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Network Capital and Urban Development:

An Inter-urban Capital Flow Network Analysis

Siu Kei Wong[1], Shuai Shi[2], Chen Zheng[3]

[1] Department of Real Estate and Construction, HKUrbanLab, University of HongKong, Hong Kong or skwongb@hku.hk.
[2] Department of Real Estate and Construction, University of HongKong, Hong Kong or alexshi@hku.hk.
[3] Department of Real Estate and Planning, Henley Business School, University of Reading, UK or chen.zheng@henley.ac.uk.

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Abstract: This study investigates the role of network capital in urban development by utilizing Mergers & Acquisitions (M&As) as a flow metric to construct China's inter-urban capital flow network. Firstly, an uneven geography of network capital is revealed, indicating regional disparity. Secondly, we identify a positive impact of outward- and gateway-network capital on urban economic growth. Additionally, the impact of the emergent network capital is moderated by local human capital and knowledge stock, indicating a networked agglomeration economy. The findings support a coordinative and place-based policy for fostering urban and regional development.

Keywords: Network Capital, Urban Development, Inter-urban Capital Flows, M&As, China

Introduction

Associated with ICT breakthroughs and financial liberalization, the spatial constraints of economic activities have been largely lifted and inter-urban interactions have tremendously extended from flows of tangible resources (e.g. commodities and labour) to flows of intangible ones (e.g. financial capital, knowledge, and information). Urban space has become a complex network system of interconnected cities that determines the dynamics of urban development (Castells, 1996; Hall and Pain, 2006; Bathelt and Glückler, 2011; Miller, 2016). Studies have shown that urban competitiveness depends on not only creating a localized highly-productive agglomeration economy (Rosenthal and Strange, 2004; Turok, 2004; Ellison et al., 2010) but also generating positive network externalities via transboundary linkages. Establishing external pipelines to distant

resources, especially capital and knowledge, has become one of the most sought-after goals for cities to improve their competitiveness (Bathelt et al., 2004; Trippl et al., 2009; Breschi and Lenzi, 2014; Huggins and Thompson, 2017; Shi et al., 2019). In this context, urban relational network analysis has become a prevailing approach to examine urban dynamics and development trajectories (Taylor et al., 2002; Coe and Yeung, 2015; Derudder et al., 2010; Sigler and Martinus, 2017; Derudder and Taylor, 2018).

However, as Derudder (2019) points out, the issues examined by existing city network studies are often self-evident, leaving the question of whether network relations can be translated into 'actual capital' for urban growth unanswered. Huggins and Thompson (2014) thus propose the notion of network capital, defined as "the form of investments in calculative relations through which organizations gain access to knowledge to enhance expected economic returns" (p.512), to bridge the gap between network relations and economic growth. Moreover, current network analysis tends to focus on flow metrics available in economic accounts, while ignoring the intangible flows that could essentially influence the construction of urban relational networks and policy (Burger and Meijers, 2016). Thus, there is a research gap in how to unravel urban network capital through measuring intangible knowledge exchanges across cities – such exchanges are preferably based on long-term commitments (e.g. partnership agreements) rather than informal and occasional interactions (Huggins and Thompson, 2014; Ellwanger and Boschma, 2015; Huggins and Thompson, 2017; Shi and Pain, 2020). This article deploys Mergers and Acquisitions (hereafter M&As) – corporate ownership transfer transactions for consolidation or restructuring – as a novel flow metric to capture the network capital embedded in inter-urban capital flow networks.

M&As are chosen as the flow metric of network capital for three reasons: 1) M&As represent a specific type of investments that is known to trigger long-term inter-organizational collaborations,

e.g. know-how learning, business resource sharing, and elite exchange etc., not just a one-off capital flow to another business (Cartwright and Schoenberg, 2006; Lee and Lieberman, 2010); 2) only M&As involving both the change of ownership control and the actual transfer of a business, rather than the financially-motivated conglomerate M&As, are included in order to signify genuine knowledge flows; 3) in the context of China, M&As are important economic activities that have facilitated industrial restructuring and upgrading during the economic transition period.[i] Current M&A studies focus only on corporate finance and operations (e.g. screening, operation and post-performance etc.) and largely neglect the spatial implications of aggregated M&A flows for urban development (Ellwanger and Boschma, 2015). Although M&As in China have received more attention recently (Wang, 2019; Sheng et al., 2020), the focus was either on the M&As' network itself or on the investigation of first-order network linkages across cities. The implications for urban development and second-order network positions have been neglected. Thus, this study fills the gap by exploiting the M&A-induced network capital (both linkage and position) and its spatial implications on urban development.

Furthermore, notwithstanding the realization of urban network economies, few studies examine how the interplay between network capital and conventional agglomeration factors affects urban development (Van Meeteren et al., 2016). In particular, does network capital reinforce or reduce the importance of conventional agglomeration factors? Their relationship needs to be disentangled before we arrive at any conclusion on their respective roles in urban economic growth (Burger and Meijers, 2016; Van Meeteren et al., 2016). This study also attempts to explore the interplay between the M&A-induced network capital and local agglomeration factors in China's urban economic growth.

Specifically, in order to address the spatial implications of China's capital flow networks on urban

development, we investigate the following three questions:

1. *What is the spatial pattern of inter-urban M&A-induced network capital in China?*

2. *Is the M&A-induced network capital associated with China's urban economic growth?*

3. *What is the relationship between M&A-induced network capital and local agglomeration factors in the process of China's urban economic growth?*

The theoretical contribution of this article hinges on the conceptualization of city network capital through unravelling the contribution of network capital to urban development and its interplay with local agglomeration factors. In terms of the analytical contribution, this article proposes a new novel capital flow metric – M&As – to capture the development of urban relational networks in order to empirically examine how the spatial organization of M&As is related to urban development. Practically, our findings offer a new perspective for urban policymakers to review the institutional capacity in organizing intangible resource flows for sustaining urban economic growth.

The remainder of the article is organized as follows: in the second section, we review the relevant literature, specifically the importance of the increasing urban connectivity and emergent network capital in relation to M&A capital flows for urban development, and develop research hypotheses accordingly; the third section elaborates the methodology of this study, including data description, variable selection, network analysis techniques and regression specifications; the fourth section discusses the results and the robustness checks; and the final section concludes the theoretical and policy implications of our findings.

Literature and Hypotheses

Network Capital and Urban Development

The study of cities has extended from land use patterns to industrial clustering and agglomeration economies through the lens of urban competitiveness and endogenous growth theory (Rosenthal and Strange, 2004; Storper and Venables, 2004; Kerr and Kominers, 2015). Notwithstanding the significance of intra-city industrial clustering, research on cities' external connectivity and urban networks, recognised as 'the second nature of cities', has drawn greater attention as a result of globalization. Along with technological advances, intangible resources can virtually flow across geographic boundaries at marginal cost without following strict distance-decay order. A new economy facilitated by ICT technologies has transcended territorial barriers and created a network space where separate markets are integrated through trans-boundary flows of products, services, labour, capital and knowledge etc., conceptualized as a paradigm change from 'space of places' to 'space of flows' (Castells, 1996, 1999; Coe and Yeung, 2015; Derudder and Taylor, 2018). The success of cities is therefore argued to rely on the quality of their "material arrangements" (e.g. telecommunications and transportation facilities) and their organizing capacity, allowing for "simultaneity of social practices without territorial contiguity" (Castells, 1999, 295).

Numerous studies have been implemented to disentangle the complexity of variegated city networks at several scales, represented by world city network (WCN) and global production network (GPN) (see Taylor et al., 2002; Derudder et al., 2010; Coe and Yeung, 2015). Compared to WCN and GPN approaches that highlight internal office hierarchy and vertical value chain linkages respectively, network capital discourse emphasizes the role of inter-organizational formal partnerships in creating innovations and knowledge spillovers (Huggins, 2010; Huggins and Thompson, 2014). They strongly argue that this kind of formal corporate linkages tends to form a

productive network space where long-term interactions and knowledge spillovers are more easily fostered. In addition, another contribution of network capital discourse is to tackle the 'self-evident' issue of urban network studies (Derudder, 2019). Former studies take one assumption for granted that increasing urban connectivity and resulted city networks can reflect urban vitality and facilitate urban economic growth as an outcome, which demands more critical clarification and empirical evidence. Huggins and Thompson (2014) identify this gap and specify an urban network growth model through incorporating network capital variables, which constructs a conceptual framework linking network capital and regional development. In conclusion, an urban network should not be simply interpreted as a spatial structure but also a 'strategic capital' owned by the connected entities.

Accordingly, a vast literature has emerged to investigate urban network capital based on flows of people, products, capital and knowledge etc. Measures of urban network capital have extended from flow volumes and morphological co-location patterns (Bathelt et al., 2004; Trippl et al., 2009; Ellison et al., 2010; Kerr and Kominers, 2015) to city network positionality (Taylor et al., 2002; Derudder et al., 2010; Sigler and Martinus, 2017; Shi et al., 2019). The latter allows the further exploration of cities' constraints and opportunities embedded in a complex inter-urban flow network. Burt (2009) also articulates that gateway positions are strategically important to generate network resources and competitive advantages. As highlighted by Derudder (2019), besides first-order direct linkages, it is the structural positions derived from 'beyond first-order neighbors' that add conceptual relevance to urban network analysis. Therefore, cities with higher economic growth are likely to be those with more network capital, which is captured not only by flow volumes based on direct linkages between cities but also by their network structural positions.

Interplay between Network Capital and Local Agglomeration Factors

Along with rising network capital, its relationship with conventional agglomeration economies which is considered to be the main driving mechanism of urban development becomes a vital question to answer. An agglomeration economy is characterized by the proximate order of resource allocation – the strength of economic interactions and spillovers declines as distance increases. A network economy, by contrast, overrides the proximate order by creating network connectivity to distant resources. Conventionally speaking, an agglomeration economy is a natural outcome of economies of scale and spatial stickiness of many industrial production activities, vividly reflected by the spatial concentration of labor pooling and knowledge spillovers[ii] (Rosenthal and Strange, 2004; Ellison et al., 2010; Fotopoulos, 2014; Kerr and Kominers, 2015). However, as its size grows, an over-agglomeration pattern could impede economic growth by generating negative externalities (e.g. congestion, inequality, environmental costs, crime and disease etc.), raising the question of whether a network economy can substitute, or complement, an agglomeration economy. Some scholars argue that the two are not substitutes but interactive mechanisms, giving rise to a networked agglomeration economy (van Meeteren et al., 2016; Meijers and Burger, 2017; Shi and Pain, 2020). In fact, since the effects of network and agglomeration economies on urban development could change with economic, institutional, and spatial contexts (Meijers and Burger, 2017), the relationship between agglomeration and network economies is yet to be clarified.

Huggins and Thompson (2017) contribute to disentangling the relationship between agglomeration and network economies by incorporating network capital variables in the function of regional growth. They find that network capital (knowledge flow volume) and agglomeration input factors (labour and physical capital) make individual contributions to regional growth, reflecting that the effects of network and agglomeration economies co-exist. Following this line of argument, Shi

and Pain (2020) investigate the effect of network capital on regional economic development in China, and detect the spatial spillovers of city network capital while controlling for agglomeration input factors, which further harnesses the interplay between agglomeration and network economies. Despite the recognition of both network and agglomeration economies as drivers of urban growth, whether a combination of agglomeration and network economies can create synergies remains unexplored. According to Huggins and Thompson (2017) and Shi and Pain (2020), city network capital and local agglomeration factors could have an interactive (joint) relationship during economic growth, resulting in a networked agglomeration economy.

M&A-induced Network Capital and Hypotheses

As discussed, M&As are considered to be a suitable flow metric to calculate city network capital and subsequently examine its association with urban economic growth. As two major types of capital flows, greenfield investment and M&As reshape local economies via different mechanisms.[iii] In contrast to the greenfield investments that affect local economy via direct capital accumulation (De Mello, 1999), M&As are more likely to influence economic growth via various underlying spillover effects (Javorcik, 2004): 1) knowledge spillover where involved firms upgrade their performance by mutually learning technologies, managerial skills, and other forms of knowledge; 2) competition-induced spillover where their rivals are forced to invest in new technologies etc. in order to improve their competitiveness; 3) M&As could reshape the business landscape due to interlocking effects on third parties, particularly the involvement of local business services (DeYoung, 2009). Thus, through long-term cumulation and integration, the aggregation of M&A capital flows could reshape the local market environment and affect city economic growth via these mechanisms. Empirically, Otchere and Oldford (2018) find that inward M&As are not only positively associated with the targets' competitiveness via knowledge spillovers but also the

overall competitiveness of the recipient's country via competition-induced spillovers. However, the effect of M&A capital flows on local economies is limited to the investigation of target companies (i.e. inward capital flows), neglecting M&A's bilateral attribute. This leaves a void in the investigation of the potential reverse spillovers to acquiring companies (i.e. outward capital flows) who may also benefit from M&As via obtaining targets' patents and network resources etc. (Nocke and Yeaple, 2008).

Accordingly, as shown in Figure 1, the cities where either a target or an acquirer company originates could benefit from M&A capital flows via either knowledge spillover or competition spillover or both, *ceteris paribus*. However, it should be noted that the impacts of M&As on local economies could be different depending on the distinctive motivations, industrial and corporate characteristics as well as local market conditions (De Mello, 1999). The impact of 'none value maximizing motivated' M&As e.g. hostile acquisition, reverse takeover, financial diversification or share swap etc. is often insignificant or even negative (Cartwright and Schoenberg, 2006; DeYoung et al., 2009). Thus, in order to reduce this disturbance, this study excludes these M&As to better enhance the assumed positive link between capital flows and local economies. Moreover, as discussed above, in a complex urban relational network, city network capital is reflected not only by bidirectional capital flows but also by network structural positions.

Accordingly, we form the first hypothesis:

> *Hypothesis 1a: inter-urban capital flows are positively related to urban economic growth.*
>
> *Hypothesis 1b: urban network positions are positively related to urban economic growth.*

[Insert Figure 1 here]

Furthermore, given the substantial regional heterogeneity in China's developmental path (Zhang and Peck, 2016), we acknowledge that the relationship between network capital and urban economic development is not a "one size fits all" story. This is particularly the case for M&A capital flows as their spatial implications on local economies are largely attuned to local agglomeration factors and institutional settings (Zademach and Rodríguez-Pose, 2009; Ellwanger and Boschma, 2015; Shi and Pain, 2020). M&As start to cast a positive impact on the economic growth unless local human capital reaches a certain threshold (Wang and Wong, 2009). In particular, Fu (2008) finds that human capital and knowledge stock are key factors in determining China's regional absorptive capability for inward capital flows. These studies essentially apply endogenous growth theory to reveal the key role of human capital and knowledge stock in determining the urban absorptive capacity to capital flows (Romer, 1994; Lucas, 2015).

Accordingly, it is postulated that the effect of network capital on urban growth is moderated by local agglomeration factors via influencing the absorptive capacity of cities (Nocke and Yeaple, 2008; Meijers and Burger, 2017). Therefore, we form the second hypothesis by distinguishing between human capital and knowledge stock:

> *Hypothesis 2a: the effect of capital flows on urban economic growth is moderated by the local human capital.*
>
> *Hypothesis 2b: the effect of capital flows on urban economic growth is moderated by the local knowledge stock.*

Method and Data

This study employs a stepwise approach to unveil the spatial implications of China's capital flow networks on urban development. Firstly, the M&As are geographically coordinated to identify both source and destination city nodes, organised into a 1-mode inter-urban capital flow network[iv]. Network capital variables are then calculated with respect to the flow volume and network positions. Finally, these network variables are specified in an urban growth model in order to examine the relationship between network capital and urban economic growth.

Network Analysis Methods

Following the aforementioned literature, cities' network capital is realized by both flow volume and structural positions (Burt, 2009; Derudder, 2019). Flow volume is a measure of inter-urban direct capital flows to reflect the individual capacity of city nodes in building interactions with its peer cities. Indegree, outdegree and self-degree are specified based on the flow directions: indegree concerns the total number of M&As that a city receives, indicating its 'attractiveness' to other cities; outdegree measures the total number of M&As that a city originates, reflecting its centrifugal forces to expand its influence in the network; self-degree measures the total number of M&As that occurred within city boundaries, indicating cities' self-maintenance capacity in the network (see Table 1).

Cities' structural positions are examined by eigenvector and betweenness indices[v], indicating cities' authority and hub roles respectively. Unlike degree indices, eigenvector evaluates whether individual cities have a high proportion of their linkages to influential counterparts, improving their own standings. Thus, a city node may not be considered important on its own, but its linkages to other well-connected cities will boost its influence in the network. The eigenvector x_v of city

node v is formally written as:

$$x_v = \frac{1}{\lambda}\sum_{t\in M(v)} x_t = \frac{1}{\lambda}\sum_{t\in G} a_{vt}x_t \tag{1a}$$

where M(v) is the neighbourhood of node v (i.e. the nodes that node v is directly connected to); a_{vt} is 1 when node v and t are connected directly; λ is a constant (the dominant eigenvalue of A calculated by power iteration); let A= a_{vt} be the adjacency matrix of network graph G. It can then be rewritten as:

$$Ax = \lambda x \tag{1b}$$

At every iteration, the vector x_k is multiplied by A and normalized as:

$$x_{k+1} = \frac{Ax_k}{\|Ax_k\|} \tag{1c}$$

until a subsequence x_k converges to an eigenvector with the dominant eigenvalue λ[vi].

The betweenness index is used to examine cities' gateway position in the network. It measures how often a city appears on the shortest paths between other cities in the network. Choosing the shortest path is regarded as the most cost-efficient way to build linkages between two unlinked cities, reflecting the importance of the betweenness-indicated gateway position. The city betweenness score $B(v)$ is formally written as:

$$B(v) = \sum_{s\neq v\neq t\in V} \frac{\sigma_{st}(v)}{\sigma_{st}} \tag{2}$$

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

Urban Growth Model Specification

The baseline urban growth model refers to the endogenous growth theory which underpins the importance of human capital and knowledge in economic growth[vii] (Romer, 1994; Lucas, 2015), formally written in linear function as:

$$Y_{it} = K_{it}\beta_1 + L_{it}\beta_2 + H_{it}\beta_3 + A_{it}\beta_4 + \mu + \alpha_t \iota_N + \epsilon_{it} \quad (3)$$

where Y_{it} is the economic output of city i in period t; K_{it} is the physical capital stock of city i in period t; A_{it} is the knowledge stock in city i in period t; H_{it} is the human capital stock in city i in period t; L_{it} is the labour input in city i in period t; β is the coefficients of independent variables; μ is the location effect term while α_t is the temporal effect term; ι_N is an N×1 vector of ones associated with the constant term parameter α and ϵ_{it} is an unobserved random term.

Next, the urban growth model incorporates network capital variables (specified in the previous section) to explore the association between network capital and urban growth. The urban growth model is then written as:

$$Y_{it} = K_{it}\beta_1 + L_{it}\beta_2 + H_{it}\beta_3 + A_{it}\beta_4 + N_{it}\beta_5 + \mu + \alpha_t \iota_N + \varepsilon_{it} \quad (4)$$

where N_{it} is a vector of network capital variables of city i in period t. The network capital N_{it} is measured from two aspects: flow volume F_{it} and positionality P_{it}. F_{it} is a vector of network flow variables (F1= Self-degree, F2= Indegree, F3= Outdegree); P_{it} is a vector of network position variables in period t (P1= Eigenvector, P2= Betweenness).

In order to test the moderation effect of the conventional agglomeration factors on the relation between network capital and urban economic growth, we use the interaction term between the network capital measures (N_{it}) and the local human capital (H_{it}) and knowledge stock (A_{it})

respectively, while controlling for urban sizes. The urban growth model is then specified as:

$$Y_{it} = K_{it}\beta_1 + L_{it}\beta_2 + H_{it}\beta_3 + A_{it}\beta_4 + N_{it}\beta_5 + (N_{it} \times H_{it})\beta_6 + (N_{it} \times A_{it})\beta_7 + \mu + \alpha_t \iota_N + \varepsilon_{it} \quad (5)$$

However, it is noted that developed cities with vibrant business environments and resources are more likely to create and attract capital flows, indicating a potential reverse causation effect of urban growth on network capital. To correct for this, we follow Leszczensky and Wolbring (2019) and Williams et al. (2018) and use the cross-lagged panel model with fixed effect (CLPM) to allow for reciprocal causation and control for unobservable individual effects simultaneously.[viii] The CLPM is formulated as structural equation models (SEM) and uses maximum likelihood estimation, briefly illustrated as:[ix]

$$\begin{cases} Y_{it} = \gamma_1 X_{i(t-1)} + \delta_1 Y_{i(t-1)}\mu + \alpha_t \iota_N + \varepsilon_1 \\ X_{it} = \delta_2 Y_{i(t-1)}\mu + \gamma_2 X_{i(t-1)} + \alpha_t \iota_N + \varepsilon_2 \end{cases} \quad (6)$$

where X_{it} is a vector of independent variables of city i in period t; $X_{i(t-1)}$ is a vector of independent variables of city i in the previous period $(t-1)$ and γ_1 is its coefficient; $Y_{i(t-1)}$ is the economic output of city i in the previous period $(t-1)$ and δ_1 is its coefficient; in the CLPM, coefficients for the effects of X on Y, and vice versa, are constrained to be equal across time periods (i.e. $\gamma_1 = \gamma_2$ and $\delta_1 = \delta_2$); thus, only coefficients for the effects of X on Y are reported (see Table 3).

Data

The capital flow data is sourced from Zephyr database which records comprehensive worldwide M&As and is updated hourly. Given data availability, the M&As in China are tracked and recorded from 2003 to 2017, including the information on target and source companies and their headquarter addresses.[x] The following criteria are applied to the sample selection process: 1) only M&As

involving both the change of ownership control and the actual transfer of a business are included; 2) by referring to Herger and McCorriston's (2016) classification, M&As based on purely financial initiatives (i.e. reverse takeover, buyout, insolvency, distressed debt, and investments from individuals and funds etc.) are excluded; 3) M&A deals below one million US dollars are excluded to avoid disturbances from small deals; 4) the status of both acquirers and targets are active until data collection in case some M&As fail to support long-term interactions. Consequently, 17,057 M&As over the period from 2003 to 2017 are included. Local agglomeration factors are drawn from the National Bureau of Statistics of China (NBS), resulting in a balanced panel dataset covering 279 cities from 2003 to 2017. Finally, we also include demographic size and built-up area to control for city size differences and the data is drawn from NBS (see Table 1).

[Insert Table 1 here]

Results

Results are presented below following the sequence of specified research questions from the spatial pattern of M&A capital flows, M&A-induced city network capital (using both flows and positions measures) and its association with urban economic growth. The analysis finds that under a centralised inter-city capital flow network, China's mega cities (i.e. Shanghai, Beijing and Shenzhen) benefit most from M&A-induced network capital, reinforcing their economic competitiveness in a bidirectional way. This also leads to the discussion of uneven regional development and following policy implications.

Spatial Network Pattern

Figure 2 illustrates the spatial pattern of China's inter-urban capital flow network. We find that cities with intensive capital flows are clustered along the coastline represented by the Beijing-

Tianjin duopoly region, the Shanghai-Hangzhou-Suzhou Yangtze River Delta, and the Shenzhen-Guangzhou Pearl River Delta, while a few are scattered sparsely in central and west China. In addition, a modularity technique is used to detect the subgroup clustering of China's inter-urban capital flow network in which cities are more statistically interlinked to each other over outsiders (Blondel et al., 2008) (see modularity function in Appendix). We find that geographically proximate cities normally belong to the same subgroups, reflecting that China's capital flows tend to follow the order of spatial proximity. In short, top-tier cities are linked to each other irrespective of distance (represented by the Beijing-Shanghai-Shenzhen triangle), while medium- and small-size cities tend to cluster with their neighbouring peers. This might be attributed to the fact that firms from mega-cities outperform their counterparts from ordinary cities in terms of search capabilities and business resources, corroborating with Zademach and Rodríguez-Pose (2009) and Ellwanger and Boschma (2015).

[Insert Figure 2 here]

City Network Capital Performance

Table 2 presents cities' individual performance in the network with respect to flow volume, eigenvector and betweenness centralities. Through ranking cities by their total flow volume, it finds that most of the top cities have more outward capital flows than inward capital flows, particularly for megacities (Beijing, Shanghai and Shenzhen), indicating that businesses in these cities have been actively expanding outwardly by acquiring companies in other cities. In terms of network structural positions (betweenness and eigenvector), Beijing, Shanghai and Shenzhen also play strong hub and authority roles, reinforcing their dominant network influence. Additionally, Chengdu is rising up as a gateway city interlinking the coast and inland China, reflected by its outperformance in betweenness and eigenvector. By decomposing its ego-network, we find that

on one hand, Chengdu establishes a well-connected regional network with its surrounding cities, reflected by its subgroup division (see Figure 2), while on the other hand, Chengdu builds strong connections with other influential cities, particular to Beijing, Shanghai and Shenzhen.

[Insert Table 2 here]

In conclusion, cities play different roles in China's inter-city capital flow network, reflecting regional variation in network capital. In this network space, outperforming cities, particularly Beijing, Shanghai and Shenzhen, hold most of the network resources, while other cities are at a disadvantage to compete, illustrating a centralised core-periphery pattern. Thus, given the variations in cities' network performance, we are able to examine whether these network advantages can translate into 'actual' economic growth in the next section.

Regression Results

Table 3 presents the results of various panel regressions estimating the relationship between urban economic growth and network capital. Given the conceptual differences,[xi] different types of network capital variables are included separately in order to avoid overidentification and multicollinearity issues and maintain the degree of freedom. Based on the Wald and likelihood ratio tests, the joint effects of these network capital variables significantly improve the model fitness. Firstly, China's urban growth is significantly associated with local agglomeration factors, i.e. physical capital investment (K), human capital (H) and knowledge stocks (A); whereas labour cost (L) returns an insignificant coefficient, reflecting the diminishing influence of labour input in China's recent economic development. This suggests that, instead of substituting Marshallian agglomeration economies, conventional input factors still play vital roles in supporting China's urban development.

Secondly, in interpreting the relationship between M&A capital flows and urban economic growth, it should be noted that CLPM (eq.6) has been employed to address the potential issue of reverse causality associated with the clustering of advantageous businesses and financial resources in developed cities – the time lags ensure that urban economic growth, if any, follows capital flows, not vice versa. With this in mind, the results indicate that city outward capital flows (F_3) is positively associated with China's urban growth at a significant level, while inward and intra-city capital flows (F_1 and F_2) are found insignificant. This reflects the importance of flow directions in the process of city network capital formation. It might be reflective of the fact that acquirers actively select and absorb target assets following their strategic goals and size advantages, in contrast to passive and small recipients. Combined with the finding of major cities' outperformance in outward capital flows, it poses a warning to the policymakers that China's financial deregulation on industrial restructuring may only benefit developed cities, leading to a widening regional disparity.

Thirdly, the measure of cities' network hub role – betweenness (P_2) – is also identified as a significant contributor to urban economic growth, supporting the necessity of incorporating bridging network position into the conceptualization of city network capital. This is in line with Burt's (2009) structural hole theory that a hub position can improve network actors' competitiveness and create network synergies (Shi et al., 2019; Shi and Pain, 2020). Thus, through long-term cumulative circulation of functional linkages, cities with strategic network positions could gain an advantage where the exchange of capital, information and knowledge etc. is stimulated and subsequently facilitates urban development in the long run. In summary, our findings suggest that network capital is significantly related to urban growth attuned to flow directions and network positions.

[Insert Table 3 here]

The last two models of Table 3 test the moderation effect of the local human capital and knowledge stock on capital flows respectively. The marginal lines of capital flows on urban economic growth at different levels of human capital or knowledge stock are illustrated in the Appendix. We find that the impact of outward capital flows on local economic growth is strengthened when there is better human capital and knowledge stock, supporting the moderation effect of the agglomerative factors. This implies that the development of local human capital and scientific technologies could influence local acquirers' absorptive capacity towards the valuable assets of their targets, resulting in changes of local economic growth. While no significant result is found on intra-city capital flows, we find a significantly negative coefficient of the interaction term between intra-city capital flows and the local knowledge stock, indicating that the impact of intra-city M&A flows on local economic growth is negatively moderated by local technological levels. One possible explanation is that, through acquiring local competitors or linked businesses, intra-city M&As may lead to a sluggish competition environment and create monopoly powers, making local market participants reluctant to invest in R&D and consequently impeding local economic development. In conclusion, network capital and local agglomeration factors are interactive in the process of economic growth, illuminating an emergent networked agglomeration economy. This finding reinforces the necessity for coordinative policies on education, technologies and financial markets.

Robustness Checks

We have conducted various robustness checks. Firstly, although individual effect is fixed in our models, the models are re-run based on China's coast and inland subsamples. We find that, regardless of marginal coefficient changes, the results remain largely unaltered. Secondly, we use an alternative HITS algorithm (Kleinberg, 1999) to estimate network authority and hub positions

(P_1, P_2). We find that P_2 remains significant, similar to betweenness, reflecting the consistent importance of hub network position for urban development. Thirdly, GDP growth rate, instead of the gross value added, is used as an alternative dependent variable. Finally, we also use an alternative measure of the human capital (the number of students in higher education institutions) and an alternative measure of the knowledge stock (the number of employees in scientific institutions). Overall, our results survive these robustness tests and remain similar to our main results reported here. For parsimonious reasons, the results of robustness tests are not reported in text, but available in Appendix. In summary, while further studies are required to understand industry and corporate characteristics, the results stand through these robustness checks and support our general findings that aggregated inter-urban capital flows and their induced network capital play a significant role in China's urban development.

Discussion and Conclusions

Castells' space of flows theory highlights technological breakthroughs as a force to transform the urban form into one where primate and remote cities are interlinked and adapted to each other (Castells, 1996, 1999). However, the regional disparity persistent in the core-periphery pattern has not been fundamentally altered, which is reflected by the uneven geographies of network capital in present analysis. This study suggests that although the transportation cost has been largely reduced, building distant economic linkages requires a higher threshold and additional maintenance costs to overcome the barriers created by information asymmetry and heterogeneous institutional settings (Malecki, 2010). The threshold will grant competitive edges to big enterprises equipped with powerful search abilities and business resources as well as the cities where they are spatially clustering in, which ultimately leads to further regional divergence (Martin, 2010; Fotopoulos, 2014). We ought to rethink the intensifying cross-territorial capital flows as a spatially

expansive process associated with regional peculiarities other than a simple solution to regional disparity (Boschma and Frenken, 2006).

The results also add weight to the proposition that urban economic growth is increasingly realised by the growth of capital flow networks, indicating that the network capital is an unneglectable composite of the economic growth function. In addition, this article complements the conceptualization of city network capital through adding network positionality as an additional aspect in order to shed light on network capital from a multi-dimensional angle (Huggins and Thompson, 2017; Derudder, 2019; Shi et al., 2019). Thus, we strongly argue that the urban system has become a complex network space where cities are interlinked via intensifying heterogeneous flows and adaptive to other cities' interactions.

Lastly, this article fills the gap in the juxtaposition between agglomeration and network economies, which mirrors a rising networked agglomeration economy. This finding supports the argument by van Meeteren et al. (2016) that urban development patterns are reshaped by the dynamic interplay between agglomeration and network externalities. Therefore, regarding agglomeration and network economies as alternatives to each other neglects the interplay between them, which is not explicit to illuminate future development paths for cities. In conclusion, the underlying mechanism of urban development should be seen as an evolutionary and adaptive process in which cities interact and adapt to each other attuned to their localised attributes (Boschma and Frenken, 2006; Martin, 2010), instead of the simple sum of the properties of city nodes and their direct interlinkages (Hausmann et al., 2014; Miller, 2016).

Given the uneven geographies of network capital, cities may be confronted with circular causation between network capital and economic growth in the future, highlighted as the driving force in

consistently maintaining regional disparity. Cities equipped with well-built industrial base and human capital etc. during the initial development phase (China's economic reform since 1978) are also advantageous to initiate capital flows and capture induced network capital during the industrial transition phase (e.g. Made in China 2025 initiatives). Consequently, without institutional innovations and policy interventions, cities are likely to form and depend upon a circular causation path, reinforcing existing regional disparity between mega and ordinary cities. Given the interactive effect of human capital and knowledge base on network capital, more resources and preferential policies need be disproportionately invested in improving higher education, R&D and business environments.

Meanwhile, policy implications should focus on improving cities' institutional organizing capacity towards important flows in order to 'borrow' positive spillovers from strategic networks and counter 'agglomeration shadows' (Krugman, 2011; Meijers and Burger, 2017). Accordingly, it is suggested to establish an inter-city cooperation platform over administrative barriers in order to enhance information sharing, knowledge exchange and entrepreneurship via regular conventions, exhibitions, joint ventures and incubators etc. Technically, along with the rise of new technologies, an up-to-date flow-tracking metadata system with artificial intelligence and machine learning capacities is necessary to adapt to complex flow circulation across territories and make in-time adjustments attuned to their dynamic network positions. In particular, due to the significance of flow directions discovered by the present analysis, policy initiatives are suggested to encourage local enterprises to search for valuable assets beyond their home cities, while intra-city M&As should be reviewed with caution due to its potential to jeopardise the local competitive environment. It should also be noted that these findings need more 'placed-based' adaptation for the policymaking of a particular city based on local contexts (Burger and Meijers, 2016). For

instance, the rise of Chengdu could be a paradigm of cities in less developed regions to seek growth through simultaneously enhancing regionalization and building linkages to national hubs.

Limitations

While this article focuses on the spatial implications of M&A capital flows on urban development, it also motivates future studies to further explore the flexibility and spatiality of other functional linkages (e.g. knowledge, information and elite flows at different spatial scales). In addition, it is also interesting to see how the industrial and corporate characteristics of M&As could interfere with the network capital effect. Therefore, following this study, we have initiated further studies to examine specific industries (e.g. Manufacturing) attuned to different M&A types (horizontal, vertical and conglomerate deals) in order to better disentangle M&A-induced network capital. Moreover, besides acquirer-target bilateral relations, their relationship with third parties (e.g. financial intermediaries) is also worthy of further investigation which could add another valuable dimension to further illuminate city network capital.

Endnotes

[i] The Chinese government has issued a series of policies in recent years to regularise its M&A market and to reduce M&A transaction costs. These policies include 'Instructions of the State Council on Further Optimizing the Market Environment for Enterprises' M&As' (State Council, 2014), 'Decision of the State Council on Issues Related to the National SME Share Transfer System' (State Council, 2013), and 'Management Measures for Major Asset Restructuring of Non-listed Public Companies' (China Securities Regulatory Commission, 2014).

[ii] The spatial pattern of agglomeration economies is generally categorized by localization and urbanization economies which highlight the importance of specialization and diversification respectively. However, this article focuses on the interaction between network capital and agglomeration input factors (human capital and knowledge stock) by controlling for urban size instead of diving into intra-city agglomeration patterns.

[iii] Greenfield investments concern intra-corporate operations to build ventures from ground up in a location.

[iv] The distinction between network data and standard data is that the network data is an actor-actor matrix as opposed to an actor-attributes matrix. 1-mode matrix for network analysis is an actor-actor matrix where actors are from the same group i.e. a city-by-city matrix in the present analysis.

[v] Eigenvector and betweenness are commonly used in social network analysis to indicate nodal structural importance. In the following robustness checks, Hyperlink-Induced Topic Search (HITS) algorithm is employed as an alternative to estimate network structural positions (Kleinberg, 1999).

[vi] The rate of convergence is linear in the ratio of the dominant eigenvalue λ to the eigenvalue whose absolute value is second largest.

[vii] The baseline model based on endogenous growth theory has been examined in China's economic growth studies. In addition to conventional input factors (labour and physical capital), human capital and knowledge are increasingly found significant to China's economic growth (for instance Fleisher et al., 2010 and Florida et al., 2012). The network models in this article incorporate M&A-induced network variables into the baseline model in order to discover the complementarity of network capital in the urban growth model and its interaction with conventional agglomeration factors.

[viii] Leszczensky and Wolbring (2019) and Williams et al. (2018) utilize Monte Carlo simulation method to compare conventional panel models (i.e. Random Effect (RE), Fixed Effect (FE), First Difference (FD), and Generalized Method of Moments (GMM) models) and CLPM under various scenarios. They find that CLPM not only provides protection against reverse causation but also produce less bias than GMM at the presence of large autoregressive parameter and non-normally distributed disturbances.

[ix] Under the SEM framework, reciprocal causation is allowed between each variable on the left hand side and all other lagged variables on the right hand side. To avoid displaying overly complicated equations, only simplified forms are presented here.

[x] Foreign M&As are excluded due to the following reasons: domestic firms and MNCs are differentiated in terms of M&A preferences, motivations and regulations; international M&As by big MNCs are concentrated in global cities, exacerbating regional disparity and heterogeneity; 3) technically, including foreign firms transforms 1-mode network into a 2-mode one, which causes the information loss on calculating structural positions.

[xi] Firstly, the nodal value (F_{it}) focuses on the number of M&A deals and the directionality of capital flows. Secondly, Betweenness and Eigenvalue are structural measures based on a city-by-city 1-mode matrix. Thirdly, the interaction effects of M&As with human capital and knowledge stock are examined.

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