a general growth model based on the Cobb–Douglas production function. The function is formally written as:

$$Y_{it} = K_{it}^{\alpha}(A_{it}h_{it}L_{it})^{1-\alpha}$$

Where K_{it} is the capital stock of region i in period t; A_{it} is the knowledge stock in region i in period t; h_{it} is the human capital stock in region i in period t; L_{it} is the labour stock in region i in period t and α is the relative importance of physical capital in the production process. The model specification in this chapter is also based on the general Cobb–Douglas production, which is used to address the specific question 'how does the indigenous growth model including capital stock, labour pool and technology explain the MYR city region development?'

Although the indigenous growth model is still the cornerstone for understanding the dynamics of urban growth, deepening globalisation and the rise of the knowledge economy has facilitated the free mobility of productive factors and challenged Tobler's principle, which transforms the urban locale into an urban space full of flows. Nowadays, regardless of geographic proximity, cities are connected to each other in various flows directly and indirectly (Friedmann, 1986; Castells, 1996; Taylor, 2004; Robinson, 2005). These flows are heterogeneous in nature, ranging from physical flows such as commodities, traffic, and labour etc. to virtual flows with few spatial constraints such as capital, information, knowledge and management through formal collaboration schemes and personal contacts

(Tura and Harmaakorpi, 2005; Walter *et al.*, 2008; Cantner *et al.*, 2009). These distinctive flows are regarded as significant exogenous factors contributing to regional development. Therefore, investigating transboundary flows is an important way to shed light on ‘space’ conceptualization and to unveil the underlying patterns of the regional economy. This analysis will test the contribution of human flows, commodity flows and investment flows to MYR city region development, in order to address the specific research question ‘how do distinctive flows including human flows, commodity flows and capital flows improve the indigenous growth model and contribute to MYR city region development?’

However, previous studies concerning the effects of flow networks on regional development focus mostly on examining flow volumes and morphological co-location patterns (see Asheim *et al.*, 2003; Bathelt *et al.*, 2004; Cooke *et al.*, 2004; Rutten and Boekema, 2007; Trippl *et al.*, 2009; Mattes, 2011). They ignore the complexity of network space and its advanced network capital that is due to the multi-directionality of flows and nodal indirect connectedness (Meijers, 2007), creating a research void for this analysis to fill. As reviewed in Chapter 5, the notion of calculative network capital is proposed in recent studies to address the deficiencies in estimating the network effect on local growth (see Huggins, 2010; Huggins and Johnston, 2010; Kramera *et al.*, 2011; Kramer and Diez, 2012). In network capital discourse, the network is not just one kind of structure or research angle but one kind of strategic resource which can generate actual profits for network actors. Kimino *et al.* (2014) made a pioneering contribution to the explanation of the network capital generated in domestic enterprise networks attracting external FDI projects in Japan. They found that the vertically structured Keiretsu[57] network is beneficial to new FDI entrants, but their work concentrated on the organisational level network in a Japanese institutional context and paid less attention to trans-boundary linkages across territories, namely spatial effects. Thus, in order to complement the lack of spatial consideration in Kimino *et al*. (2014) and the lack of advanced network capital (positions) calculation in regional development studies, Shi *et al.* (2017) analysed the effects of network positions across Chinese cities in the domestic investment network in attracting FDI, and clarified the significance of network capital in improving cities’ competitiveness

[57] Keiretsu is one kind of informal association scheme of Japanese companies, normally through business partnerships and cross-shareholdings in order to prevent stock market fluctuation and takeover attempts. There are two types of Keiretsu: horizontal Keiretsu that centres around a Japanese bank providing financial services, and vertical Keiretsu that align with value chains.

for foreign investors. Therefore, the contribution of network capital to MYR regional growth calculated by the structural positions of cumulative flows is also tested in order to address the specific research question ‘can calculative network capital (based on network positions) facilitate regional development?’

As discussed in Chapter 4, in order to tackle spatial associations and heterogeneity interference in standard economic models, the spatial econometric modelling technique is becoming the prevailing way to fix this problem and produce consistent results (Corrado and Fingleton, 2012). Since the brief history and rationales of spatial econometrics have been reviewed in Chapter 4, this section will focus mainly on the empirical applications of spatial econometrics on China’s urban growth.

Under the simultaneous processes of rapid urbanisation and economic agglomeration, the spatial effects of urban growth in China have begun to draw research attention. The spatial endogenous spillover effect is found significant in regional convergence studies at province level (Ying, 2003; Lin *et al.,* 2006; and Jeon, 2007) and city level (Madariaga and Poncet, 2007). In addition to regional convergence studies, by using the SAR model, Coughlin and Segev (2000) also detected endogenous spillover effects between Chinese regions in terms of their attractiveness to FDI. Meanwhile, Tian *et al.* (2010) employed SDM to investigate urban growth from 1991 to 2007 and identified positive endogenous interactions across Chinese cities. While a negative exogenous spillover effect of capital stock is also identified across neighbouring cities, which is detrimental to neighbours’ economic development. In addition, they found that the spatial interactions between the east, the centre and the west of China are largely circumscribed within each region’s boundary. Specifically, they found that in contrast to the east and the west, the centre of China showed faster economic convergence across cities.

In terms of knowledge spillovers, by using patent panel data over the period from 2002 to 2010, LeSage and Sheng (2014) identified the positive endogenous spillovers of intellectual growth across province-level regions, and the exogenous spillovers of the involvement of enterprises and individuals, but not in a university sample. In contrast to the knowledge spillovers that are circumscribed within regional boundaries in Tian *et al*’s (2010) work, this manifested as the east region taking more advantage of spatial spillovers from the knowledge stock of the centre region, while the centre benefited less from the east, which indicates divergence in terms of knowledge stock across regions.

In addition to endogenous and exogeneous spillovers of these indigenous factors, the spatial resonance of these distance-free flows and emergent network capital, is not explained explicitly in current literature, which is another motive for this analysis.

Although the mobility of flows, especially virtual flows, is not strictly restricted to spatial distance and takes advantage of reduced transaction costs, even advanced virtual flows are dependent on physical arrangements and people (Castells, 1996), thus they are likely to generate spatial spillover effects. Therefore, both endogenous and exogenous spillover effects of indigenous factors, distinctive flows and calculative network capital in the regional development process are tested in order to address the specific question 'is economic development in the MYR city region affected by spatial interdependence and, if any, how much?'

8.3 Data and Model Specification

The primary research interest is to investigate, in addition to indigenous input factors i.e. capital stock, labour pool, and technology, how distinctive flows (human flows, commodity flows and investment flows) and the network capital embedded in structural positions contribute to the MYR city region development associated with spatial spillovers while controlling for population and land area. Network capital is calculated based on M&A deals by reference to authority, hub and clustering network attributes calculated in Chapter 7. All cities are geocoded to calculate a contiguity matrix W. Through cross-matching, the final database is a balanced panel dataset covering 36 cities and 10 time periods spanning the years 2004 to 2013. The panel data include information about how changes in input factors and the capital network from one year to the next relate to changes in regional development from one year to the next. For reasons of data availability, attribute data in 2003 and 2014 were not available for analysis. Thus, the data on M&A in 2003 and 2014 are only used in Chapter 7. In this panel dataset, network capital variables are calculated annually, so as not to interfere with the model's consistency. The variables' statistical description is presented in Table 11. In this chapter, cities are regarded as nodes and M&A deals are regarded as ties between cities to establish a multi-directional inter-city network, as shown in Figure 39.

Variables (logged)	Observation	Mean	Std. Deviation	Min	Max
GDP	360	6.513	0.791	4.565	9.111
Labour Cost	360	9.953	0.427	9.030	10.940
Capital Stock	360	5.905	0.990	3.763	8.695
Technological Advances	360	5.559	1.453	1.609	9.674
Human Flows	360	8.796	0.691	6.872	10.583
Commodity Flows	360	8.680	0.854	6.565	10.704
Capital Flows	360	1.349	1.172	0.000	4.812
Hub	360	0.037	0.163	0.000	1.000
Authority	360	0.065	0.152	0.000	0.775
Clustering	360	0.107	0.184	0.000	1.000

Table 11 Spatial Regional Growth Model Variables' Statistical Description (Source: NBS, Zephyr and SIPO databases).

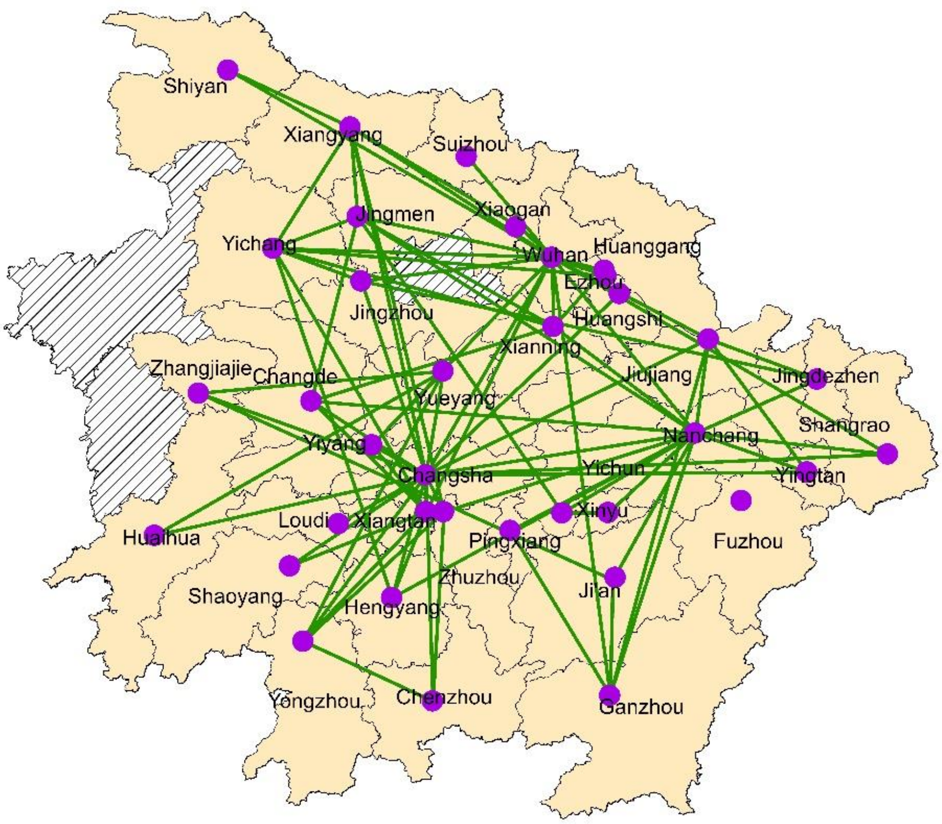


Figure 39 Inter-city Capital Network Overlaid on the MYR City Region Geo-map (Source: Zephyr database).

In terms of model specification, as LeSage (2014) argued, it is plausible to specify SDM as the departure which includes the spatial lag of Y, spatial spillover effects of X and spatial disturbance term u, and make adjustments according to the Lagrange Multiplier (LM) tests and fitness tests. Based on the literature review and the research objective, this chapter employs the spatial panel model with time and region fixed effects. Formally, the formula of the regional growth model is written as:

$$Y_t = \rho W Y_t + X_t \beta + W X_t \theta(optional) + \mu + \alpha_t \iota_N + u_t(optional), \ u_t = \lambda W u_t + \varepsilon_t \quad (1)$$

Where Y_t is the regional output at time t; X_t is the explanatory variables at time t; W is the spatial matrix; μ is regional fixed effects while α_t is time fixed effects; u_t is the spatial heterogeneous factor; ι_N is an N×1 vector of ones associated with the constant term parameter α. The spatial regional growth model in this chapter is based on the Cobb-Douglas production function (Ha and Howitt, 2007) which includes labour pool, capital stock and technological advances as inputs, formally written as:

$$Y_{it} = K_{it}^{\alpha}(A_{it} h_{it} L_{it})^{1-\alpha}$$

Furthermore, based on the literature review, capital flows, human flows and commodity flows are included in the production function as the exogenous explanatory variables. In addition, since this chapter focuses on investigating the network capital embedded in cities' structural positions in the regional growth model, Hub, Authority, and Clustering[58] network attributes are also included. Lastly, based on LM tests, exogenous spatial spillover effects are not identified significantly, the regional growth model does not specify WX, which avoids the endogeneity issue and maintains a degree of freedom. In conclusion, based on the indigenous growth model, the space of flows theory and network capital discourse, the regional growth model is specified as:

$$\log(GDP_{it}) = \rho \log(GDP_{neighbour}) + \beta_1 \log(labour_{it}) + \beta_2 \log(Capital_{it}) +$$
$$\beta_3 \log(Technology_{it}) +$$
$$\beta_4 \log(laborflow_{it}) + \beta_5 \log(Commodityflow_{it}) + \beta_6 \log(Investmentflow_{it}) +$$

[58] Based on multicollinearity tests, three network capital indicators are selected, namely hub position, authority position and clustering coefficient.

$$\beta_7 \log(Hub_{it}) + \beta_8 \log(Authority_{it}) + \beta_9 \log(Clustering_{it}) + \mu + \alpha_t \tau_N + u_t(optional), \;\; u_t = \lambda W u_t + \varepsilon_t \quad (2)$$

Given the selection of estimators, this chapter employs Ordinary Least Squares (OLS), Maximum Likelihood (MLE), Spatiotemporal Autoregression[59] (STAR) and Two-Stage Least Squares (2SLS) estimators to make comparison and robustness checks in order to choose the most fitted model with unbiased results. As testified by Monte-Carlo simulation, Elhorst (2003) articulated that the MLE estimator can produce consistent and efficient results when variables comply with normality and a dataset has large number of observations and a small number of time periods. Another advantage of the MLE estimator is that it can produce the statistical significance of direct and indirect spatial effects by simulating the distribution of the direct and indirect effects using the variance-covariance matrix (LeSage and Pace, 2014). In addition, considering both temporal dependence and spatial dependence, Pace *et al.* (1998) proposed the STAR estimator. Despite using fewer degrees of freedom, the STAR approach improves the model fitness and facilitates error reduction by 37.35 per cent in Pace *et al.*'s (1998) study of the housing market in Fairfax County Virginia in the US. The spatial relations in the STAR model take into account previous spatial relations, contemporaneous relations and future relations. But it may have little influence on the sample in this analysis, since the panel data are absolutely balanced, which leads to there being no difference in spatial relations across time. Lastly, as Elhorst (2010) argued, the models including a spatial lag and additional endogenous variables can be estimated straightforwardly by two-stage least squares (2SLS). In order to take into account the potential endogeneity issue, 2SLS estimators are employed to add a robustness check since indigenous input factors (capital stock and technology) are widely regarded as endogenous factors.

In addition, due to the feedback effects that arise as a result of impacts passing through neighbouring cities and back to the cities themselves, the magnitude of overall direct effect

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[59] By referring to Pace *et al.* (1998), STAR takes the current value of a variable at one location and subtract an average of past, surrounding values scaled by a constant less than 1. It has both time weight and spatial weight, by partitioning W into a matrix S that specifies spatial relations among previous observations and T that specifies temporal relations among previous observations. Hence, the matrix T is a lag operator for regularly observed data. Also, S functions in space much like a lag operator does in time. The matrix is ordered temporally and spatially, the first row of S, T is associated with the oldest neighbouring spatial relation (non-diagonal values). T does not appear by itself but only in combination with other variables (TY; TX; TSX; TSY). Thus, each column contains the running averages of the respective variable over time.

eventually increases, so the coefficient β cannot be interpreted as direct effects that X makes on Y (Elhorst, 2014). LeSage and Pace (2010) therefore proposed a method to report direct effects by the average of the diagonal elements of the matrix on the right-hand side of equation (4), and indirect effects by the average of either the row sums or the column sums of the non-diagonal elements of the matrix. Consequently, indirect effects do not occur if both ρ=0 and $\theta_k = 0$, since all non-diagonal elements will then be zero. When both ρ≠0 and $\theta_k \neq 0$, indirect effects are interpreted as local indirect effects, while when only ρ≠0 but $\theta_k = 0$ (no WX), indirect effects are interpreted as global indirect effects. Therefore, the model equation (1) can be rewritten as:

$$Y_t = (I-\rho W)^{-1}\alpha_t \iota_N + (I-\rho W)^{-1}(X_t\beta + WX_t\theta) + (I-\rho W)^{-1}\varepsilon \qquad (3)$$

Then the matrix of partial derivatives[60] of Y with respect to the kth independent variable of X in observation 1 to observation N is formulated as:

$$\left[\frac{\partial \mathrm{Y}}{\partial x_{1k}} \cdot \frac{\partial \mathrm{Y}}{\partial X_{Nk}}\right] = \begin{bmatrix} \frac{\partial \gamma_1}{\partial x_{1k}} & \cdots & \frac{\partial \gamma_1}{\partial x_{Nk}} \\ \vdots & \vdots & \vdots \\ \frac{\partial \gamma_N}{\partial x_{1k}} & \cdots & \frac{\partial \gamma_{1N}}{\partial x_{Nk}} \end{bmatrix}$$

$$= (I-\rho W)^{-1} \begin{bmatrix} \beta_k & w_{12}\theta_k & \cdots & w_{1N}\theta_k \\ w_{21}\theta_k & \beta_k & \cdots & w_{2N}\theta_k \\ \vdots & \vdots & \ddots & \vdots \\ w_{N1}\theta_k & w_{N2}\theta_k & \cdots & \beta_k \end{bmatrix} \qquad (4)$$

Although the MLE estimator can draw inference regarding the statistical significance of direct and indirect effects, an accurate inference requires a large sample size. Therefore, given the small sample size for this analysis, in this chapter more attention is paid to scalar summary estimates in addition to statistical significance.

Lastly, based on the reviewed in Section 6.3, the spatial weight matrix W is specified as a queen contiguity matrix for three reasons. First, as LeSage (2014) testified, sparse matrices that contain fairly large numbers of zero elements work best for a small sample. Thus, the contiguity matrix is selected to represent the spatial weight matrix rather than the inverse distance matrix. Second, the application of multiple Ws is a pitfall causing biased results,

[60] The partial derivatives denote the effect of a change of a particular explanatory variable in a particular spatial unit on the dependent variable of all other units.

particularly for social W and technological W that change over time and create an endogeneity issue, especially in small size datasets (Elhorst *et al.*, 2013). Thus, this analysis chooses the sparse W defined by queen contiguity and does not include other Ws in the function. Last, since all cities share a boundary with their neighbours, the k nearest neighbours matrix that is used to include islands in spatial relationships is not applied in this analysis.

8.4 Results

8.4.1 The Spatial Surface of the MYR City Region Economy

Firstly, the spatial surface of regional economic performance is illustrated in Figure 40 by means of a Triangulated Irregular Network [61](TIN) technique. It can be seen clearly that the economic performances across territories are uneven, showing plateaus and valleys on the TIN surface. It is found that economic power in the MYR city region is spatially concentrated in Wuhan city in the north, Changsha city in the centre, Nanchang city in the east, and Yichang city in the northwest. The rugged surface reemphasizes the spatial heterogeneity in the underlying spatial regime of MYR city region development. In addition, the nonparametric autocorrelation test within 396 km[62]elaborates how cities' economic development is correlated to their neighbours along with distance. As shown in Figure 41, it is found that, interestingly, spatial autocorrelation is falling dramatically to the bottom after one interpolation point (nearest neighbour). This finding indicates that spatial autocorrelation resonates mostly with nearest contiguous neighbours, which also justifies the choice of the contiguity spatial matrix. The fluctuated line of spatial autocorrelation justifies that spatial association is not only locked in a contiguity relationship but that it

[61] TIN surface is a vector-based digital geographic illustration constructed by triangulating a set of vertices (points). The edges of TINs form contiguous, non-overlapping triangular facets and can be used to capture the position of linear features that play an important role in a surface. The resulting triangulation satisfies the Delaunay triangle criterion, which ensures that no vertex lies within the interior of any of the circumcircles of the triangles in the network. An advantage of using a TIN in analysis is that the points of a TIN are distributed variably based on an algorithm that determines which points are most necessary to an accurate representation of the terrain. In regions where there is little variation in surface height, the points may be widely spaced whereas in areas of more intense variation in height the point density is increased.

[62] The Mean distance between one city and all others (396km) is calculated as the cutting-off bandwidth to confine the circular of the neighbourhood under spatial autocorrelation, and interpolation points are identified as the mean of neighbours within bandwidth (19 neighbours) through random sampling.

also needs network thinking that does not follow contiguous orders to understand the economic interactions of cities comprehensively.

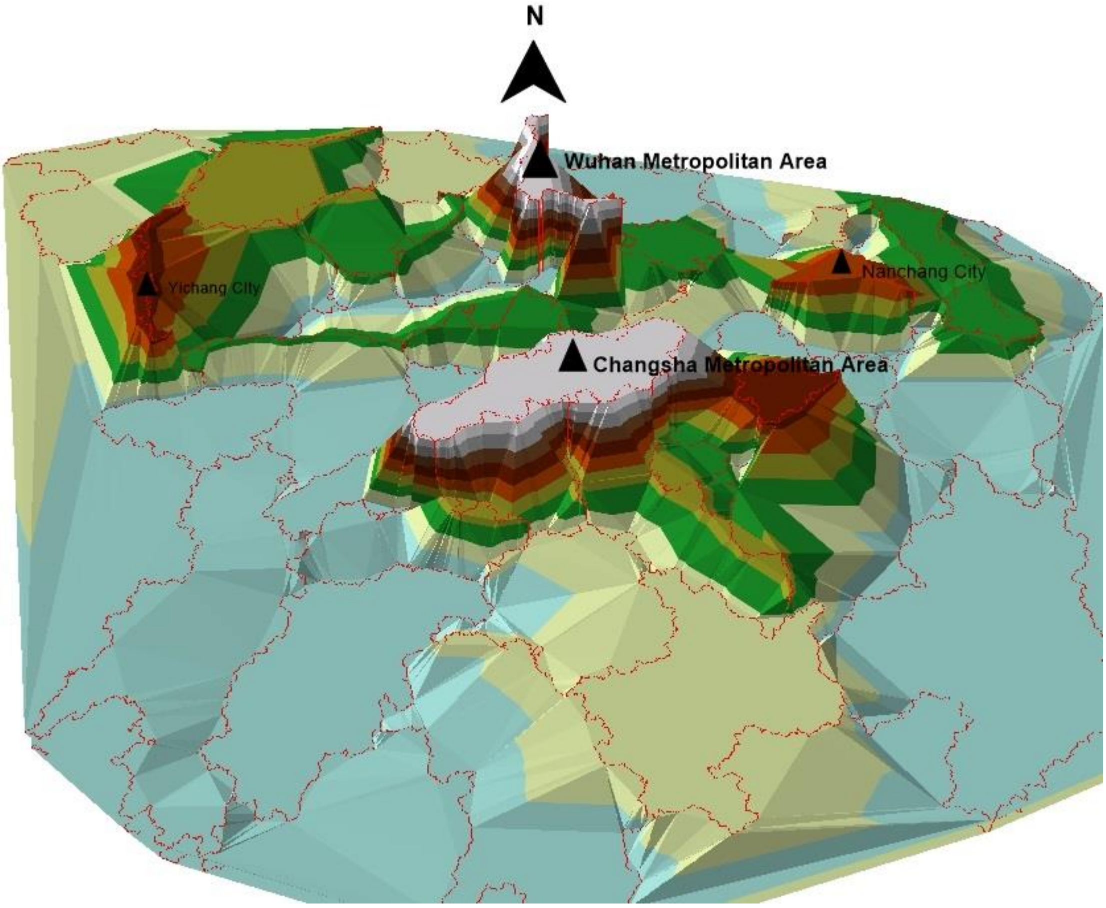

Figure 40 TIN 3D Surface of Spatial Economy in the MYR City Region Economy (Source: Author calculations using NBS database).

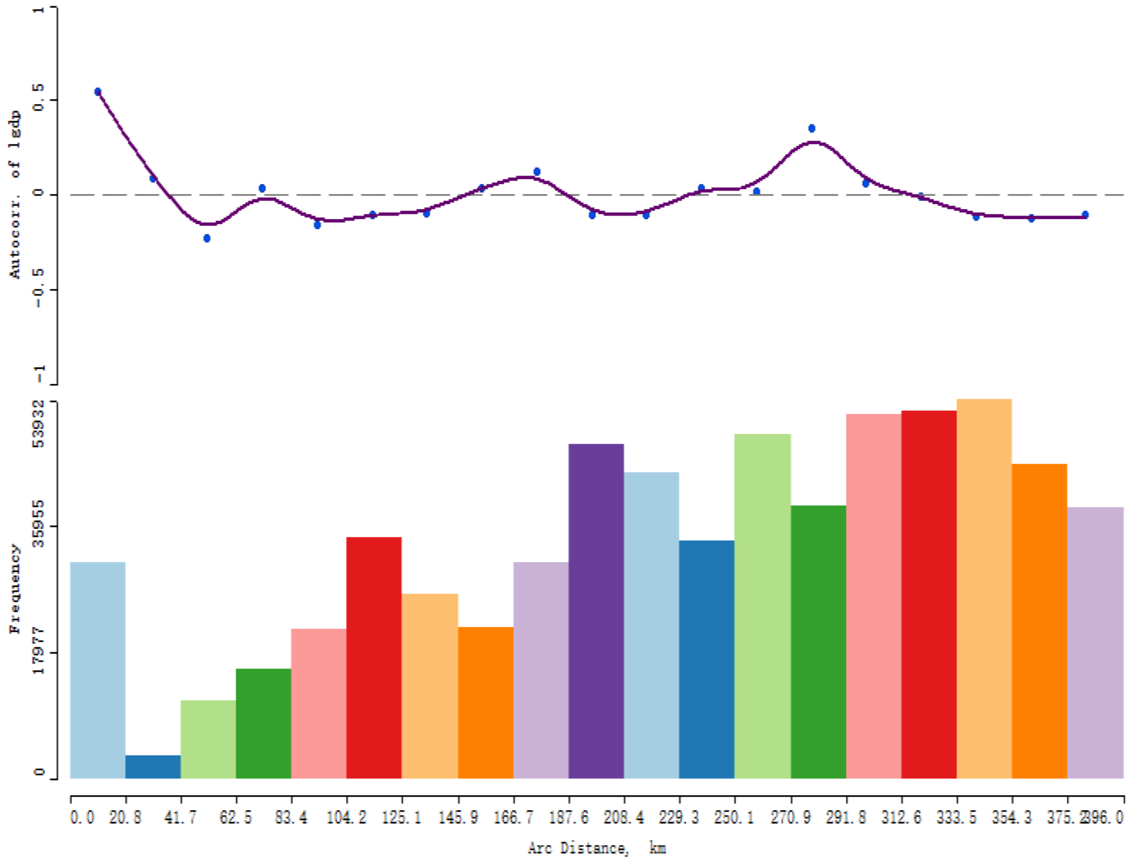

Figure 41 The Nonparametric Spatial Autocorrelation Test of GDP with Distance (Max distance: 396 k m; Bins indicate how frequent the pairs of possible neighbours have corresponding autocorrelation at certain distance through 1000000 iterations of random sampling) (Source: Author calculations using NBS database).

8.4.2 The Results of the Indigenous Growth Model

Secondly, Table 12 shows the contribution of indigenous factors, distinctive flows and network capital to local growth without considering spatial-temporal factors. It is seen that the model fit of the data is reasonable across the Indigenous Growth Model (IGM), Space of Flow Model (SFM) and Network Capital Model (NCM), explaining over 90 per cent of the variation. Specifically, SFM that incorporates flow factors increases the explanatory power by 4 per cent more than IGM that is based on the Cobb-Douglas production function. Similarly, NCM improves the explanatory power of SFM by 1 per cent. It is shown that the coefficients of indigenous factors and flows factors are consistently significant at confidence level, explaining most of the variation. Among indigenous factors, the magnitude of capital stock’s positive effect and of labour cost’s negative effect is subtracted, while the positive effect of technology on local growth increases. Among flow factors, the positive effect of human flows stays constant, the positive effect of commodity flows decreases, and the positive effect of capital flows increases. Among network capital factors, only authority and hub are identified significant. However, since this analysis does not take into account time-region fixed effects and spatial effects, the growth model is likely to produce biased results. In addition, it should be noted that high R-squared can only partially represent fit goodness and its increase may be spurious in improving efficacy and explanatory power. This step is just to present a baseline model for subsequent analysis which will include BIC, AIC, LM and LR tests to compare the models' goodness of fit.

VARIABLES	IGM Pooled OLS	SFM Pooled OLS	NCM Pooled OLS
Capital Stock	0.436***	0.423***	0.422***
	[0.038]	[0.036]	[0.036]
Labour Cost	-0.224**	-0.154*	-0.201**
	[0.060]	[0.058]	[0.054]
Technological Advances	0.085***	0.063***	0.091***
	[0.009]	[0.010]	[0.011]
Human Flows		0.198***	0.198***
		[0.046]	[0.021]
Commodity Flows		0.125***	0.091***
		[0.039]	[0.020]
Capital Flows		0.028**	0.040***
		[0.011]	[0.013]
Authority			0.140**
			[0.048]
Hub			0.181*
			[0.086]
Clustering			-0.030
			[0.068]
Controls			
Population Size	0.300***	0.186***	0.186***
	[0.042]	[0.048]	[0.048]
Urban Size	0.217***	0.199***	0.196***
	[0.061]	[0.064]	[0.066]
R-squared	0.905	0.944	0.9512

*Table 12 Estimation Results of the MYR City Region Growth Model (robust standard errors[63] in parentheses; *** p<0.01, ** p<0.05, * p<0.1) (Source: Author calculations using NBS, Zephyr and SIPO databases).*

[63] For all models in this chapter, a 'vce (robust)' option in STATA is used to ensure that the standard errors are adjusted for heteroscedasticity.

The estimation results with fixed region and year effects are then illustrated in Table 13. It is shown that the regional growth model with time and region fixed effects has the best fitness. Given the results, capital stock, technological advances, human flows, commodity and capital flows are identified as significant contributors to regional economic development. Specifically, capital stock is still the main leveraging tool to drive economic development; 1 per cent capital stock growth leads to 0.471 per cent GDP growth. Meanwhile, technological change also plays a significant role in driving the regional economy, reflected by patents' 1 per cent growth contributing to 0.054 per cent GDP growth. Among flows' variables, human flows contribute most to GDP growth by 0.148 per cent with every 1 per cent growth. In addition, a 1 per cent increase in commodity flows and capital flows will lead to 0.097 per cent and 0.043 per cent increases in regional GDP respectively. Among network capital factors, only authority is identified as significant; a 1 per cent increase in authority network capital will lead to a 0.106 per cent increase in local GDP. Lastly, an important methodological issue is the detection of spatial dependences in the data generating processes. Lagrange Multiplier (LM) tests are normally used in spatial modelling (Anselin *et al.*, 1996). The results of LM tests in Table 13 found that spatial dependence consistently existed in the model, while spatial error is only identified in the baseline model and the region-fixed model. However, robust LM diagnostic statistics suggest the consistent significance of the combined spatial lag and spatial error factor in the data generating process, albeit there is insignificance of spatial error in two models. Consequently, the SAC Model is justified at significance level, which verifies the postulation of spatial association and heterogeneity in Chapter 6.

VARIABLES	**Pooled OLS**	**Pooled OLS Time-fixed**	**Pooled OLS Region-fixed**	**Pooled OLS Time-Region-fixed**
Capital Stock	0.422***	0.426***	0.436***	0.471***
	[0.036]	[0.025]	[0.025]	[0.025]
Labour Cost	-0.201**	-0.156**	-0.218***	-0.140**
	[0.054]	[0.043]	[0.043]	[0.048]
Technological Advances	0.091***	0.083***	0.073***	0.054***
	[0.011]	[0.011]	[0.013]	[0.013]
Human Flows	0.198***	0.193***	0.162***	0.148***
	[0.021]	[0.020]	[0.021]	[0.021]
Commodity Flows	0.091***	0.085***	0.097***	0.097***

	[0.020]	[0.020]	[0.021]	[0.020]
Capital Flows	0.040***	0.040***	0.049***	0.043***
	[0.013]	[0.014]	[0.014]	[0.014]
Authority	0.140**	0.118**	0.138*	0.106**
	[0.048]	[0.046]	[0.048]	[0.046]
Hub	0.181*	0.098	0.178*	0.072
	[0.086]	[0.082]	[0.085]	[0.082]
Clustering	-0.030	0.051	-0.040	0.053
	[0.068]	[0.066]	[0.067]	[0.064]
Controls				
Population Size	0.186***	0.169***	0.191***	0.166***
	[0.048]	[0.026]	[0.026]	[0.025]
Urban Size	0.196***	0.193***	0.207***	0.196***
	[0.066]	[0.022]	[0.021]	[0.021]
R2 Adjusted	0.951	0.957	0.952	0.960
AIC	0.031	0.029	0.031	0.028
BIC	0.035	0.035	0.035	0.033
Robust LM Error	6.033**	2.302	6.606**	2.123
Robust LM Lag	10.918***	5.351**	13.827***	5.855**
Robust LM Lag & Error	13.304***	4.927*	16.384***	6.539**
Observations	360	360	360	360

*Table 13 Estimation Results of the MYR City Region Growth Model with fixed effects (robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1) (Source: Author calculations using NBS, Zephyr and SIPO databases).*

8.4.3 The Results of the Spatial Growth Model

Thirdly, given the estimation of the SAC spatial growth model, OLS, MLE, 2SLS and STAR estimators are adopted to make comparisons in order to secure the robustness of results. In addition, a Likelihood ratio (LR) test verifies that the SAC model is preferred over SAR and SEM models. In terms of the selection of estimators, based on the Akaike Information Criterium[64] (AIC) and Bayesian Information Criterium[65] (BIC) indicators, the

[64] The AIC estimator is used to examine the relative quality of candidate models. It introduces penalty term (2k) to tackle overfitting issue caused by increasing parameters. Its result is an estimate of the information lost in data generating process. Thus, the model with the lowest AIC can minimize the information loss.

[65] BIC is a similar estimator to AIC for model selection. However, it uses a different penalty term ($ln(n)\,k$) to tackle the overfitting issue caused by increasing the number of parameters. For N>7, BIC has a strong penalty for models with a larger number of free parameters k.

MLE estimator is preferred over others (the best model is the one which minimizes the AIC and BIC estimators).

As shown in Table 14, it is clearly shown that economic development in the MYR city region is influenced by negative endogenous spillover effects consistently at significance level. It can be seen that every 1 per cent GDP increase from neighbours leads to around -0.2 per cent GDP decrease for specific cities. On the other hand, spatial heterogeneity does not have a significant effect on regional development. Therefore, it is indicated that the economic development of the MYR city region is characterised by a fragmented agglomeration process and high-low clustering rather than an integrated market and positive spillover effects, which reinforces a core-periphery pattern and may lead to further divergence across cities in future. Due to spatial feedback effects, beta (β) coefficients cannot be interpreted directly as direct effects on local economic development, as explained in Section 8.2. Thus, scalar summary estimates are presented in Table 15.

VARIABLES	**SAC OLS**	**SAC MLE**	**SAC 2SLS**	**SAC STAR**
Spatial Lag (ρ)	-0.212***	-0.200***	-0.160**	-0.195***
	[0.036]	[0.035]	[0.049]	[0.035]
Spatial Error (λ)		-0.033		
		[0.096]		
Capital Stock	0.494***	0.487***	0.327***	0.492***
	[0.026]	[0.026]	[0.028]	[0.026]
Labour Cost	-0.157**	-0.153**	-0.105*	-0.153**
	[0.068]	[0.064]	[0.069]	[0.064]
Technological Advances	0.058***	0.057***	0.041*	0.057***
	[0.013]	[0.012]	[0.012]	[0.012]
Human Flows	0.119***	0.124***	0.116***	0.123***
	[0.022]	[0.021]	[0.026]	[0.020]
Commodity Flows	0.085***	0.087***	0.094***	0.086***
	[0.020]	[0.018]	[0.021]	[0.018]
Capital Flows	0.038***	0.039***	0.032***	0.039***
	[0.014]	[0.013]	[0.011]	[0.013]
Authority	0.155**	0.151**	0.108*	0.148**
	[0.061]	[0.058]	[0.054]	[0.058]
Hub	0.037	0.040	0.062*	0.041
	[0.088]	[0.078]	[0.078]	[0.079]
Clustering	0.081	0.081	0.054	0.078

	[0.071]	[0.069]	[0.051]	[0.068]
Controls				
Population Size	0.136***	0.136***	0.324***	0.139***
	[0.024]	[0.022]	[0.050]	[0.022]
Urban Size	0.201***	0.201***	0.188***	0.201***
	[0.020]	[0.022]	[0.023]	[0.023]
Time Specific Effect	Yes	Yes	Yes	Yes
Region Specific Effect	Yes	Yes	Yes	Yes
R2 Adjusted	0.962	0.978	0.861	0.939
Log AIC	-3.684	-4.339	-2.502	0.883
Log BIC	-3.446	-4.112	-2.264	1.120
LR Test-SAC-OLS	N/A	29.817***	5.222**	29.651***
Observations	360	360	360	360

*Table 14 Estimation Results of the MYR City Region Spatial Growth Model (robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1) (Source: Author calculations using NBS, Zephyr and SIPO databases).*

Given total effects, as shown in Table 15, it can be seen that indigenous input factors and flow factors are significant to regional development at the global scale. Specifically, capital stock still contributes most to regional development, driving 0.483 per cent of growth by every 1 per cent increase. While labour cost poses a negative effect on regional development, which means 1 per cent growth in wages will cause 0.15 per cent GDP loss, which verifies the postulation in Chapter 6. Technological advances represented by authorised patents play a positive role in driving economic development. In addition, distinctive flows are verified as significant contributors to regional development, which support the general Hypothesis 3 that regional development is not limited to indigenous input factors, but also has broken boundaries, benefiting from the space of flows. Among them, human flows contribute most to regional development as a 1 per cent increase leading to 0.123 per cent GDP growth, followed by commodity flows (0.086 per cent) and capital flows (0.039 per cent). Given network capital factors, only the authority indicator is identified as a significant factor to regional development positively, driving 0.15 per cent GDP growth by every 1 per cent increase, which indicates the importance of ‘power’ network capital in MYR city region development. However, Hub and Clustering are not identified as significant, which denotes that ‘brokerage’ and structural ‘cohesion’ are not identified as network capital driving city region development during the period considered in the analysis. Thus, the Hypothesis 3 that the calculative network capital is beneficial to regional development is partly proved but is limited to ‘power’ network capital.

Given direct effects, compared to the non-spatial model results, it is found that the magnitudes of coefficients are generally underestimated at various degrees. Since the coefficient of capital stock in the non-spatial model is 0.471 and the direct effect of capital stock is 0.593 in the SAC model, the effect of capital stock on local growth is underestimated by 26 per cent. Meanwhile, the effect of labour costs and technological advances are underestimated by 33 per cent and 28 per cent respectively, followed by capital flows by 12 per cent, commodity flows by 8 per cent, and human flows by 1.4 per cent. Overall, indigenous input factors are more underestimated in the non-spatial regional growth model than flow factors and network factors, which verifies the reduced spatial constraints relating to distinctive flows in the regional growth model.

Lastly, given indirect effects, only capital stock is identified as negatively significant in generating exogenous spillover effects. Since the WX vector is not specified in the model, the indirect effects are global effects, which means that indirect effects influence all cities rather than contiguous cities alone. This finding indicates that capital stock is not only the biggest driver of local growth, but also it generates negative spillover effects on regional development. The finding indicates that capital stock is a competitive resource across cities. However, as Elhorst (2014) testified, the statistical significance of the indirect effects of explanatory variables needs to be supported by a large sample size. Given the small size of the dataset in this analysis, it can be postulated that all of these factors have a high possibility of generating negative spatial spillovers to MYR city region development. In addition, the indirect effects of explanatory variables amount to 18.5 per cent of direct effects[66].

Variable	Total Effects	Direct Effects	Indirect Effects
Capital Stock	0.483***	0.593***	-0.103***
	[0.027]	[0.027]	[0.027]
Labour Input	-0.151**	-0.186**	0.034
	[0.061]	[0.061]	[0.061]
Technological Advances	0.056***	0.069***	-0.013
	[0.012]	[0.012]	[0.012]
Human Flow	0.123***	0.150***	-0.028
	[0.020]	[0.020]	[0.020]
Commodity Flows	0.086***	0.105***	-0.019

[66] In the SAC model, the quotient of direct and indirect effects is the same for every explanatory variable (Elhorst, 2010).

	[0.015]	[0.015]	[0.015]
Capital Flows	0.039***	0.048***	-0.009
	[0.012]	[0.012]	[0.012]
Authority	0.150**	0.184**	-0.034
	[0.054]	[0.054]	[0.054]
Hub	0.039	0.048	-0.009
	[0.048]	[0.048]	[0.048]
Clustering	0.080	0.099	-0.018
	[0.068]	[0.068]	[0.068]

*Table 15 Total Effects, Direct Effects and Indirect Effect of Spatial Growth Model (Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1) (Source: Author calculations using NBS, Zephyr and SIPO databases).*

8.5 Discussion

The aim of this chapter was to build a spatial regional growth model for the MYR city region, based on indigenous growth theory, space of flows theory and network capital discourse. The research interest lies in testing how indigenous factors, distinctive flows and network capital contribute to city region development in the spatial regime, which addresses general research question 3 and corresponding hypothesis presented in Chapter 5.

Here the specific research questions posed in this chapter (developed from general research question 3 presented in Section 5.4) are returned to.

First, how does the indigenous growth model including capital stock, labour pool and technology explain the MYR city region development, and what are the corresponding policy implications to facilitate MYR city region development? It is found that these three factors are all fundamentally significant for regional development, which justifies the fitness of the indigenous growth model and endogenous theory in the city region spatial context. Among the factors, capital stock is the main driver of economic development over the decade. Meanwhile, technological advances presented by authorised patents are identified as significant to the regional economy, while increasing employee wages will impede this stage of economic development, which indicates that the city region is taking advantage of its cheap labour costs as a driver in the manufacturing-based economy. In terms of policy implications, firstly, encouraging investments in capital construction and innovation, and reducing administrative barriers for these can be regarded as a fundamental way of supporting city region development. In addition, local governments could play a bridging role to deepen the collaboration between research institutions and enterprises in order to stimulate cross-industrial innovations. As Porter (1998) articulated, upgrading the industrial base is a fundamental way of improving competitiveness, while a dependence on labour-intensive production is not sustainable path to long-term growth. Therefore, in addition to encouraging investments in capital construction and innovation, a policy focus on the provision of training opportunities, expenditure on higher education, and the stimulation of APS activities can be expected to add value to production.

Second, how do distinctive flows including human flows, commodity flows and capital flows improve the indigenous growth model and contribute to MYR city region development, and what are the corresponding policy implications to facilitate MYR city region development? It is found that these three flows are all identified as significant contributors to regional development. This finding not only verifies the importance of circulating productive factors for regional development, but also proves the relevance of Castells' (1996) space of flows theory in the city region. In terms of policy implications, the upgrading of modern transportation systems, such as high speed rail, should be consistent to provide the physical arrangements required for the accommodation of distinctive flows. In addition, the MYR city region could take advantage of its pivotal geographic location and the Yangtze River waterway to enhance connectivity to the Yangtze River Delta, Pearl River Delta and Cheng-Yu city regions (see China administrative map in Appendix). Lastly, reform of the Household Registration System[67] by the introduction of city cooperative schemes, could positively facilitate the free mobility of labour.

Third, can calculative network capital facilitate regional development, and what are corresponding policy implications to facilitate MYR city region development? It is found that authoritative network capital is a strategic resource to facilitate regional development. This finding proves that authoritative network capital is not limited to an organisational level and social capital but can assist actual regional development. Meanwhile, hub network capital is not identified as a significant driver of regional development, which

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[67] The Household Registration System, 'Hukou' in Chinese, entitles people to state social welfare, working rights and education rights etc. according to their residence status in order to control migration across territories.

contradicts Burt's (2009) theory that a hub position is advantageous in transmitting capital and information, contributing to local growth as an outcome. Thus, policy should be informed by the identification of the network positions of cities and analysis of the network structure based on an up-to-date flow-tracking system. Specifically, on the basis of the results, it is indicated that local growth can attract transboundary capital links from important hub cities, improving their network authority, such as Wuhan and Nanchang (the two outperformers in the hub attribute identified in Section 7.4.3).

Fourth, is economic development in the MYR city region affected by spatial interdependence and, if so, by how much, and what are corresponding policy implications to facilitate MYR city region development? It is demonstrated that incorporating spatial effects is relevant to correct the misspecification in the regional growth model. In non-spatial models, the direct effects of input factors are underestimated due to ignorance of neighbours' effects. As discussed in Chapter 4, spatial interdependence is investigated for the endogenous spillover effects of the dependent variable (GDP in the model specified) and for the exogeneous spillover effects of independent variables (indigenous factors, distinctive flows and network capital in the model specified).

Given the endogenous spillover effect, economic development across cities can be expected to be confronted with competitive intercity relationships in a territorial sense, which reinforces the core-periphery pattern and may lead to further divergence and market fragmentation in future. It is shown that, as an emerging city region, MYR is still going through the early agglomeration process in which resources in neighbouring regions are agglomerating into core growth areas, rather than developing positive spillover effects from core regions to neighbouring region cities. Given the concentration of economic activities and spatial heterogeneity of primate cities identified in Chapter 6, at the present stage of its development, MYR city region expansion has resonance with process B (city regions of proximate cities) referred to in the European literature, which lack the Jacobsean upgrading of cities surrounding primate cities. In addition, this finding is contrary to Tian *et al.*'s (2010) results where central China has a faster convergence rate.

Given the exogeneous spillover effect, only capital stock is identified as significant to the generation of exogeneous spillovers. However, this finding coincides with Tian *et al.*'s (2010) analysis which also found negative spillover effects of capital stock in central China. Capital stock in central China is a competitive resource, mirroring the trade-off process across cities. However, other factors' exogenous spillovers are not identified at a significance level. This can be partly attributed to the small number of observations in the analysis. Another possibility is that the spatial spillovers of these factors remain within or between primate cities, referred to as the 'lock-in' effect (De Goei *et al.*, 2010; van Oort *et al.*, 2010). For example, over the decade analysed, network capital has not generated significant spatial spillovers influencing neighbouring cities. This may be attributed to the fact that local network capital is not intrinsically strong enough to transcend city boundaries or that network capital is not compatible with the spatial regime based on Tobler's first law of geography (Tobler, 1970). It should be noted that due to the data availability limitation, network capital is calculated using M&A investment flows only, so other types of flow need to be explored in future research to inform network capital in greater depth.

In conclusion, through addressing these specific research questions, general Hypothesis 3 presented in Chapter 5 is proved, '*urban growth across cities in the MYR city region is spatially interdependent, and indigenous factors, productive inter-city flows and network positions not only contribute to city region development as an outcome but also generate spatial spillovers*', however spatial spillovers are limited to endogenous and physical capital exogeneous spillovers. Given the negative spillovers identified, it can be argued that economic agglomeration continues to concentrate in core areas of the MYR city region, generating a circular causation effect which reinforces a core-periphery pattern (Fujita *et al.*, 2001). Competitive intercity relationships would impinge on the coordination of city region development and may disrupt the implementation of strategic economic transition policies. In order to avoid competition and market fragmentation that would weaken regional aggregate competitiveness, policy implications should be oriented to the encouragement of industrial diversification and cross-territorial cooperation. As discussed in Section 6.5, establishing an authorised organization to provide planning oversight across sub-regional administrative boundaries and fund cooperative projects related to factors identified factors in the analysis, could help to promote synergies between MYR cities.

In previous studies, debate has primarily concentrated on whether distance-free network capital makes spatial proximity meaningless, or whether spatial proximity remains the fundamental way to unveil the underlying regional spatial mechanism and generate spillover effects. However, it is found that the rationale of spatial proximity and that of distance-free network capital are not mutually exclusive but are instead associated in influencing regional development, which introduces an analytical departure to the investigation of the mixed regional growth model under simultaneous effects of spatial proximity and borderless flows. Although only authority network capital is identified as significant, more research is required to study different city region scales using larger datasets. This would allow exploration of the contribution of other forms of network capital to regional development and their resonance in the underlying spatial regime. In conclusion, the MYR city region is a complex space where material arrangements circulate distance-free flows, generating network capital and spatial resonations through the geo mechanism.

Summary Points

1. Capital stock, labour input and technological advances are still cornerstones driving the MYR local economy.
2. Human flows, commodity flows and capital flows are also beneficial to the local economy.
3. Power (authority position) network capital is discovered to be a significant contributor to the local economy.
4. Cities in the MYR city region may be confronted with competitive intercity relationships in this initial phase of the agglomeration process.
5. Physical capital stock is found to be a competitive resource generating negative spillover effects on neighbouring economies. However, the spatial spillovers of network capital are not identified, albeit it is opposite to direct effects.
6. The regional growth model can be improved by incorporating flow factors, network capital, fixed effects, and spatial effects.

9. CONCLUSION AND DISCUSSION

As discussed in Chapters 4 and 8, the orthodox theoretical framework used to investigate regional growth is the indigenous growth model which states that stocks of human and natural resources, physical capital and technology, are fundamental drivers of economic growth. Technically, the indigenous growth model normally employs a standard econometric modelling technique to shed light on the casual relationship between indigenous factors and economic growth in an urban system. If significant factors contributing to the local economy are identified, appropriate urban policies can be designed and implemented to upgrade these factors in order to maximise economic growth.

The logic of this approach has been regarded as a fundamental way of shedding light on and informing urban growth in a number of large studies (see Solow, 1957; Solow and Stiglitz, 1968; Romer, 1986; Lucas, 1988; Helsly and Strange, 1990; Krugman, 1997; Henderson, 2003; Bathelt *et al.*, 2004; Tirpl, 2004; Ha and Howitt, 2007; Capello and Nijkamp, 2009; Stimson *et al.*, 2011). However, the approach oversimplifies city region development as constituting a one-way causal relationship between independent indigenous factors and economic performance. Specifically, standard econometric models assume the independence of observations (cities), by regarding cities as relatively isolated markets while disregarding their dynamic spatial relations that are established by economic actors (people, firms, and institutions etc.). Therefore, the indigenous growth model has become less relevant and less applicable for explaining regional development for very large urban agglomerations and emerging city regions in the contemporary networked space economy. Cities are not isolated nodes. The development of cities is spatially associated with neighbouring cities as well as distant city network counterparts. This limitation of the indigenous growth model is therefore likely to produce biased results and to inhibit a view of the panoramic spatial regime that underlies the process of city region development.

This thesis has attempted to remedy the omission of such spatial relations and interactions in the regional growth model by taking into account the spatial spillovers that follow Tobler's law (first introduced in Section 4.3), and the network capital that emerges from city network interactions that defy spatial constraints. First, taking into account spatial relations in the indigenous growth model reduces the bias associated with the interpretation of indigenous factors and also estimates the effects of spatial proximity on city region development. The application of orthodox spatial econometrics introduces a spatial proximity matrix into the econometric model in order to estimate spatial relations to reflect that a distance decay effect determines the magnitude of interdependence (i.e. more proximate spatial entities are more connected) according to Tobler's first law of geography (see Chapter 4). This method is based on the assumption of standard economic theory that economic agents as rational decision makers, tend to minimize the cost of their economic activities, since overcoming spatial distance will consume resources, and transaction costs escalate with increasing distance. In addition, as discussed in Chapter 4, long distance (farness) is argued to be detrimental to the successful cultivation of business partnerships and business trusts due to cultural differences and institutional obstacles. The logic of spatial econometrics makes sense and reduces bias in the indigenous model, particularly when trade and the exchange of commodities are mainstream business activities in manufacturing production.

However, spatial econometric modelling also has a flaw which centres on how spatial relations across territories can be understood in the regional growth model. The rationale of spatial econometrics is that spatial effects 'cling' to the spatial order that ranges from nearness to farness geographically. If spatial effects are interpreted as spatial spillovers, spatial econometric modelling is able to calculate the magnitude of spatial effects accurately. However, importantly, spatial econometric modelling is a proxy method since it cannot track actual flows or observe discrete spillovers but can only assume that aggregate flows spread out to neighbouring areas collectively. Interpreting spatial effects solely as spatial spillovers can also result in hasty generalizations because in the information age and knowledge economy, spatial effects have become increasingly complex and less distance-dependent. Consequently, two forms of spatial effects emerge: spatial spillovers (associated with Tobler's first law) and distance-free flows (associated with Castells' network society theory). Currently, high-end manufacturing and advanced services have become the main pillar sectors driving the global economy, requiring more distant interactions such as elite, knowledge, innovation, and information, than local resources. These significant geographically extensive flows are largely virtualised and financialised, overcoming spatial constraints at a marginal cost. Meanwhile, in contrast to the significance of knowledge and information in value creation, the cost of travel and communications for producers and service providers has been reduced, facilitated by modern developments in transportation systems and telecommunications technologies.

In order to address this spatial econometric modelling flaw, some spatial econometrists suggest introducing a relational matrix based on actual flows, instead of a spatial matrix based on distance or contiguity, to estimate the spatial effects of direct flows that are not heavily dependent on geographical distance. However, this method has two drawbacks. First, in contrast to a heterogeneous spatial matrix based on geographic coordinates, introducing a relational matrix into an econometric model may lead to a severe endogeneity issue, producing inconsistent and biased results; second, it is argued that the main problem of a relational matrix in an econometric model lies in limited understanding of the spatial effects of distance-free flows. In addition to the endogeneity issue, introducing a relational matrix is also limited by its simplistic volume calculation, because it only counts ties interconnecting bilateral cities to estimate spatial relations. However, in reality, inter-city flows are characterised by multi-directionality and indirect-connectedness as discussed in Chapter 5, constructing an interconnected complex network as an outcome. In other words, introducing a relational matrix omits network positions in the inter-city flow network that could elaborate the spatial effects of distance-free flows in depth. Lastly, replacing the spatial matrix by a relational matrix does not permit investigation of spatial spillovers created by heterogeneous flows and associated network capital. Taking this research as an example, when the spatial matrix is replaced by the M&A relational matrix, the 'neighbours' specified in the spatial model become cities interconnected by M&A flows as opposed to being geographical neighbours. Thus, this method can only estimate the spillovers between M&A interconnected cities as opposed to geographically associated spatial spillovers.

Thus, incorporating calculative network capital embedded in network positions in a regional growth model can not only avoid the endogeneity issue by introducing an endogenous spatial matrix in econometric modelling, but it can also deepen understanding of the spatial effects created by distance-free flows in city region development. The thread of the theoretical and empirical approach that is developed in this research and is interwoven through the thesis, therefore relies on a geo-spatial mechanism (see in particular the theoretical review in Chapter 4 and the empirical analysis in Chapter 6), distance-free network capital (see the theoretical review in Chapter 5 and the empirical analysis in Chapter 7), and their convergence in an economic growth model (see Chapter 8).

In addition to the empirical contribution of the underlying PhD research, the emergence of a geo-space mechanism and a network space mechanism makes an epistemological contribution to in-depth understanding of the evolution of the city region system by drawing on CAS ideas: network positions embedded in cities are seen as 'emergent behaviours' derived from intricate interactions between networked city region nodes (cities); and the identified contribution of 'emergent' network positions to the local economy is seen as the 'adaptive' behaviour of local actors to an evolving environment. In conclusion, city region development should be conceived as a complex evolving process in which geo-space and network space mechanisms interact and converge. This chapter is therefore designed to address the general research question 4 'How should the spatial mechanism of the city region system be understood and what are the consequent policy implications?'.

According to the logic explained above, the first two sections of this chapter first draw together the findings from the estimation of spatial effects and network capital in a spatial regional growth model and, second, discuss their implications for understanding city region development. In the third section, the paradigm of CAS or complexity theory is referred to in order to gain a better understanding of spatial complexity in the city region system and to build a generic conceptual framework relevant for the operational practices of urban economic actors and policy makers. Reference to the CAS paradigm, draws attention to the interaction between the practices of urban agents in complex regional systems that can be interpreted as in a state of tension between 'order' and 'chaos' (Eidelson, 1997) and associated potential MYR city region outcomes..

9.1 The Spatial Mechanism in City Region Development

Based on the literature reviewed in Chapter 4, there is little doubt that spatial factors are highly influential in shaping regional economies. Nevertheless, the starting point for understanding the spatial economy remains ambiguous for most economic agents and policy makers. Due to the prevalent application of advanced spatial econometric models in regional economic analysis, spatial characteristics and patterns have become of less interest to regional scientists since they are generally seen as descriptive and are thereby not amenable to causality testing. However, as discussed in Chapter 6, if spatial characteristics such as spatial associations and heterogeneity are not illustrated, it is difficult to select suitable models with which to explore complex spatial relationships and to interpret results from advanced spatial econometric models. For example, , although potentially competitive territorial relationships between neighbouring cities are indicated in the spatial growth model, the conditions underlying such competition are not evenly distributed across territories due to spatial heterogeneity and diverse clustering situations.

If regional research does not pay due attention to the vital role of spatial characteristics and patterns in urban growth modelling, there is a danger that economic and policy actor research user actions will be misguided. It is demonstrated by the present research that recognition of spatial characteristics and patterns as well as individual city idiosyncrasies, can bring forth valuable understanding relevant for economic and policy actors.

More specifically, identifying economic gravities and drawing economic ellipses provides a macroscopic view of the regional economy, such as urban concentrations, regional disparities and orientations that can inform regional strategies and investments. In addition, recognising similarities and dissimilarities between cities by using a subgrouping technique is more than just a categorisation process since it can also assist the strategic decision making of urban actors by drawing attention to the relativity of spatial homogeneity and spatial heterogeneity. For example, in theory, if spatial heterogeneity exists ubiquitously, there is strong evidence that spatial heterogeneity needs to be taken into account in growth model specification, albeit this was not identified empirically at a significance level for the MYR city region. Furthermore, recognising which economic activities outperform others in distinguishing city network subgroups should assist urban seeking to promote a vibrant city region economic structure (for example, in relation to real estate and scientific research activities discussed in Chapter 6). Lastly, spatial association and clustering analysis can assist the identification of advantageous and disadvantageous locations within the city region system. For example, the existence of high-value clustering is identified in manufacturing and foreign investments and this may inform the strategies of manufacturers and foreign investors seeking to cluster in proximity to counterparts (for example in the cases of Wuhan and Changsha) and to take advantage of potential spillovers. Similarly, urban planners, for example those based in Wuhan and Changsha, could draw on spatial association and clustering analysis findings in designing policies for the creation of suitable business environments, including upgraded physical infrastructure, to attract inward investment in manufacturing.

As discussed in Chapter 6, recognition of spatial patterns and characteristics allows the spatial spillovers that follow the order of distance decay to be detected, informing understanding of spatial relationships in the process of city region development. Mainstream regional science and economic geography attribute spatial spillover effects to mass agglomeration in urban cores. Whereas, according to Castells' articulation of the space of flows, an urban core (once understood simply as a 'place' in regional science) has transformed into a three-dimensional 'space' generating centripetal forces which attract major growth-related flows and centrifugal forces which extend 'core' growth to surroundings. In this sense, there are two ways of explaining the extending spatial process of core growth spaces: natural spillovers and active spillovers. Firstly, regardless of the transformation of cities from a two-dimensional 'place' to a three-dimensional 'space', the "physical arrangements" of urban 'space' (Castells, 1999, p.295) are not always able to accommodate major flows, thus urban spaces can become saturated *ceteris paribus*, as in the case of traffic congestion, excessive stocks, information asymmetry, capital volatility and environmental issues etc. (Tabuchi, 1998; Mayer and Sinai, 2003; Turok, 2004; Sweet, 2014). In such cases of market saturation, certain functions or activities that are sensitive to spatial congestion are likely to spillover to neighbouring more 'spacious' areas. This process is a passive spatial mechanism generating spatial spillovers. Secondly, spatial spillovers can also be triggered as an active mechanism for a number of reasons, such as market expansion, industrial diversification and financial investments etc., because economic agents tend to locate their regional operations close to their headquarter cities (Krugman 1996a; Capello, 2009). Some of these active operations still comply with Tobler's law and therefore seek to locate in 'near' places.

On the other hand, other active operations are distributed without sensitivity to spatial constraints, as seen in the global distribution of MNCs and global production networks. European research referred to in the literature review demonstrated that a lack of attention to the interrelationship between the city region space of flows and space of places has led to a failure of policy to appreciate and respond appropriately to two distinctive city region expansion processes (Process A and Process B). As discussed in Chapter 8, MYR city region expansion is characterized by Process B in its contemporary development stage. Thus, in order to facilitate the transition from Process B to Process A, not only a suitable industrial strategy (specialisation vs diversification discussed below) based on the MYR space of places but also network thinking (discussed in the next section) based on the MYR space of flows is needed. In conclusion, combining spillover effects and network effects in city region growth modelling makes an important contribution to deeper conceptual understanding of the role of spatial effects in a city region system.

As one form of spatial effect in the context of the city region economy, spatial spillovers can potentially occur as a consequence of both endogenous and heterogeneous channels. In this research, endogenous spillovers are interpreted as cities' economic development that is affected by their neighbouring cities' economic development. In Chapter 8, negative endogenous spillovers are identified at significance level consistently in the regional growth model, reflecting competitive relationships across cities in the MYR city region. This finding revealed a divergence process in the MYR city region which may be counter to the development of urban complementarities emphasized in city region theories and China's relevant regional coordinated development policies. In addition, by referring to the Cobb-Douglas production function and the findings in Chapter 8, it can be seen that local productivity is largely explained by the endogenous accumulation of indigenous endowments i.e. capital stocks, labour input and technological advances. Thus, it is postulated that competitive city relationships in the MYR city region are attributed to a shortage of capital, labour or technology resources. This explanation is partly proven by the identified heterogeneous spillover effects of capital stock at significance level in Chapter 8, meaning that the growth of investments in local capital stock is detrimental to neighbouring cities' economic development. Furthermore, it is found that the heterogeneous spillover effects of capital stock (coefficient: -0.103) accounts for 52 per cent of the endogenous spillover effects (coefficient: -0.200). Therefore, compared to other factors, capital stock is a more competitive resource across neighbouring cities, actively affecting regional development via spatial mechanisms. This capital stock attribute can be partly attributed to the fact that physical capital is identified as the main driver of regional development in the MYR city region. Meanwhile, it can also be attributed to the fact that the spatial distribution of capital stock continues to reflect Tobler's first law of geography (distance-dependent attribute) as opposed to Castells' theoretical model (distance-free attribute). In conclusion, it is argued that indigenous factors and their endogenous accumulation not only make a contribution to local development at different scales, but also respond to spatial interactions differently. Lastly, compared to direct effects that are a concern for local policy, these indirect effect (spillover) findings are of relevance for city region policy.

As discussed in Chapter 3, the conceptual framework of city region theories is grounded in functional recognition and positive spillovers across cities in the process of regional development. Essentially, the conceptual framework coincides with the rationale of standard economic theory which highlights the equilibrium status of the economic system, reflecting the balance of industrial specialisation and diversification across cities via distributing urban functions in a spatial sense (Henderson, 1974; Duranton and Puga, 2000). However, some hurdles are presented for economic and policy actors to take into account functional city region or polycentric functional region relations in their practices. The example of the MYR city region illustrates that, in the context of competitive relationships and a shortage of input factors, local governments' competitive city development relations may arise and these are likely to impinge on the aggregate development of the MYR city region. Thus, the equilibrium economy status or functional balance highlighted in standard economic theory and city region theory is unlikely to be convincing for local governments in the MYR city region. At the same time, these competitive institutional relations will motivate local planners to pay more attention to the stimulation of indigenous factors such as physical capital, labour and technology, and to seek to control outflows of these indigenous factors especially capital stocks, in order to offset negative effects from neighbouring cities' inward investment policies.

Specifically, given the relevance of technology and labour inputs identified in Chapter 8, improving labour efficiency and stimulating innovations and scientific research are likely to be beneficial for MYR city region development in terms of upgrading the industrial base and improving the economic competitiveness of its cities (Porter, 1998). However, if in pursuit of city competitiveness, local policies focus on increasing fixed asset investments that contribute to local growth but can also hold back the development of neighbouring cities (identified in Chapter 8) a fragmented regional market would result, negatively affecting aggregate city region development. The latter scenario would limit aggregate city region development and create a fragmented regional market due to a lack of strategic planning. Thus, achieving a balance between regional industrial specialisation (supported by Marshallian economics) and a diversification strategy (advocated by Jacobsean economists) is therefore likely to be a key issue that needs to be addressed in strategy for the city region.

By referring to the discussion in Section 4.1, this research indicates that an industrial specialisation strategy, which would help to reduce inter-city competition, may be appropriate for MYR medium size cities (Henderson, 1997; Blacck and Henderson, 1998; Fujita and Thisse, 2013); on the other hand, an industrial diversification strategy can be expected to be appropriate for the triad-plus-one cities. The first reason is that cross-industry interactions in a diversified structure have been demonstrated to not only be more effective than specialized one-sector clusters in producing knowledge locally but also in generating positive spillovers to neighbouring areas (Glaeser *et al.*, 1992; Fujita and Ishi, 1998; Chandler *et al.*, 1999; Feldman and Audrescht, 1999; Pain, 2008; Antant-Bernard and LeSage, 2011), illustrating Jacobsean externalities. The second reason is that only big cities are equipped with well-established economic structures (particularly advanced services and high-end manufacturing) and infrastructure configurations that provide a necessary environment for facilitating cross-industry interactions and innovations (Fujita and Ishii, 1998; Sassen, 2000; Duranton and Puga, 2001). In other words, the diversification in big cities may not only generate local innovations and economic growth, but also generate positive spillovers to neighbouring cities, reducing competing city investment policies to some extent. In addition, investment in R&D activities and technological innovations that are argued to be an endogenous factor in adjusting the proportional contribution of input factors to productivity (Romer, 1990; Evenson and Westphal, 1995; Peri, 2005) could be another measure preventing market fragmentation and territorial competition. In light of the findings, policy objectives for development and economic growth at the city region scale require long term strategic vision that takes into account the distribution of economic functions.

In conclusion, compared to the inter-city functional balance (equilibrium status) highlighted in city region theories, it can be seen from the present research that the "actually existing" (Brenner and Theodore, 2002, p.351) spatial regime is relatively complex and accordingly requires innovative policy perspectives going forward. This finding leads to the epistemological question: is the city region a complex system with some chaos characteristics?

The literature review drew attention to contemporary Chinese planning policy 'neoliberal characteristics' which frame strategy for the realization of MYR as a 'national level city region' (see review in Section 3.4). The Chinese variant of neoliberal capitalism mixes a market logic with a regulation logic to spur urban economic development under the growing influence of private capital alongside the maintenance of strong state capital (Harvey, 2005; He and Wu, 2009). However, the tension between a local government focus on short-term returns (associated with intercity competition) and a central government focus on long-term strategic planning aims, has been argued to have caused regulatory chaos (Grengs, 2005). The research focus of the PhD has not been the contradiction underpinning local policy regulation and neoliberalism ideological positions but the city region outcomes of this contradiction. Thus, the findings on the evolving MYR city region space economy at the interface of regulation and market mechanisms are reflected upon in this final chapter to address general research question 4 'How should the spatial mechanism of the city region system be understood and what are the consequent policy implications? The remainder of this chapter aims to answer this question to some extent in part by borrowing from the paradigm of complexity theory in the third section. This will allow final consideration of Hypothesis 4: '*the city region is a complex adaptive system generating an emergent balanced urban configuration in a state of economic and spatial transition.'*

Thus, another contribution of this research is its injection of insights into the construction of a conceptual paradigm can assist understanding of the roles of urban agents in the construction and reconstruction of a complex city region system. In the next section, the significance of network thinking in city region development is discussed, and the complexity of the inter-city flow network is illustrated.

Lastly, in order to address the limitation of the geographical scope of the research, Table 16 provides a summary of the most relevant empirical studies that investigate spatial spillover effects in the regional economy in China. It can be seen that competitive relationships across Chinese provinces were significant during the decade after China opened up to international markets. This may be attributed to the fact that local endowments and the foreign capital flows that are relatively new and thereby deficient resources driving regional economic growth at the beginning of reform in China. However, since 1990, positive spillovers have emerged across Chinese cities. With regard to city region scope, the Yangtze River Delta city region benefited from positive endogenous spillovers from 1990 to 2012, while the Pearl River Delta (1990-2012) and MYR (2004-2013) city regions have been confronted with competitive relationships between cities. In terms of exogenous spillovers, it is shown that foreign capital has generated positive spillovers to neighbouring economies in China (1990-2002) and in the Pearl River Delta city region (1990-2012) respectively, while it has influenced neighbouring economies negatively in the Yangtze River Delta city region (1990-2012). In addition, on the one hand, physical capital was identified as a competitive resource across cities in China (1991-2007) and in the MYR city region (2004-2013). On the other hand, physical capital increase was beneficial to neighbouring cities' economic growth in the Pearl River Delta city region. Therefore, even homogeneous factors could generate opposite spillover effects in different city regions (e.g. foreign capital to the Yangtze River Delta and Pearl River Delta city regions respectively). Meanwhile, it is seen that aggregate positive relationships across urban economies cannot prevent negative spillovers from specific factors, and vice versa (e.g. negative spillovers of foreign capital in the positively associated Yangtze River Delta versus positive foreign capital spillovers in the negatively associated Pearl River Delta). Lastly, it is noteworthy that, as discussed in Chapter 5, since most network capital studies focus on innovation production at the organizational level, there are few studies that investigate network capital in regional development, particularly in China. Thus, no relevant empirical studies could be included in the Table 16 comparisons.

In conclusion, the reference to relevant studies in China reinforces the MYR finding that the spatial regime in regional development is dynamic, heterogeneous and scale-sensitive, leading to a complex city region system displaying tensions between short term local policy (intercity competition) and long-term strategic state aims (coordinated development) for economic rebalancing.

Region	Spatial Scale	Data Period	Dependent Variable	Endogenous Spillovers	Exogenous Spillovers	Author(s)
China	Province Level	1978-1998	GDP	-0.899***	N/A	Ying (2003)
China	City Level	1990-2002	GDP	0.208**	0.109*** (Foreign Capital)	Madariaga and Poncet (2007)
China	City Level	1991-2007	GDP Growth Rate	0.536***	-0.015*** (Physical Capital)	Tian *et al.* (2010)
Yangtze River Delta City Region	City Level	1990-2012	GDP	0.32**	−0.035** (Foreign Capital)	Wen (2013)
Pearl River Delta City Region	City Level	1990–2012	GDP	−0.135**	0.178** (Foreign Capital) 0.603** (Physical Capital)	Wen (2013)
MYR City Region	City Level	2004-2013	GDP	-0.200***	-0.103*** (Physical Capital)	Shi, Chapter 8

Table 16 The Comparison of Relevant Empirical Studies in China.

9.2 Network Capital in City Region Development

In addition to examining indigenous factors and their spatial resonations in city region development, the investigation of 'emergent' inter-city networks derived from intricate flows that overcome spatial constraints, is another important aspect of the contribution of this research to understanding the underlying evolving mechanisms of city region systems and the contribution of agent practices to this. The network thinking introduced not only complements the conceptualisation of spatial effects in regional development but also justifies the necessity of reference to the CAS paradigm to understand the evolution of city region systems due to their 'complex' interactions and 'emergent' network properties.

The network concept is clearly not new but has become a central topic in social sciences analysis concerning human interactions and social capital. Predating the information technology revolution and the creation of the Internet, the network concept was popularised in research fields such as media and business. A distinctive application of network thinking in this research however has been the focus on calculative network capital associated with transboundary direct interactions of economic agents who operate through multiple city locations and emergent network structures in city region development in an emerging economy context.

As discussed in Chapter 5, extensive city interactions in deepening globalisation are not limited to physical commodity trade but involve advanced productive factors (financial capital, knowledge, information and human resources), transforming two-dimensional physical 'places' into three-dimensional 'spaces' and initiating the necessary transition from a research focus on land use and traffic networks to relational networks such as business, value chain, knowledge exchange and financial flow networks. It can be postulated that heterogeneous distance-free flows can transform city regions from a geography of 'ordered' territories to a 'chaotic' state. Thus, in the context of complex inter-industry and inter-city relations, neither network thinking nor distance-sensitive geographical mechanisms can be neglected in understanding complex city region systems. Prior to considering complexity in the MYR city region system, some fundamentals that should underpin network thinking revealed by this research, are briefly reviewed next.

As discussed in Chapter 5, tracking direct network flows is one efficient way of understanding inter-city networks since approaches using proxy data can lack robustness. In this research, human flows, commodity flows and capital flows have been highlighted as important flows driving a regional economy. As testified by the spatial growth model, these three types of flows have been shown to be significant contributors to local growth in the MYR city region. Reflecting findings from research in Western Europe (Taylor *et al.*, 2003), corresponding policy implications for local governments are the need to reduce institutional barriers and build business-friendly environments to encourage these flows. In particular, in relation to M&A deals, government institutions should ensure that there is appropriate regulation of financial markets alongside market openness and dissipation of competitive local protectionism.

However, theoretical perspectives considered in the literature review and the empirical findings from this research emphasise the need also for advanced network thinking to be informed by empirical investigation into emerging network patterns, city functions and positions, and the practices of multiple actors that also determine these. The potential power of such an empirical lens is that as Sawyer (2005) argued, actors are not only responsive to their own behaviours but are also influenced by emergent patterns and their positions in socioeconomic systems. It follows that, intertwined with the interaction between and accumulation of heterogeneous flows, some emergent properties will be embedded in urban 'locales', creating network capital for regional development. These emergent properties will be discussed systematically in the next section of this chapter. Thus, the calculative network capital discourse and the SNA approach discussed in Chapter 5, endorse the importance and value of data on the dynamics of cumulative multi-directional flows to augment data on direct flows. Indirect city connectedness revealed by spatial econometric modelling and structural positions embedded in network space, is another characteristic of importance for understanding network space where cities can be connected to networks via economic agents operating in other cities. Cities' distinctive network positions have been calculated in this research by estimating Betweenness, Closeness, Clustering Coefficient, HITS and Internet Page Ranking to shed light on embedded network capital. It is found that different cities hold different network positions in the MYR inter-city network, while most network capital is concentrated in a limited number of cities.

Investigating the evolution of the MYR inter-city network has established that the transition from a dispersed network to a centralised network is not a linear transition over time (another characteristic of CAS). Meanwhile, in addition to the network analysis itself, emergent network authority has been detected as a significant contributor to local economies in the spatial growth model. Thus, related 'authority' network capital is beneficial for economic actors and also for the local economy. This finding partly verifies the internalization of network capital in 'locales' (local spaces). Accordingly, strategically policy needs to be informed by a comprehensive tracking system for transboundary flows that are determinants of cities' network positions. After the tracking system is established, up to date 'authority' network capital scores can be calculated and can subsequently inform economic development policy. However, it should be noted that network capital in city regions is generated in unique pathways conditional on heterogeneous flows and temporal and local contexts. For example, the MYR city region is characterised by a centralised network pattern where most network capital is held by prime cities, based on M&A financial flows during the relevant period. Thus, given the deficiency of city region studies in exploring the relationship between 'natural' network positions and the regional economy, additional quantitative and qualitative empirical and theoretical research in this area is required (see also Section 9.4 'Limitations of the Research and Future Research Directions').

A further consideration relevant for policy to be noted is that in China's economic transition, many cities and regions have been aiming to become advanced business services hubs with high value-added activities as discussed in Chapter 3. However, in line with international global cities research, the MYR case illustrates the need for major agglomeration of specialised skilled labour and deep business and technological infrastructures to sustain such clusters and the importance of 'gateway' (hub) network capital that connects medium size cities to the global economy. In conclusion, the different but complementary network positions of MYR cities contribute to a connected city region economy and diverse positions in networks can inform coordinated development strategies.

Lastly, as Castells (1999, p.255) argued that even the most advanced flows have to be stored and circulated in "physical arrangements". Accordingly, by referring to the identified spillovers of indigenous factors, this research has assumed that 'emergent' network capital is not only embedded in 'locales' contributing to local development, but is also supported by spatial mechanisms reflecting Tobler's first law of geography. The fact that spatial spillover effects of 'natural' network positions have not been identified as significant in the MYR city region may be attributed to the fact that in comparison with mature city regions, network capital is not sufficiently developed to transcend 'locale' boundaries and generate spatial spillovers. Nonetheless, exploring spatial spillovers associated with embedded network capital can be a meaningful avenue to pursue in order to unveil underlying city region spatial mechanisms albeit technical difficulties in estimating nonlinear relationships between inter-city flows and regional aggregate economy need to be addressed.

9.3 The MYR City Region: A Complex Adaptive System or a Planned Scheme?

As discussed in the first two sections of this chapter, geo-spatial mechanisms and network space mechanisms are both meaningful considerations that can shed light on the underlying spatial regime of city region development. Correspondingly, implications from this research for policy concerned with regional growth discussed so far have reflected the empirical results on geo-spatial and network mechanisms (translating the findings of this thesis into some tentative policy recommendations). Some ‘emergent’ properties and nonlinear development paths revealed indicate resonance with complexity theory and the CAS paradigm, as discussed next.

9.3.1 What is a CAS?

The CAS discourse, which derives from the investigation of nonlinear (sometimes abrupt and dramatic) transformations and non-equilibrium systems in the physical and natural sciences, has diffused into several fields of social and behavioural sciences, including economics, management science, archaeology and political science (Nicolis and Prigogine, 1989; Gell-Mann, 1995). CAS is not a specific model or approach but is rather a set of conceptual ideas to assist understanding of the evolution of systems in different fields, such as self-organization, path dependency, heterogeneity, decentralization, randomness and upheavals. The rationale behind the theory is that systems are not the sum of the properties of their components and simple interactions but are instead complex adaptive systems (Miller, 2016). As Holland (2006) defined, “CAS are systems that have large number of components, often called agents, that interact and adapt or learn (p. 1).” In consequence, reference to CAS can also potentially assist investigation in future research of the sub-nodal network level of agents who create the network through city nodes (Knoke and Kuklinski, 1982).

CAS is characterised by two prominent properties: ‘complex’ and ‘adaptive’ properties. The ‘complex’ property of CAS is attributed to the fact that the behaviours of the ensemble cannot be predicted by the behaviours of its components. Meanwhile, the components of ensembles are 'adaptive' in a dynamic environment where both individual interactions and collective behaviours often mutate and are self-organising (Holland, 2006; Miller and Page, 2009; Anish and Gupta, 2010). Holland (1992) used a biological metaphor to assist understanding of the 'adaptive' property of CAS:

> Consider the immune system, it consists of a large number of highly mobile units, called antibodies, that continually repel or destroy an ever-changing cast of invaders (bacteria and biochemical), called antigens. Because the invaders come in an almost infinite variety of forms, the immune system cannot simply develop a list of all possible invaders. Even if it could take the time to do so, there is simply not room enough to store that information. Instead, the immune system must change or adapt its antibodies as new invaders appear (p18).

The structure of CAS can be hierarchical, but it more often exhibits self-organization "by which a structure or pattern emerges in an open system without specifications from the outside environment (Barton, 1994, p.7)". Holland (1992) further specified self-organization by articulating that "systems change and reorganize their component parts to adapt themselves to the problems posed by their surroundings. …. they constitute a moving target (p. 18)"; however, self-organization does not mean that components are operating individually in the same way. In contrast, components acquire distinctive self-organization capacities in adapting to intricate interactions and interdependencies (Holland, 1992).

In terms of operating mechanisms, CAS proponents argue that a CAS is operating between order and disorder, referred to as 'the edge of chaos'. The edge of chaos is regarded as a positive environment for components to evolve adaptive self-organization. As Eidelson (1997) argued, neither an ordered regime nor a disordered regime can build a positive environment to facilitate sustainable systems because under an ordered regime, systems are too rigid to promote information exchange across components, limiting responsiveness to a dynamic context. In contrast, under a disordered regime, systems are too turbulent to organise interconnections smoothly, causing effectiveness malfunctions (Eidelson, 1997). This dilemma has relevance for the Chinese neoliberal policy variant.

Eidelson (1997) articulated the positive operating mechanism under the edge of chaos as follows:

> Through a dynamical, continuously unfolding process, individual units within the system actively (but imperfectly) gather information from the neighbouring units and from the external environment. This information is subjected to local rules, and responses are formulated; these responses then work their way through the web of interconnected components (p.43).

However, in spite of applications in other social sciences fields, the CAS paradigm has not penetrated deeply in spatial economics and regional development studies albeit some economic geographers and regional scientists refer to complexity discourse in their work, challenging conventional theoretical perspectives (see Krugman, 1996b; Arthur *et al.*, 1997; Manson and O'Sullivan, 2006; Plummer and Sheppard, 2006; Martin and Sunley, 2007; Hausmann *et al.*, 2014). In conventional economics, the regional economy is seen as an equilibrium system in which rational economic actors overcome distance constraints and access to markets, pursing profit maximisation and cost minimization. The chaotic or unstable state of systems is normally attributed to contemporary disorganization or malfunction. Actors in economic systems act collectively and are observed as indirect interactions via market mechanisms (Beinhocker, 2006). Standard economic models that have been the dominant research approach to the investigation of economic phenomena have relied on assumptions and have employed mathematical analyses in order to control for homogeneous markets and actors. However, economic geographers and regional scientists have noted the importance of spatial heterogeneity in shaping the behaviours of economic agents across spatial entities, leading to a complex economic system in a geographical sense (see Anselin, 1988; Krugman, 1991, 1996b; Fujita *et al.*, 2001; Redding and Venables, 2004; Manson and O'Sullivan, 2006; Plummer and Sheppard, 2006; Martin and Sunley, 2007; LeSage and Pace, 2010; Hausmann *et al.*, 2014).

The penetration of complexity theory in economic analysis can be argued to have begun with Marshall's argument that "the mecca of the economist lies in economic biology rather than economic dynamics'' (Marshall, 1930, xiv). In the late 1990s, borrowing from biological models in economic studies became popularised in the investigation of increasing returns and positive 'lock-in' effects in economic processes (Arthur, 1989, 1990, 1994). Based on Arthur's works on path dependence in economic development, Krugman (1994, 1996b) elaborated the complexity framework as one of the conceptual strands in the New Economic Geography in order to investigate economic landscapes and the self-organisation of the spatial economy. He argued that 'order from random growth' in economic fields (such as urban growth) can be understood by ‘order from instability’ emerging in the CAS (1996b, vi). Thus, the CAS paradigm was conceived by economists as an ‘umbrella’ for unveiling ‘complex’ economic activities and related spatial reflections (Buchanan, 2004; Beinhocker, 2006). On the other hand, Beinhocker (2006) also stressed that the CAS paradigm is more plausible for setting up a conceptual framework contributing to the ontological understanding of economic systems, than it is as a coherent and synthesized approach.

Martin and Sunley (2007) specified the significant connection between the CAS paradigm and spatial economy studies explicitly:

> the notions of self-organization, emergence and adaptation resonate closely with questions about how the spatial structure of an economy emerges and changes; about how regional and urban economies rise and fall in relative prosperity; about why some regional and urban economies appear more adaptable than others over time to shifts in technology, markets, policy regimes and the like; about why certain industries and technologies develop in particular geographical areas but not others; and about how the various spatial networks of economic relationships and flows form and evolve (p. 594-595).

In addition, among spatial entities, city region systems that are constituted by interactive cities are conceived as a quintessential example of the CAS paradigm (Batty *et al.*, 2006). However, the complexity discussion in regional science has tended to be staggered in metaphorical implementations which have demanded more rigorous empirical studies. Therefore, this research can make a positive contribution to policy relevant understanding of the evolution of the city region system by drawing on complexity theory. However, it remains for other studies to introduce consideration of the interaction between economic and policy actors in a CAS approach which could have high significance for Chinese city regions in political economy transition.

In conclusion, the CAS paradigm has value for building a generic conceptual framework for regional scientists to dissect complexity in the process of city region development, in particular given the convergence of geo-spatial and network space mechanisms in this research, as discussed next.

9.3.2 The Complexity in City Regions

Next, by referring to the CAS paradigm and related studies, an attempt is made to dissect the complexity of the MYR city region based on empirical findings examined in this research. It should be noted that in the context of this research, the resemblance between CAS and the city region system can only illustrate potential ways of exploring underlying operating mechanisms of city region systems, rather than verifying the city region as a standard CAS. However, the dissimilarities between CAS and the city region system will be discussed in the next section. Here the resemblance between the city region system and CAS is considered from the perspectives of the three main CAS characteristics: complexity, emergence, and adaptive capacity.

Firstly, the ‘complex’ properties of the MYR city region system are mostly attributable to heterogeneous spatiality reflected in spatial dissimilarity, modularity and clustering, illustrated in the Chapter 6 analysis. As Dopfer and Potts (2004) argued, heterogeneous attributes of observations are fundamental sources to generate complex economic systems. Meanwhile, interactions between heterogeneous actors are capable of generating complex aggregate dynamics and intricate structures in space and time, reflecting the fluidity of economic systems and making economic systems more complex (Flake, 1998; Potts, 2000), identified in Chapter 7. These interactions are initiated by heterogeneous agents ranging from individuals, institutions, and governments in different ways. Lastly, the ‘complex’ properties of city region systems are also revealed by the way in which any constituent city can affect several others or the whole system, as shown by spatial indirect effects identified in Chapter 8. Thus, understanding of an individual city’s growth cannot simply be aggregated to convey the behaviour of the whole city region system. In this sense, the city region is a ‘complex’ system where the spatial regime is not the aggregation of individual static entities (cities).

Secondly, the emergent properties of city regions are mainly reflected by the embedded network positions emerging from intricate inter-city flows generated by economic agents. These emergent network positions in the city region system arise from the myriad of unintentional outcomes of micro-level actions by economic agents. The network evolution atlas (see Figures 26 to 28 and the video clip in the attached disk) shows how cities’ network positions emerge dynamically in their surroundings according to centripetal forces created by interactions and centrifugal forces created by urban mass. Table 8 illustrates these different emergent network positions.

Thirdly, economic actors and constituent cities in city region systems have to improve 'adaptive' capabilities to emergent surroundings where heterogeneous flows are circulating dynamically. As Potts (2000) argued, it is connections or interactions that make economic systems complex and make economic agents adaptive and self-organised. The 'adaptive' properties of city regions are reflected in two aspects. First, the detected contribution of people, commodities and capital flows to the local economy provides evidence of cities' 'adaptive' responses to intensifying heterogeneous flows. Second, the authority position that emerged in the inter-city network is shown to have a regressive impact on local economies (identified in Chapter 8), influencing local actors' behaviours and actions as an outcome. This finding verifies that city region systems not only adapt to 'actually existing' flows but also adapt to emergent network positions. Accordingly, policy actor interventions such as reducing barriers for transboundary flows is essential to improve cities' adaptive capability. In this sense, the contribution of inter-city flows to city development can be interpreted as 'first order adaptation', while the feedback effect of emergent network capital on city development can be interpreted as 'second order adaptation'.

Economic geographers have focused on unveiling the effects of spatial patterns (e.g. clusters and urban agglomerations) in shaping the behaviours of economic actors at a local level, such as the circulation of knowledge which makes systems complex (see Maskell, 2001; Pinch *et al.*, 2003; Martin and Sunley, 2007). However, studies that look into the feedback effect of intensifying inter-city interactions impacting on city region development remain insufficient, in particular regarding emergent properties derived from intricate interactions across territories. This empirical research not only bridges this gap but also provides an important avenue to investigate "upward and downward causation" (micro-level interactions give rise to global network properties that reversely influence the local economy) (Martin and Sunley, 2007, p.596) in the evolving process of city region systems.

Lastly, as discussed in Section 5.3, in contrast to a star network or a complete network, an incomplete network (centralised network in the case of this research) is a more active network space where network capital is generated, which has resonance with the imperfect information exchange in the edge of chaos highlighted in the CAS paradigm (Eidelson, 1997). Thus, an incomplete network can provide a positive evolving environment for complex city region systems where complex interactions circulate and economic agents become self-organised and adaptive to dynamic environments.

In addition, the CAS paradigm provides insights that can inform discussion of city region boundaries. As reviewed in Chapter 3, there are two main methods of defining city region boundaries: first, traditionally, territorial administrative boundaries are used to circumscribe city regions, especially in institutional definitions and empirical studies; second, natural economic areas are seen as circumscribing city region soft boundaries albeit these are limited by data availability. Both methods are intrinsically based on the assumption that the city region can be circumscribed by a line on a map. Martin and Sunley (2007) proposed a novel way of understanding the boundaries of economic systems based on the CAS paradigm. They argued that the boundaries of economic systems cannot be circumscribed as polygon shapes by drawing lines, but are folded in or internalised within systems as "functional components that do not separate but connect systems with their environment" (Martin and Sunley, 2007, p.586). This argument articulates the way that constituent cities in city region systems are never far from the functional boundary regardless of geographic location and administrative division where local polices are decided. The formation of boundaries will not be determined by geographic proximity or artificial planning schemes but by intricate interactions over territories and the capacity of cities to maintain their configurations in the process of self-organisation. However, Martin and Sunley (2007) did not clarify how to identify capacity in maintaining configurations, which leaves a research gap and ambiguous space in understanding the boundaries in economic systems. In addition, their idea presents an epistemological conflict between the paradigm of CAS and that of conventional city region theories, since the notion of the city region is intrinsically based on the importance of physical contiguity in forming an integrated market as a basic assumption in standard spatial economic models.

The internalization of boundaries in a city region is more realistic and is capable of enlightening economic actors' understanding of the complexity of a city region system in depth, particularly in generating innovations, knowledge, and strategic operations etc. over spatial constraints while reducing a focus on intercity competition. However, a difficulty is that folded-in boundaries are too complex and too dynamic to be estimated empirically. At least, due to the limitations of contemporary technology, it would be impossible to illustrate the 'folded-in' boundaries in a two-dimensional map or a three-dimensional model (e.g. Figure 39 in Chapter 8). Lastly, the boundaries of CAS in a geographic sense are ambiguous, which presents the difficulty of distinguishing endogenous dynamics and exogenous influences.

Since the complex ‘folded-in’ boundaries cannot be illustrated and physical boundaries cannot be abandoned in regional planning, a solution could be to investigate the outcomes of ‘folded-in’ boundaries indirectly by estimating the global ‘emergent’ properties derived from complex transboundary interactions and estimating the maintaining capacity that is not clarified in Martin and Sunley’s (2007) work. In terms of the research gap, this thesis presents a research avenue: at the first step, SNA or other graph theory tools are utilized to identify global emergent properties of systems by tracking direct interactions across cities; at the second step, identified emergent properties from SNA are specified in local growth models in order to estimate their contribution to the local economy; if they are identified as significant contributors, we can say that to some degree these cities have capacity in maintaining their configurations such that the boundaries of city regions are relatively reasonable, or vice versa. The rationale behind this deduction is that although these properties emerge at a global level, they have to be stored in local space (such as network positions stored in individual cities); if they are not able to embed in the ‘locale’ where physical arrangements are provided to accommodate flows, their storage space will be taken by other beneficial indigenous factors. However, even if the emergent properties are capable of driving the local economy, it does not indicate that the boundaries of cities are optimal and absolutely positive to the evolution of a city region system; this method can only identify the detrimental effect of boundaries on the development of a city region. Thus, it is argued that, for the foreseeable future, spatial contiguity will be maintained as the precondition to define the boundaries of city regions, but economic and policy actors within a city region need take into account complexity to comprehend ‘folded-in’ boundaries and be able to initiate operations such as investments and strategies across cities instead of merely complying with Tobler’s law. In conclusion, given the resemblance between CAS and the city region system discussed above, MYR city region development is characterised by a complex adaptive process in a spatial sense where dynamic interactions, emergent behaviours and imperfect information exchange exist within a folded-in boundary. This finding verifies general Hypothesis 4 presented in Chapter 5 that is: *the city region is a complex adaptive system generating an emergent balanced urban configuration in a state of economic and spatial transition*.

9.3.3 How to Estimate Complexity in City Regions?

In terms of an epistemological perspective, CAS studies are focused on understanding non-deterministic phenomena (such as quantum mechanics as a typical example or deterministic-yet-chaotic systems such as weather patterns) and adaptive processes in distinctive systems through analysing emergent behaviours and interactive patterns of components derived from a "kaleidoscopic array of simultaneous interactions" (Holland, 1992, p19). Since components are constantly revising their conditioned rules for interaction and are embedded in the changing context created by novel interactions of other components, the global state is often dynamic and intricate. Thus, CAS studies normally employ natural reflection methods or biological models to explain the non-deterministic phenomena.

However, borrowing directly from biological models to investigate economic patterns of city region systems is not sufficiently robust, since some economic phenomena are deterministic, such as the Cobb-Douglas production function. As Martin and Sunley (2007) argued, applying the formal models of CAS from the natural sciences cannot unveil full information on economic interactions precisely, and may produce distorted results in the investigation of economic patterns through investigating the evolution of socio-economic systems rather than natural reflections of neurons and chemicals because the trigger mechanism of economic behaviours is intuitive, reflecting human practices and behaviours such as knowledge and foresight (Potts, 2000; Foster, 2004; Hodgson and Knudsen, 2006; Manson and O'Sullivan, 2006; Ramlogan and Metcalfe, 2006). For example, some powerful economic actors are capable of transforming their economic surroundings by buying out competitors, switching investments into new sectors and locations, introducing breakthrough innovations in products and operating processes, or remaking markets through mass advertising (Porter, 1998). Meanwhile the interactions of policy and economic actors in CAS demand attention in different political economy contexts. In addition, if certain components are disabled in a CAS, the others are able to reorganise themselves and compensate for the loss with changes that may even create niches where none had previously existed (Eidelson, 1997). However, if a city is disabled, it will be catastrophic for people who live there no matter how successful peer cities are in adapting to the new environment. The withdrawal of urban functions (Mumford, 1961; Starr, 1976) has already proved to have major negative economic and social effects in the 1980s, as reviewed in Chapter 2. In a similar vein, different from CAS studies in natural science, cities, as the components of a city region system, cannot be sampled to design experiments in a laboratory like neutron systems or biological bodies or to build up ‘flight simulator like’ interfaces employing parallel computers and mathematics.

In conclusion, it is argued that the CAS paradigm can provide a “philosophically inclined social-ontological approach” (Martin and Sunley, 2007, p.595) to understand the underlying operating mechanisms of city region development, albeit it is less useful for providing specific models in an epistemological sense. This raises the question, if it is not possible to abduct complexity from natural science for application to city region systems directly, how can complexity in city region systems be estimated?

Pursing the same line of reasoning as Arthur and Krugman (Arthur, 1994; Krugman, 1996b; Arthur *et al.*, 1997), a spatial econometric model has been adopted in this thesis to reduce the bias of perfect assumptions in standard economics, such as the independence of observations and inherent equilibrium in an economic system. Although complexity theory highlights the nonlinear path of CASs, regional development is still characterised by linear (or mathematical) dynamics to some extent. This may be attributed to the fact that city region systems are still not as ‘complex’ as, for example, a brain system. Therefore, econometric models can provide some valuable insights to understand city region development. Essentially, they are a bottom-up approach since they explain the regional economy as a whole by estimating the contribution of indigenous factors to the local economy primarily, and spillover effects to neighbours subsequently. However, as Rosser (2004) and Cilliers (2005) pinpointed, this approach restricts the mechanism of socio-economic systems to a pre-determined geometry under Tobler’s law and remains committed to formal deductive models (such as non-linear equations, power law functions and the like) rather than actual interactions, albeit spatial-temporal considerations can reduce the bias of standard economic models. By drawing on Beinhocker’s articulation of economic systems (Beinhocker, 2006), the economy is an open system illustrating a non-linear developmental path where components’ local interactions lead to emergent patterns at global scale and these global patterns generate feedback effects on local behaviours. This means that a formal economic model based on mathematical functions that are used to explain deterministic behaviours is not sufficient to understand the complex behaviours of an economic system.

Thus, in addition to spatial econometric models, an SNA approach was used in this research to shed more light on spatial complexity in city regions. Firstly, an SNA approach can investigate intricate direct flows across cities that do not follow a spatial order in inter-city networks. As Sawyer (2005) argued, direct interactions across cities contain the representation of global emergent properties of regional socio-economic systems. Secondly, SNA is a more suitable approach to illuminate a “kaleidoscopic array of simultaneous interactions” (Holland, 1992, p19) since the applications of graph theory in SNA can illustrate the emergence and evolution process of multiple connections in the form of networks (Potts, 2000). More importantly, the emergent network capital calculated by the SNA approach can be specified in spatial econometric models to examine local adaptive responses to global emergent properties (network positions in this research), which avoids the simplistic one-way sequence from local interactions to global emergent properties (Potts, 2000; Martin and Sunley, 2007, p.587). This approach also provides a trajectory to examine whether geo-space mechanisms and network space mechanisms are converged in a state of order or of chaos. For example, if the local effects and spatial spillover effects of emergent network positions coincide, no matter whether positively or negatively, it indicates that the convergence of network space and geo-space mechanisms is relatively ordered, or vice versa. Lastly, as discussed in Chapter 5, compared to GPN and ION models, SNA is a scale-free network approach which can be applied at different geographical scales.

In conclusion, the cross-fertilization of geo-space mechanisms by estimating spatial spillovers and network space mechanisms using SNA can shed more light on the complexity created by intricate and dynamic transboundary interactions in the process of city region development. Thus, this research trajectory paves the way for future regional studies to unveil complex spatial regimes in city regions.

9.3.4 Active Adaption to Complex City Region Systems

By drawing on Miller’s (2016) perspective and the CAS paradigm, policy reflections can be focused on how to minimize the emergence of negative phenomena and provide a positive environment to facilitate the emergence of positive phenomena in city regions. In other words, although economic actors’ adaptive behaviours and cities’ self-organisation may give urban systems strong resilience in the face of turbulence (Lindsay, 2005), government interventions can play a key role in CAS relevant to systematic vibrancy versus crisis. As Martin and Sunley (2007) argued, while markets show forms of self-organization and coordination, it is clear that there are numerous institutional and political preconditions which allow these coordinating effects to occur. Therefore, insightful strategies and planning are necessary and in the context of China's political economy transition, network and CAS understanding is likely to be especially relevant.At the beginning of economic reform in China, strategic policy-making adopted a 'crossing the river by feeling the stones' principle (Hope *et al.*, 2003; Cai and Wang, 2010) due to lack of government experience in developing a capitalism economic system in the Chinese institutional context. However, having passed the initial stage of capital accumulation and become a global manufacturing centre, strategic planning in China needs to build up dynamic feedback mechanisms to provide empirical evidence for decision-making and policy adjustments. In particular, building up a tracking platform is necessary to observe dynamic flows across territories. Currently, the establishment of these platforms is largely restricted to data collection on intricate interactions and data confidentiality, which demands more policy attention. Thus, local and regional governments are encouraged to collect interaction data from all societal fields and to produce scientific reports to dissect complex regional environments for economic actors. In addition, associated with growing capacity in tracking flows, the identification of cities' network positions and cohesive sub-groups has become strategically significant for policy making.

In addition to strategic network positions, defining the boundary of city regions for the allocation of strategic resources to facilitate regional economic growth, is particularly important in China where government and state-owned enterprises play a significant role in shaping economic and institutional environments. Although boundary definition under the CAS paradigm cannot yet be illustrated on map, policy makers should pay due regard to the dynamics of cross-territorial flows as opposed to arbitrary boundaries on administrative maps. For example, the overlap of cohesive subgroups and geographical contiguity is a more appropriate and scientifically informed indicator for the definition of city region boundaries.

It is generally argued that policies cannot create urban prosperity directly (Taylor *et al.*, 2003) or determine the evolution of city regions (Hall and Pain, 2006). However, urban and regulatory policies are able to provide the context for the generation of positive emergent behaviours and support the adaptive capability of economic actors. As Eidelson (1997) articulated, "the dynamics of the positive feedback cycle are self-reinforcing and potentially amplify the impact of a small change or adjustment (p.49)." In particular, the amplification effect of the adjustment has the most resonance in the transition phase. It is argued that the transition phase is when a system has maximum adaptability and maximum effective information exchange. Thus, it is relevant for economic actors to take advantage of the city region transition phase to improve their capacity in positive self-organization and accomplish nonlinear growth, such as in the economic transition of China and the city network transition from a star network to a centralised network in the MYR city region.

9.4 Limitations of the Research and Future Research Directions

Firstly, a limitation of the research is its focus on one Chinese case study - the MYR city region. Significant differences are likely to exist across city regions in China due to their specific industrial and institutional development contexts. However, none of the empirical studies most relevant for the present research, referred to in Table 16, have used the same analytical approach to investigate the convergence of geo and network spaces in regional development. In consequence, the results are not generalizable since it is not possible to know their relevance for other city regions. In addition, they are conditional on specific time periods, sectoral definitions, geographical selectivity and to a lesser extent the spatial weight matrix that reflects the spatial relations of cities in the MYR city region. In conclusion, while the research finding on the significance of geo- and network space mechanisms is portable to other studies, further research employing the same analytical approach is needed for the investigation of the underlying spatial regimes in other city regions.

Secondly, since the sample data are limited to prefecture city level only, the research may miss information at smaller scales i.e. county and urban district levels. Although aggregating to city level scale can diminish the problem of zero patents or M&As (zero M&As also cause zero network capital), it will detract from the ability to produce estimates and inferences that are representative of intra-city interactions and patterns. Therefore, multi-scale spatial analysis is needed to unveil the full panorama of the city region spatial regime and to shed light on scale effects in further city region studies when data are available.

Thirdly, the network capital analysis is limited to M&A deals in the MYR city region due to data availability and limitations. This means that the effects of heterogeneous inter-city flows and their embedded network capital cannot be solely represented by M&A capital flows, regardless of their long-term spillovers, as discussed in Chapter 7. It should be noted that M&A deals are clearly not the sole channel to diffuse network capital and generate spatial effects. Other channels constructing inter-city networks and diffusing network capital include, for example, joint ventures, non-financial investments, strategic cooperative partnerships, co-funded projects, concurrent executives (elite exchange) and trade deals. In addition, heterogeneous flows resonate in spatial regimes in different ways (e.g. some are distance-free while some are relatively distance-dependent). Thus, further research is needed to collect more flow data to facilitate network analysis and to better identify the different channels of network capital, particularly during the economic transition period in China. Meanwhile, a qualitative approach such as interviews with economic and policy actors is missing and needed to investigate in depth network actor behaviours, practices and initiatives in order to understand the role of network capital in space more deeply and to improve the efficacy of policy.

Fourthly, policy implications based on the research findings are limited to the issues of coordinated development within the city region. There is no doubt that China's economic development is highly related to its policy orientations which are in transition due to its powerful territorially focused interventions which now incorporate neoliberal characteristics. As reviewed in Section 3.4, the strategic position of the MYR city region is highlighted in China's national planning scheme during present ongoing economic transition. However, since these policies are relatively new and few studies have examined the 'real' strategic position of the MYR city region and its relevance for territorial policy orientations. Strategic policy questions that need to be addressed include, whether the MYR city region really is absorbing surplus productivity from the developed coast and interconnecting it economically with the underdeveloped west. Thus, more research is needed to clarify the ways in which Chinese cities are servicing global capital and the external connections of the MYR city region at the fuzzy end of World City Network (Markusen, 2003), in order to inform pressing policy questions.

Fifthly, there have been two more minor technical concerns in the production of the results. First, the strong concentration of advantageous factors in Triad+1 cities and their heterogeneous economic structures may influence the results. Second, due to the small dataset and multicollinearity across variables, the research specified only three network capital variables in the regional growth model, which limits the results to specific forms of network capital in city region development.

Lastly, the investigation of regional development in the research has been empirically limited to the economic field. The research has focused on capturing economic drivers from the association of network and geographical factors. Other spaces requiring investigation in assessing city region development, for example, institutional, social, cultural, and environmental spaces etc., which are active in and may be compromised by the pursuit of economic growth should be taken into account in future research. This limitation further illustrates the complexity of city region systems, and the need for more attention to network and complexity thinking in future city region strategic planning. In addition, the relationship between the CAS paradigm derived from biological models and city region theory derived from spatial dynamics remains vague and limited to theoretical discussion e.g. evolutionary economics. Given this, future empirical studies combining both paradigms are needed to clarify this relationship, particularly in terms of how to generate positive adaptions in complex dynamically adapting spatial-economic systems. Thus, while examining the convergence of geo-space and network space is of great importance, it is not the sole lens required to dissect complexity in city region systems.

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Appendix

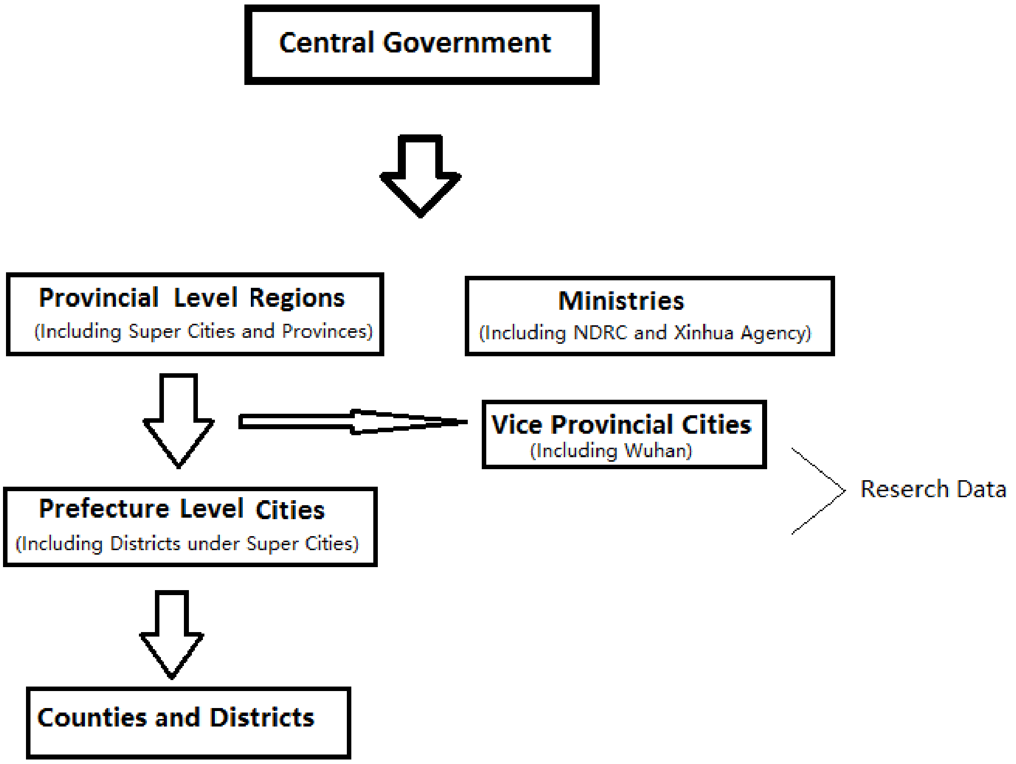

Figure A2 China's Administrative Structure.