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Global Cluster Networks – Foreign Direct Investment Flows From Canada to China

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Abstract (ca. 130 words). Using a network perspective of multinational firms, the paper first formulates a global cluster-network hypothesis suggesting that multinational cluster firms are more likely to set up new foreign affiliates in other, similarly specialised clusters, rather than investing in non-clusters, to keep up with wider industry dynamics. Second, it is hypothesized that cluster networks generate connections between various city-regions in different countries, thus supporting the formation of global city-region networks. To test these hypotheses, we investigate the spatial patterns of nearly 300 foreign direct investment (FDI) cases from Canada to China between 2006 and 2010. After developing a consistent typology of city-regions and clusters for both countries and identifying relationships between the source and target regions of such investments, the observed spatial patterns of FDIs support both hypotheses.

Keywords. Foreign direct investment (FDI), global cities, global cluster networks, global city-region networks

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1. Introduction: Clusters, Foreign Direct Investments (FDIs) and the Globalization Paradox

Although modern technologies have greatly facilitated the exchange of goods and knowledge across regional, national, and cultural boundaries, global economic success still seems to depend on the utilization of local/regional resources (Bathelt and Taylor, 2002). Research has shown that closely intertwined regional concentrations of firms from a particular sector, together with supporting suppliers and service providers – so-called industrial clusters (Porter, 1990), continue to attract further firms in those or related sectors. A globalization paradox results from the fact that, despite powerful globalization processes, a considerable part of global economic production agglomerates in these regions (Scott and Storper, 2007). Along with deepening globalization, further concentration of related activities in these regional clusters is reinforced by the locational choices of foreign direct investments (FDIs) (De Propris and Driffield, 2006). On the one hand, knowledge about product technologies and organizational forms disseminates locally as foreign firms set up production facilities in these clusters. On the other hand, multinational firms can appropriate and export local knowledge because they are in a position to standardize the knowledge developed in the original locations through codification in such a way that it can readily be transferred to other locations and countries (Maskell and Malmberg, 1999).

The development of clusters through localization activities of multinational firms and internationalization processes of local firms calls for a reinterpretation of regional growth paths in a trans-local perspective that goes beyond a separate understanding of the local and global spheres. In economic geography, trans-local or interregional connections have been formulated from both regional cluster and global network perspectives. In knowledge-based cluster theories, the regional imperative of the global economy is explained by the argument that the adaptation of new technologies results in

continuous reproduction and further development of regional competitive advantages related to the dissemination of tacit knowledge that requires face-to-face communication (Malmberg and Maskell, 1999). Such communication is realized in geographical proximity based upon the spatial 'stickiness' of local labour markets. However, with the increasing mobility of labour – especially related to emigrant elites in transnational technical communities – face-to-face communication spans over greater distances and tacit-knowledge sharing occurs regularly across boundaries (Saxenian, 2006). Studies in economic context have gradually realized that it is beneficial – and has become common practice – to combine different forms of permanent with temporary and real with virtual face-to-face communication in complex global production settings (Leamer and Storper, 2001; Bathelt and Turi, 2011).

In global context, spatial reconfigurations of production activities link multinational corporations in advanced clusters in developed economies with manufacturing clusters in developing economies. Trans-local connections may be realized either by attracting FDIs from within multinational production networks or by receiving contracts from global lead firms within a value chain (Dicken et al., 2001).

Although many theoretical discussions and case studies exist about forms of trans-local linkages at the local and global scale, surprisingly little is known about the spatial patterns of durable international linkages between different firms, production-chain sites, clusters, or innovation networks. On the one hand, much of the work on clusters, innovation networks, and global cities – although acknowledging the important role of trans-local linkages, power relations, and control functions – is focussed on a specific regional or metropolitan perspective (Cooke and Morgan, 1988; Maskell and Malmberg, 1999). On the other hand, studies of global production networks – while being aware of the spatialities of such production configurations – tend to emphasize the flow patterns within technology fields or product chains, while underplaying the complex

regional expressions of corresponding linkages (Gereffi et al., 2005). As Storper (2009, 1) forcefully put it: “How should we think of the role of regions in relation to the global economy? Theory has surprising gaps when it comes to building a unified vision of these two scales of development.” Clearly, there are undertheorized areas with respect to the dynamic role of regional clusters in the global economy.

The nature of linkages between different clusters, or different types of city-regions, and other spatial entities at a global level, has not been thoroughly analysed in academic studies. For instance, do firms in clusters develop strong networks with other clusters at a global level to maintain competitiveness? Or, are linkages extending from existing clusters primarily oriented toward low-cost locations at the periphery? Or, do international linkages follow a centre-periphery dynamic based on technological aging as, for instance, product-life cycle conceptions would suggest (Vernon, 1966)? And, how are industries in global cities linked with other city-regions and countries? Do they primarily develop control functions in lower-ranked spatial entities, or do they link up with other global cities to reproduce their dominance? These and other related questions require substantive empirical research.

Taking these observations as a starting point, we designed a study to investigate the nature of economic linkages, first, between clusters and non-clusters and, second, between different types of city-regions. As opposed to most other studies on clusters, global production chains, or global cities, our focus is not on trade flows and input-output relations, which are sometimes only temporary in nature. We are interested in more permanent commitments of firms and therefore investigate foreign-direct investments (FDIs). We view these as the basic infrastructure for the development of further material, human capital, and knowledge linkages over time. Specifically, we analyze a total of about 300 FDI cases – across all industrial sectors – between Canada and China between 2006 and 2010. In our explorative study, we first aim to investigate

the nature of spatial linkages between source and target regions of FDIs. Second, we aim to identify spatial linkage patterns between different types of city-regions. Our third goal is to analyse how these international linkage patterns vary across different sectors in the economy.

In what follows, we next compare theories of global cluster linkages, global cities, and global production chains/networks, with respect to the manner in which they conceptualize long-distance linkages between city-regions (Section 2). In a novel reinterpretation of FDIs, Section 3 develops hypotheses regarding global cluster networks and global city-region networks using a nested framework combining different conceptualizations. Section 4 presents our database of about 300 FDI cases from Canada to China between 2006 and 2010, and describes the methodology developed to identify a consistent typology of clusters and city-regions that can be applied in a cross-country comparison. Section 5 explains the results of our analysis and identifies spatial FDI linkages between different types of clusters and city-regions in Canada and China, confirming our initial propositions. Finally, Section 6 concludes by discussing the significance of these findings and drawing some implications.

2. Framing Trans-Local Connections: Transnational Communities, Clusters, and Production Chains

In the past decade, numerous conceptions in economic geography and regional economics have suggested that regional economic success, especially in industrial agglomerations, requires that local/regional linkages and networks are connected to cross-regional, trans-local, and global contexts, which provide access to wider markets, pockets of knowledge, and new technologies. In the literature, transnational-community, production-network, value-chain, global-pipeline, and global-city frameworks have been developed that focus on (i) individual, (ii) organizational, (iii) cluster, and (iv) city-region

levels of trans-local linkages (Table 1). However, as Sturgeon et al. (2008, 301) observe regarding such studies, “the focus remains on how these linkages play out within the cluster, not on the larger economic structures that are created when clusters are woven together”. Up to now, these frameworks remain vague with respect to conceptualizing the nature and spatial patterns of durable global linkages.

(i) At the individual level, with the increasing mobility of emigrant entrepreneurs and engineers, interregional knowledge flows occur within and through transnational communities. Highly educated mobile emigrant professionals become “the new argonauts” generating novel business opportunities between their first and second home countries related to their unique identity and background (Saxenian, 2006). They operate as boundary-spanners circulating up-to-date market and product information across national borders between distanced places. These transnational community networks enabled Hsinchu in Taiwan and Bangalore in India to upgrade economically through functional specialization and cooperation with Silicon Valley (Saxenian, 2006).

The transnational-community literature presents a convincing argument about inter-local or inter-cluster connections as it is based on empirical investigations, yet it remains unclear whether this concept can be applied to other industries and regions. Generalizations of transnational communities with brain-circulation effects have, for instance, been criticized as being restricted to few immigrant groups, such as Chinese or Indian immigrants (Whitford and Potter, 2007). Another limitation is that this literature focusses on cultural and network characteristics of emigrant entrepreneurs, while neglecting their organizational embeddedness. On the one hand, without considering the level of the firm, there is a danger of over-interpreting the roles of transnational communities, as acknowledged by Hsu and Saxenian (2000). On the other hand, although there is no precise evidence, it is expected that a substantial part of the “new argonauts” are corporate managers who are transferred within their firms, as, for

instance, observed in producer-service legal firms headquartered in London (Beaverstock, 2004). The organizational dimension of trans-local linkages, on the contrary, is strongly conceptualized within production and value chain frameworks.

(ii) The importance of a local cluster's connection with global lead firms has been emphasized since the debate about new industrial districts in the early 1990s when Amin and Thrift (1992, 571) suggested that new localized industrial complexes are "set firmly within a context of expanding global corporate networks". By framing trans-local linkages as value chains, Gereffi (1994) recognized that changes in fashion markets and in the organization of the retail sector had a tremendous impact on the organization and social division of labour between U.S. retailers and brand producers, on the one hand, and overseas factories and buyers associated with global sourcing strategies, on the other. Following Gereffi's (1994) value-chain concept, the approach of Humphrey and Schmitz (2002) focuses on developing contexts to investigate how regionally concentrated producers of value chains can benefit from or be restricted in their interactions with global lead firms in a vertical setting of producer-user linkages. They suggest that trans-local vertical linkages, to some extent, enable local producers to engage in the development of skills, knowledge, and competencies. In extended forms of value chains, a modular production network may lead to a situation where a cluster's trans-local connections in developing countries may involve turn-key manufacturers, rather than global leaders. With the adoption of global standards in linking different parts of value chains, local nodes in global networks become more closely linked with codified information (Sturgeon, 2002).

As such, the value-chain concept emphasizes different kinds of knowledge and types of linkages, which industrial clusters can access or develop differentiated by industries. One of the limitations of the approach, however, is its focus on vertical relationships in trans-local connections of cluster firms. Criticizing the linear nature of

the value-chain argument, Dicken et al. (2001) propose an actor-network-based understanding of global production networks drawing on the complex interrelationships of economic networks across different scales and emphasizing the tensions between networks and territories, as well as the roles of power relations. Overall, these approaches open up possibilities for analyzing production networks that span widely across countries by focusing on the role of the dominant agents in these networks (i.e. lead firms and states), and how they impact production conditions at different levels of the production network. At the same time, however, such studies are technology- or value-chain-focused and often do not employ a deeper understanding of the different localized contexts and consequences associated with such linkages. They are also primarily focused on input-output relations and do not distinguish between arms-length, temporary relations and more durable commitments, such as those induced through FDI.

(iii) At the cluster level, trans-local linkages have also been emphasized, especially in recent studies, suggesting that it is decisive to look beyond the regional boundaries of clusters – i.e. the trans-local, external cluster relationships – to understand why firms are successful in maintaining their competitive strength (e.g. Fitjar and Rodriguez-Pose, 2011). This has been conceptualized in a knowledge-based cluster approach emphasizing the external dimension of clusters (Bathelt and Taylor, 2002). The Boston biotechnology sector is a good example of this, indicating that critical knowledge transfers often do not result from the internal knowledge ecology of clusters – or their "local buzz" – but derive from strategic partnerships of international dimension (Owen-Smith and Powell, 2004). Firms deliberately establish trans-local relationships in order to obtain information about new or different technologies and organizational forms.

Access to such "trans-local or global pipelines" entails considerable uncertainties and high investment costs (Bathelt, 2007; Maskell and Malmberg, 2007). The

interaction within “global pipelines” is heavily dependent on the level of trust between the partners. This trust is not automatic, but has to be established gradually through deliberate efforts. Effective collaboration in innovation processes further depends on a common language, shared basic understanding, and mutually compatible interpretative schemes. Obviously, this cannot be taken for granted, as is evident by the problems which beset strategic partnerships and mergers. It is not easy to establish long-distance relationships, since the cultural and institutional contexts in which the firms operate have different roots (Henn and Laureys, 2010). Due to the high uncertainties attendant in relationships, in which the partners start out knowing relatively little about each other, knowledge transfers are concentrated on pre-defined objectives and are established in an explicitly structured way, compared to the communication flows within clusters.

While this conception emphasizes that a cluster’s competitive success can only be understood in relation to its entire set of external or supra-cluster linkages, it still focuses on the internal or intra-cluster social relationships and prioritizes individual analyses of clusters. Trans-local or global linkage patterns are only vaguely conceptualized, and emerging global networks are not explored. As many cluster approaches focus on linkage patterns or knowledge flows, it also becomes a necessity to distinguish temporary from durable relationship patterns.

(iv) At the urban and city-region level, trans-local linkages are further explored in the global-cities argument. Approaches of global or world cities argue that these centres exercise control and dominance over other cities and regions through a high concentration of global financial and advanced business services and headquarters of multinational corporations (Sassen, 1994; Taylor, 2004). They are connected to other cities and production regions by means of sophisticated information-technology infrastructure and transportation networks, such as international airports (Beaverstock et al., 2009). Through this, they become the first-tier decision-making cores in the global

hierarchy of city-regions and determine in substantial ways the development of other spatial entities. They extend their leading role, first, by establishing linkages with other global cities to reproduce high-order control functions and, second, by developing a hierarchical functional division of labour that produces a centre-periphery dualism.

Aside from emphasizing and hypothesizing trans-local or global linkages, this literature does not, however, systematically draw conclusions regarding the patterns of linkages that develop and the resulting city-region *networks*. Instead, studies often focus on identifying hierarchies of global/world cities without analyzing the nature of interdependencies between these cities. In fact, similar to cluster approaches, this literature primarily focuses on the top group of global cities and does not conceptualize the role of other cities or the relationships to these cities.

In sum, these conceptions emphasize certain aspects regarding the wider spatial relationships in economic production and control, yet each has clear limitations in terms of what it can explain – and what it cannot. As a consequence, we know relatively little about the wider spatial patterns of economic linkages that result between clusters and between city-regions and what kind of networks might develop from this – neither in conceptual nor in empirical terms. In order to develop a framework for such an analysis, we next propose a conceptualization that utilizes elements from the above approaches, and develop a nested explanation from the individual to the cluster and city-region scale. To explore the spatial configuration of durable trans-local linkages, we formulate a framework of global cluster linkages and city-region linkages related to FDI connections across borders.

3. Global Cluster-Network Hypotheses: Global Linkages of Clusters and City-regions

In this section, we advance global cluster-network and global city-region-network hypotheses by synthesizing the above discussions about trans-local linkages at different scales. Similarly synthetic methods of conceptualizing the architecture of the global economy can also be found in the approaches by Coe and Bunnell (2003), Depner (2006), Engel and del Palacio (2009), or Henn (2012). The reason for applying such a method of framework building in this study is that the various frameworks about trans-local linkages, although individually limited in their reach, can be fruitfully combined into a wider nested argument as, for instance, demonstrated by Saxenian (2002) who linked the transnational-community and production-network literature or by Coe et al. (2010) who draw an integrated framework on global-production and global-city networks. What is different in and central to our argument about cluster networks connected by FDI linkages is a network-based understanding of FDIs. This helps us develop a nested framework connecting the levels of individuals and firms with clusters and city-regions.

In his classical eclectic theory of FDIs, Dunning (2001) assumes a transaction-cost-based view of the firm. Accordingly, whether and where a foreign affiliate will be established depends on cost-benefit calculations of rational and fully-informed decision-makers in atomistic multinational corporations. Following this interpretation, empirical studies on spatial investment patterns have found that FDIs tend to be directed to places where the same or related industries are located (Head et al., 1995; Hilber and Voicu, 2010).[1] From a knowledge perspective, this can be explained by the need of firms to acquire localised knowledge that encourages foreign firms to participate in clusters (Nachum and Keeble, 2003). Martin and Sunley's (2011) conceptualization of cluster evolution, for example, draws from the assumption that clusters develop linkages with other clusters to access different, yet related knowledge pools. This may include

[1] Such local agglomeration effects that attract FDIs can be incorporated into the locational-(L)-advantage component of Dunning's (2001) eclectic theory.

advantages by obtaining knowledge through observation of competitors and benefiting from sophisticated regional labour markets (Li, 2011). Therefore, one could expect that global cluster networks form through FDI linkages.[2] Many empirical FDI studies focus on the question of how foreign affiliates benefit from the respective local context, while leaving the vice versa question of whether FDIs also contribute to the local economy unexplored. Studies on the latter question have found that FDIs established in a cluster context also tend to transfer more knowledge to the local economy (Thompson, 2002). Therefore, a more appropriate understanding of the interaction between FDIs and clusters, from a knowledge-based perspective, would suggest that foreign affiliates and regional industrial clusters both benefit from the impacts of FDIs (Almeida, 1996; De Propris and Driffield, 2006).[3]

In the large body of literature on the spatial patterns of FDIs, almost all studies are restricted to the analysis of the destinations of such investments. Partly due to data limitations, the question of where FDIs come from is usually neglected, except for some aggregate statistics at the national level. This leaves an important question unanswered: are firms in clusters likely to set up FDI affiliates inside or outside similar clusters when they invest in other countries? Facing global competition, new internationalisation tendencies of many cluster firms from traditional industrial districts suggest an affirmative answer of this question (Whitford and Potter, 2007; Chiarvesio et al., 2010). Oliver et al.'s (2008) observation in two ceramic clusters points at the possibility that

[2] The related term "global networks of clusters of innovation" is used by Engel and del Palacio (2009) who aim to show how globally connected clusters of innovation become established in high-technology industries. Focusing on Silicon Valley and a technology-based definition – as opposed to a regional perspective - of clusters, they discuss several factors that characterise such clusters of innovation. In a similar way, other papers have also recognized the importance of global networks that link different clusters (e.g. Andersen and Lorenzen, 2007). Much of this work, however, seems to assume the existence of such networks, and does not test this proposition empirically or present a comprehensive conceptualization.

[3] A different, yet related question is, of course, whether FDIs can stimulate the development of new clusters – especially in less developed regions. While some observers are sceptical about this form of cluster stimulation (e.g. De Propris and Driffield, 2006), in-depth case studies exist which are more optimistic about such prospects (e.g. Depner 2006).

internationalised local firms connect different clusters in the same sector. Leading glazing firms in the Castellon ceramic tile cluster in Spain have, for instance, established affiliates in an Italian ceramic cluster in Emilia with advantages in the ceramic equipment segment, and ceramic equipment firms from Emilia have vice versa set up affiliates in Castellon. Through these FDI linkages, up-to-date industrial knowledge can quickly be transferred between the two clusters. Similar matching investments can also be found between Silicon Valley and Hsinchu in the information technology sector (Saxenian, 2006), and between Hollywood and Vancouver in the motion-picture industry (Scott and Pope, 2007).

Inspired from anecdotal empirical evidemce, and scaling up to a global level, we propose the hypothesis that FDI affiliates serve to create global networks of clusters in similar or related fields. This proposition calls for a novel interpretation of FDI-related firms. Instead of a transaction-cost view of the firm, we adopt Ghoshal and Bartlett's (1990) view of the firm as an interorganizational network. Such a network view goes beyond headquarter-subsidiary linkages that imply unidirectional hierarchical flows of knowledge within multinational corporations. Embedded in cluster contexts in both the source and target regions of FDIs, multinational corporations can be viewed as *networks within networks* (Dicken and Malmberg, 2001). In order to adjust to changing local demand conditions and specific needs, FDI affiliates require more autonomy and innovative capability, which makes headquarter-subsidiary relationships within multinational corporations less appropriate in the global knowledge economy. This is especially the case in a cluster context where industrial knowledge is localised as if it was 'in the air'.

By 'being there', FDI affiliates can learn through local horizontal monitoring and vertical interacting (Malmberg and Maskell, 2006; Bathelt, 2007; Li, 2011). Labour flows within the local market also unintentionally contribute to knowledge circulation among

FDI affiliates and other local firms (Glückler, 2007; Belussi, 2010). Within cluster contexts, FDI affiliates can integrate their operations into the local milieu in various ways as if they were domestic firms. What differentiates FDI affiliates from other cluster firms is that they can get access to external knowledge from other units of the same organisation across distance, thus establishing a natural 'pipeline' for the local cluster. In a global cluster network where headquarters and other FDI affiliates are more likely to be located within clusters, such affiliates act as knowledge brokers between distant clusters. Codified knowledge can be transferred across the cluster network through FDI linkages, for instance, by means of new communication systems linking global corporate networks (Glückler, 2011). But even more important is the cross-local dissemination of tacit knowledge, realized particularly through assignments and reassignments of expatriate managers within multinational corporations (Beaverstock, 2004; Riusala and Suutari, 2004; Hocking et al., 2007). These mobile individuals or boundary-spanners provide grounds for the trans-local diffusion of tacit knowledge across national borders within global cluster networks (Coe and Bunnell, 2003; Depner, 2006). The combination of spatial proximity within local clusters and organizational proximity with other corporate units across distant clusters, gives FDI affiliates the unique opportunity of transferring both codified and tacit knowledge beyond and across clusters (Bathelt and Turi, 2011). Through organizational proximity, FDI affiliates in a global cluster network challenge the traditional dichotomy of tacit knowledge as being local and codified knowledge as being ubiquitous (Amin and Cohendet, 1999). Through geographical proximity within a cluster context, FDI affiliates operate as durable pipelines of trans-local knowledge flows and, as such, complement temporary learning of cluster firms in trade fairs and professional conferences (Bathelt and Schuldt, 2010) in more permanent ways. Following this, a first hypothesis can be formulated as follows:

Global cluster-network hypothesis (H1): *FDIs are more likely to originate from and be directed to clusters, as opposed to non-clusters. As a consequence, global cluster networks are formed between clusters in similar or related fields. These clusters are connected by FDI affiliates, within which codified and tacit knowledge is disseminated through the transfer of expatriate managers.*

Global cluster networks result from a nested framework that connects the firm and individual with the cluster level (Figure 1). These networks provide a mechanism for trans-local knowledge linkages and, at an aggregate scale, reflect some structural features of the global economy in a novel way. In a similar spirit as in Coe et al.'s (2010) analysis of production chains and geographical networks, we further explore how a global city-region network pattern can be derived from FDI-connected clusters.

By viewing clusters and FDI linkages as networks, following Dicken et al.'s (2001) argument of the territorial embeddedness of networks, we can expect that spatial patterns of global cluster networks develop. Although clusters are defined as geographical phenomena, it is not easy to delineate their spatial boundaries precisely (Porter, 1990). To be consistent with the method of cluster identification applied in this study, we restrict the scale of clusters in our exploration of the spatial dimension of global cluster networks to the level of cities or city-regions.[4] At an aggregate level, city-regions can include one or more clusters. No matter whether clusters are innovative or less successful industry configurations at the national level, they typically reflect the function of the city-regions, or parts thereof, within which they are situated.[5] In the global system of city-regions – from global cities at the top of the hierarchy to manufacturing cities in the middle range and highly-specialized or rural cities at the

[4] We are fully aware that some clusters stretch across city or even national borders, but from the large body of literature of individual cluster cases, we feel confident that this limited definition applies to most clusters.

[5] Here, we do not intend to equate clusters with innovative local industries, as warned by Martin and Sunley (2003). Locally successful industries may in fact consist of vertically-integrated firms. Also, clusters in developing contexts may, in turn, be trapped in low-cost competition.

bottom – the dominant economic functions of cities are often reflected by a group of clustered firms in manufacturing or service sectors. From the existence of global cluster networks within which clusters are connected through FDI linkages, we therefore expect that global networks of city-regions build upon FDI linkages between clusters. In other words, it can be expected that global cluster networks are structurally embedded in global networks of city-regions.

City-regions develop different economic functions, related to the different clusters that form inside of them. Similarly specialized, distant clusters are connected through networks, as are therefore different city-regions. First, embedded in manufacturing cluster networks, manufacturing city-regions are connected with each other through FDI affiliates. Traditional FDIs in manufacturing sectors are more attracted to get access to low labour cost, input supplies, or potential markets in target regions. However, as argued in the global cluster network hypothesis, FDI affiliates across clusters put specific emphasis on the local knowledge pools as clusters even in the same sector become specialized in different directions in different contexts. From this, global networks of city-regions in which cluster networks are situated, are less likely to be composed of FDI linkages spanning from developed regions to export processing areas in developing countries, but are more likely to be formed between city-regions of similar or related industrial structures (not necessarily only connecting manufacturing cities). Connections across these global city-region networks are usually bilateral, rather than unidirectional as in traditional manufacturing FDIs. Examples of such global city-region networks can be found between Silicon Valley, Hsinchu and Bangalore (Saxenian, 2006) in the high-technology industry, between Castellon and Emilia in the ceramic industry (Oliver et al., 2008), or between Prato and Wenzhou in the textile and garment industry (Hooper, 2010).

Second, in professional services, which represent central control functions of city-regions, FDIs are likely to generate linkages from global cities and to other global cities. The cluster-based network of global cities thus combines the views of Sassen's (2001) global-city model and network analyses of world cities (Alderson and Beckfield, 2004; Taylor, 2004). In the latter, networks of world cities, drawn from relational data of multinational producer services, demonstrate intensive connections between high-order cities through headquarter-affiliation linkages. Since Sassen's (2001) global-city framework emphasizes the clustering of advanced producer services in global cities, one might assume that cluster-based networks of global cities are formed by corporate FDI affiliates nested, in parts, in the financial clusters in these cities. But such functional reasoning could be reductionist. It is, for instance, also possible that cities in the upper-middle range of the city-region network would be connected by FDI linkages of cluster firms in professional services. However, since resources in regional control centres are limited, such FDI networks are expected to remain moderate at the global scale.

Third, city-regions with different functions and status are also linked through FDI affiliates of cluster firms. Agglomerated producer servicers in global cities may, for instance, set up FDI affiliates in manufacturing clusters to attract local demand. In fact, the power of global cities can be strengthened by specialized producer services establishing affiliates in connection with dispersed manufacturing activities (Sassen, 2001). Also, global cities may link up with regional control centres and lower-order city-regions through cluster-based FDIs in producer service sectors to extend their control functions in competition with other high-order city-regions. Such cross-order connections of cities are also reflected in network analyses of world cities (Alderson and Beckfield, 2004; Taylor, 2004).

These arguments suggest that various connections among clusters in manufacturing and service sectors can be articulated within the context of city-regions,

not necessarily reflecting a strictly hierarchical but a diversified multilateral spatial pattern. A global city-region-network hypothesis can thus be derived from the global cluster-network hypothesis:

Global city-region-network hypothesis (H2): *Global city-region networks may be formed by FDI affiliates of cluster firms in manufacturing and service activities. Global cluster networks are structurally embedded within global city-region networks.*

Altogether, the above reasoning leads us to suggest the existence of a nested framework of cluster and city-region networks at the global level (Figure 1). The various networks are established by individuals, such as engineers, entrepreneurs or other professionals, who operate in trans-national contexts and become important boundary-spanners. They provide decisive linkages between multinational establishments across different countries and negotiate and translate rules, practices, and differences back and forth between these establishments. Multinational firms in clusters are the key actors generating such trans-local pipelines and building durable inter-cluster infrastructure from which broader networks can develop. City-regions, especially global cities, may have one or more than one cluster. What is decisive is that clusters, which are typical for a specific type of city-region, develop inter-cluster networks in the way described above which then become established in and formative for inter-city-region networks at the global level.

4. Data and Methods: FDI Investments, Cluster Identification and City-region Classification

Testing the global cluster-network and global city-region-network hypotheses requires both case-specific FDI data connecting cross-border regions and detailed local industry data to identify clusters and classify city-regions. Our data on FDIs are drawn from the monthly investment monitoring of the Asia Pacific Foundation of Canada

between 2006 and 2010 (Asia Pacific Foundation of Canada, 2006-2010). The Asia Pacific Foundation of Canada was created by an Act of Parliament of Canada in 1984, and has become an independent think-tank sponsored by the Canadian Government to analyse Canada's relations with Asia. The investment monitor is based on firm press releases and business news. For the five years from 2006 to 2010, it includes 299 FDI cases from Canada to China and 40 investments from China to Canada.[6] Since investment cases from China to Canada do not reach a critical mass to allow for general exploration, we focus on the 299 FDIs from Canada to China. For each of these FDI cases, the investment monitor includes the firm name, the geographical origin and destination of the investment, and a brief description of the investment based on which industry and investment specifics can be identified. Table 2 lists the distribution of the 299 FDIs across industry groups. Although widely spread across different industries, FDIs from Canada to China concentrate in the areas of manufacturing, mining, finance and telecommunications.

To identify clusters, we consult detailed industry data in the two countries. In Canada, following Holmes and Stevens' (2003) study on the spatial distributions of industries, we use the 2006 Canadian business patterns data (Statistics Canada, 2006), which cover all registered business establishments in Canada. Within this database, each establishment is characterized by a 3-6 digit North American Industry Classification System (NAICS) code, a Census Metropolitan Area (CMA)/Census Agglomeration (CA) code[7] and one of nine employment size categories.[8] As we define clusters within city-

[6] As Si (2011) emphasizes in her analysis of outward-directed FDIs from China, such investments have only become significant after 2004 – but have since reached a high level with China being the 6th largest investor worldwide in 2009. Main destinations of Chinese outward-directed FDIs are East and Southeast Asia, while Canada plays only a minor role (Asia Pacific Foundation of Canada, 2009a).

[7] CMAs and CAs represent all urban economic areas in Canada. According to Statistics Canada (2006), these areas are defined by a larger urban core with at least 10,000 people combined with one or more closely-related adjacent municipalities according to commuter flows. There are 33 CMAs and 111 CAs in Canada in 2006.

regions, a 3-6 digit industry classification with CMA/CA codes satisfies our data needs. Next, we use the number of establishments and employees in each industry at the CMA/CA level to calculate locational quotients (LQs). To exclude extreme cases with only extremely small firms or with one single giant firm, both LQs are used in combination to identify clusters in the analysis.

The next step of the analysis is to estimate employment numbers in all FDI-related industries based on detailed Canadian business patterns.[9] In estimating employment numbers from employment categories, the mean of each category is usually viewed to provide better estimates than the midpoint, since employment distributions within each size category might be skewed (Holmes and Stevens, 2003). However, in Holmes and Stevens' (2003) estimation of employment numbers for the U.S., there is no significant difference between mean and midpoint estimates in each category. We also compute both mean and midpoint estimates for employment by detailed industry group for each CMA/CA.[10] It turns out that in calculating LQs of relevant industries, the differences between both estimates are very small resulting in the same groups of CMAs/CAs with LQs larger than 1.

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[8] The nine categories are "indeterminate", 1-4, 5-9, 10-19, 20-49, 50-99, 100-199, 200-499, and 500+. The "indeterminate" category includes employers that do not have employees, or may have a workforce of contract workers or family members (Statistics Canada, 2006). We designate 1 employee to these firms in our analysis.

[9] Available census data would also include the employment numbers of 4-digit industries at the CMA/CA level. We decide not to use this data because 4-digit industry data is not detailed enough to construct more accurate structures of clusters. For example, in identifying the Calgary oil and gas cluster, geophysical surveying and mapping services (541360) should be included in the calculations, but this industry branch cannot be separated from architectural, engineering, and related services (5413) at the 4-digit industry level. For a study that identifies Canadian clusters based on census data, see Spencer et al. (2010).

[10] In Canada, average employment in each category is obtained by dividing the number of employees at the national level by the number of national establishments. The categorized national employment data originates from the business payroll survey 2008 (Statistics Canada, 2008a), and the number of national establishments from Canadian business patterns in December 2008 (Statistics Canada, 2008b). An additional problem in the calculations arises from the fact that there is no upper limit in the last category of 500+ employees. We solve this by using the mean of five subcategories of 500+ employees from U.S. data as an estimate, i.e. 1260.56 (Holmes and Stevens, 2003), thus assuming that U.S. and Canadian data are comparable in this respect.

In China where corresponding business pattern data is not available, economic census data from 2004 (National Bureau of Statistics of China, 2004) is used, since it encompasses the establishments and employees for each 4-digit industry according to the China Industry Classification System (CICS) at the city level.[11] The high degree of consistency of the NAICS and CICS databases in the two countries provides the basis for our cluster identification and comparison. As opposed to the Canadian database, there is no need to estimate employment data in China. A problem of using economic census data in China is, however, that it only covers mining and manufacturing activities, and not services and agriculture. This is not a severe problem since most clusters in China are in manufacturing industries, but it has to be addressed to ensure compatibility with the Canadian data. To resolve this lack of data, we use employment numbers in the agricultural and service sectors from the China City Statistical Yearbook for 2005 (National Bureau of Statistics of China, 2005). This enables us to calculate LQs of the number of firms and employees in China and Canada in a comparable manner.

Next, we classify investment cases in the most detailed way possible according to industry statistics in both countries. In Canada, a total 198 local industries are identified that are related to the FDI cases in China; 118 local industries in China are related to these Canadian FDIs. We then calculate the LQs for both number of establishments and number of employees in the respective industries and city-regions. In Canada, 80 of the 198 local industries meet the criteria of having LQs in the number of establishments or the number of employees that are near or larger than 1. Of these 80 industries, we discard 9 in education, retail, and crop production which do not have cluster potential. In China, 51 local industries meet the same LQ criteria. The resulting 71 local industries

[11] The CICS from 2003 is a classification system similar to the NAICS, with the 4-digit level as the most detailed one that is comparable to the 6-digit NAICS classification.

in Canada and 51 industries in China exhibit strong agglomeration tendencies and are thus regarded as potential cluster candidates.

To insure that the identified potential clusters have coherent internal structures, we assign local industries to each potential cluster that are technologically related, using the most detailed industry classification available. In other words, we view the identified agglomerated industries as core activities and combine them with technologically related 4-6-digit NAICS industries that exist in the same city-region (3-4-digit SICS industries in China). These are industries exhibiting strong potential for producer-user linkages with the core industries. For example, Toronto has an agglomeration in the area of motor vehicle parts manufacturing (3363). This 4-digit industry does not, however, encompass the full breadth of an auto parts cluster as other relevant industries are scattered in other sections of the industry classification system. For the auto parts cluster, we therefore add the branches industrial mould manufacturing (333511), battery manufacturing (335910), and other related sectors. This step is quite time-consuming as it requires the identification of technologically related sectors in each potential cluster setting. Having constructed clusters with coherent structures, we recalculate the revised number of establishments and employees, as well as the respective LQs, to be used as final criteria for cluster identification. If these industrial ensembles have a sufficient scale in meeting the lower size limits for the number of establishments and employees,[12] and if both LQs are near or larger than 1, we identify them as "clusters".[13] In our analysis, these four

[12] To ensure that clusters have a sufficient size to potentially generate self-sustaining growth triggers, we define a lower limit in the number of establishments of 100 and an employment minimum of 5,000 people. The lower limits are chosen based on case studies of clusters to insure the identified clusters reach a critical mass for local interaction, knowledge exchange, and learning. The cut-off points chosen may seem somewhat arbitrary, but our final results of clusters are resistant to variation in the minimum number of establishments and employees. Of the identified clusters in Canada, only 4 of a total of 32 clusters have less than 10,000 employees and 5 have less than 200 establishments. In China, only 1 of 31 identified clusters has an overall employment of less than 10,000 and 12 have less than 200 establishments.

[13] Strictly speaking, these are still potential, and not real, clusters as we do not use data about input-output linkages or knowledge flows between the local industry branches. For the sake of simplification, we refer to them as clusters throughout this paper.

numerical criteria prove to be coherent since, in most cases, they are either simultaneously met or they fail altogether. Through this stepwise procedure, we finally identify 32 clusters in Canada and 31 in China (Table 3 and 4).

In the next step, we develop a typology of city-regions in both countries. In accordance with the theoretical discussion of global city-region networks and in taking competitive economic advantages of the cities in both countries into consideration, we distinguish five types of city-regions based on two criteria: economic function and influence (power) within the city-region system. The respective city-region types are: global city, regional control centre, manufacturing city, resource centre, and rural and other city. Global cities are identified according to their worldwide economic, political, and cultural influences, especially their dominant role as financial and producer-service centres in the global economy (Sassen, 2001). We define Toronto, Beijing, and Shanghai as global cities, since they are widely acknowledged as such in related studies.[14] Compared to global cities, regional control centres in our typology are defined as national capitals (i.e. Ottawa), capitals of provinces and China's city-level provinces (e.g. Chongqing). These city-regions are assumed to have political and economic power primarily at the national or sub-national level. Of the 38 FDI-related CMAs/CAs in Canada, 7 are grouped as regional control centres, and of the 91 city-regions in China, 22 are classified in this group.

Manufacturing cities are characterized by a large share of employment in manufacturing, but lack regional political powers. Since China, as an industrializing country, generally has a much higher percentage of manufacturing employment than Canada, we need to apply differentiated but comparable criteria to separate

[14] The three cities are all in the top 20 global cities ranked by Foreign Policy, A.T.Kearney and the Chicago Council on Global Affairs (available from: http://www.foreignpolicy.com/node/373401 [18 August 2011]) and Citi Private Band and Knight Frank (available from: https://www.privatebank.citibank.com/ann_2010.03.23.htm [18 August 2011]), and are classified as world alpha cities (available from: http://www.lboro.ac.uk/gawc/world2010t.html [18 August 2011]).

manufacturing cities from other city-regions. Using the national employment share in manufacturing as a benchmark (28 per cent in China and 12 per cent in Canada), we define manufacturing cities as those city-regions, not assigned as control centres, where the manufacturing employment is 2 per cent points above the national average. Of the 38 related CMAs/CAs in Canada, 14 are accordingly classified as manufacturing cities, and 32 of the 91 city-regions in China.

Resource centres are another unique and interesting group related to Sino-Canadian investment flows. The identification of resource centres is straightforward since these city-regions have an above-average share of employment in mining. We identified Calgary as the only Canadian city-region in this category with an employment share in mining of 6 per cent and 6 Chinese city-regions which have a share of more than 10 per cent of employment in mining. In comparison, other FDI-related city-regions in both countries show substantially lower employment in mining (mostly less than 2 per cent). The remaining city-regions in both countries and several rural areas are regarded as rural and other cities. Of the FDI-related 38 CMAs/CAs in Canada and 91 cities in China, 15 and 29 are classified as rural and other cities, respectively.[15] The results of the city-region classification in both countries are summarized in Table 5.

5. Results: Spatial Patterns of FDI Linkages from Canada to China

Having justified our methodology, this section presents the results of the analysis regarding the formation of cluster and city-region networks due to FDI linkages.

[15] In Canada, Vancouver joins this group of city-regions. Vancouver is a specific case in the Canadian city-region system. Arguments can be found to classify Vancouver alternatively as a resource or manufacturing centre (e.g. Rees, 2004) – or if combined with Victoria as a regional control centre – although it does not meet any of the criteria discussed above. This situation is a reflection of the highly unequal structure and size distribution of the Canadian city system, which makes it extremely difficult to identify a homogenous set of regularities that describe the growth patterns of cities in Canada (Simmons et al., 2004). To avoid an arbitrary element in our typology, we choose to assign Vancouver to our group of rural and other cities. The consequence of this is that it is not possible to identify typical investment patterns related to this group of cites in Canada as this is a rather heterogeneous group of city-regions, with Vancouver being dominant in terms of the number of FDIs.

Table 6 summarizes FDI linkage patterns depending on whether or not they originate from clusters in Canada or whether they are directed to clusters (or non-clusters) in China across different industry groups. Since we identify clusters according to 2004 census data in China and 2006 business pattern data in Canada, spatial patterns of FDI linkages from Canada to China since 2006 should be interpreted as the outcome of locational decisions of multinational firms based on pre-existing regional clusters. In Table 6, for all investment cases across all industries, 44 of 66 Canadian cluster firms (66.7 per cent) decided to set up a foreign affiliate in a Chinese cluster, whereas of the 233 investment cases from non-clusters in Canada, only 30 firms (12.9 per cent) opened branches in Chinese clusters. The bulk of the 203 Canadian non-cluster firms (87.1 per cent) opened their Chinese facilitates outside a cluster. The chi square test ($\chi^2_{df=1} = 79.91$, $p < 0.0000$) is highly significant, indicating that for FDIs from Canada to China, locational choices of multinational firms are not independent from their localised industry setting. Indeed, cluster firms in Canada are five times more likely to form cross-cluster linkages through FDIs in China than are Canadian non-cluster firms.

The fact that cluster firms are more likely to establish FDIs in clusters can be observed across different industries. Contingency tables of manufacturing, telecommunications, and finance and insurance industries indeed show similar patterns of cluster connections (Table 6): 63.6 per cent (14 out of 22), 100 per cent (23 of 23), and 53.8 per cent (7 of 13) of the FDI cases from Canadian manufacturing, telecommunications, and finance and insurance clusters choose to establish foreign affiliates in Chinese clusters, respectively. The chi square tests in these industries ($\chi^2_{df=1} = 13.04$, $p < 0.0003$ for manufacturing; $\chi^2_{df=1} = 3.97$, $p < 0.0463$ for telecommunications; $\chi^2_{df=1} = 3.3$, $p < 0.0692$ for finance and insurance) all support our observation that FDIs lead to spatial patterns of connected clusters formed by multinational firms that

originate from within cluster contexts. It is also important to note that Canadian firms from outside clusters are much more likely to direct their FDIs to a non-cluster context.[16]

Overall, Table 6 confirms the first part of the global cluster-network hypothesis (H1). What remains unexplored is what kind of clusters are connected to what kind of clusters through these FDI linkages. Are global cluster networks constituted through connections between clusters in similar or closely related technologies or industries as implied in the hypothesis? Or do firms from a specific technological cluster context direct their investments to different, yet somewhat related technological contexts? To answer this question, Table 7 specifies what kind of linkages between which cluster industries are formed by the 66 FDIs originating from Canadian clusters. Of the 23 FDI linkages from telecommunications and software clusters in Canada, 19 (82.6 per cent) provide connections to information, communication, and software clusters in China, while 2 of the remaining 4 firms are directed to specialised, technologically related telecommunication equipment and computer manufacturing clusters. For finance clusters, 7 of 13 FDI (53.8 per cent) linkages are directed to other finance clusters in China. In other sectoral contexts, 4 of 9 firms (44.4 per cent) from pharmaceutical clusters, 6 of 7 firms (85.7 per cent) in computer equipment clusters and 4 of 6 firms (66.7 per cent) in auto parts clusters choose to establish FDI linkages in places of the same industry where both competitors and related firms are agglomerated. Table 7 confirms the trend that clusters in similar or closely related technologies or industries

[16] In fact, the high significance levels in our analysis are especially related to non-cluster firms investing in non-clusters. While this finding is beyond the scope of this paper, it clearly points to the need to further investigate the investment patterns of these firms and why they do not invest in clusters. According to Table 6, non-cluster firms in telecommunications prefer cluster city-regions in China, while, in other industry groups, non-cluster firms are more likely directed to non-clusters. From this, we could expect that FDI linkages of non-cluster city-regions may be industry-specific. More generally, non-cluster networks may reflect that non-cluster firms without experience of operating in clusters tend to bypass clusters in China avoiding a local context of high competition which they are not familiar with.

are connected through FDI linkages. Altogether Table 6 and 7 strongly support our global cluster-network hypothesis (H1).[17]

As suggested in the conceptual part, spatial patterns of FDI linkages can also be explored at the city-region level which may establish global city-region networks as suggested by H2. Figure 2 summarizes structures of the city-region networks between Canada and China across different industries, with five categories of origins of city-regions from Canada and five types of destinations of city-regions in China related to the identified FDI cases. A general comparison of the structure of regional networks reveals different FDI-related spatial patterns of city-regions in different industries.

The upper left corner of Figure 2 displays the city-region connections across all industries. Most FDIs originate from the two large cities Toronto and Vancouver (Toronto being classified as global city and Vancouver as rural and other city), both of which have strong immigrant linkages with southern China. For FDIs from Toronto, most international investments concentrate in global cities, manufacturing centres and regional control centres, while FDIs from Vancouver agglomerate in rural and other areas, global cities and manufacturing centres. The high concentration of Vancouver FDIs to rural and other areas in China can be explained by investments in the mining industry (lower left corner in Figure 2). As a global centre of mining exploration (Russell et al., 2009), Vancouver takes the lion's share of the mining-related FDIs from Canada and most of the mining FDIs go to rural areas in western China, where important natural mineral deposits can be found.

The upper right corner of Figure 2 shows cross-border spatial networks of manufacturing investment. Most of manufacturing FDIs originate from Toronto where 5 of a total 19 manufacturing clusters in Canada are identified. The global city, Toronto, is

[17] These and the following results are stable and do not change with alterations in the cluster criteria used or classification procedure applied.

linked with other manufacturing centres, as well as regional control centres, in China where manufacturing clusters are located. For finance and insurance, Toronto completely dominates FDIs from Canada to China (lower right corner of Figure 2). As argued in the global city-region hypothesis and Sassen's (2001) global-city model, global cities are likely connected to other global cities by means of inter-cluster linkages in advanced producer services. For the financial FDIs originating from Toronto, most are indeed agglomerated in global cities in China. Generally, however, global cities are also linked to other city-regions with different functions when, for instance, firms in producer service clusters set up affiliates in manufacturing clusters to extend their control over economic activities. Therefore, a moderate part of financial FDIs from Toronto is directed to manufacturing centres and regional control centres in China, strengthening Toronto's global-city function.

The connections between global cities and manufacturing centres in manufacturing and among global cities in finance illustrated in Figure 2 are consistent with the first part of the global city-region hypothesis, in that global city-region networks are formed by FDI affiliates of cluster firms in manufacturing and service activities. Figure 2 also confirms that FDI linkages are established from Canadian regional control centres to manufacturing and resource centres in Chinese city-regions, yet these linkages are relatively small in number and are focused on manufacturing industries. Primary beneficiaries of these investments are Chinese high-level control centres. As such, these linkages support rather than challenge the existing city-region hierarchy.

The other part of the global city-region hypothesis concerns the relationship between the entire city-region network and cluster networks as reflected in Table 8. Table 8 shows the primary and secondary centres of cluster and city-region networks from Canada to China across major industries. The first two columns present the centres of outgoing FDI networks in Canada, and the last two columns those of incoming FDIs in

China. For each industry group, FDI linkages are differentiated into cluster and total city-region linkages. For example, for all industries, 50 per cent of FDIs generated by Canadian clusters originate from Toronto and 33 per cent from Vancouver. This is then compared with the total pattern of linkages between city-regions in both countries. Accordingly, in the case of all industries, Toronto accounts for 41 per cent and Vancouver for 37 per cent of total FDIs from Canada. What we see is that, at the city-region level, the same primary and secondary city-regions stand out with a similar share of linkages. A key pattern of FDI linkages emerging for all industries (as well as differentiated for manufacturing and telecommunications) is that cluster networks and city-region networks, which are generated through FDIs, share the same centres of core activities, both in terms of centres of FDI origins and centres of FDI destinations (Table 8). Therefore, when looking beyond clusters, the overall spatial patterns of FDI linkages from Canada to China support our hypothesis that cluster networks are embedded in city-region networks, and, in fact, strengthen or support these broader networks.

6. Conclusion: Towards Global Cluster Networks

In line with other theorisations of trans-local economic linkages at various scales, this paper develops a global cluster-network framework for exploring dynamic spatial patterns and connections in the global economy. Global cluster networks are generated through cluster firms setting up FDI affiliates in clusters with similar or related industries. FDI linkages across clusters provide an important mechanism for the global dissemination of knowledge generated in specific localities and the localised learning processes related to this global knowledge that take place in other localities. This is because FDI connections are able to exploit both spatial proximity within local clusters and organizational proximity within corporate networks at a distance. In a cluster context, FDI linkages with other cluster nodes develop into durable global pipelines for

the transfer of codified and tacit knowledge, complementing the role of temporary meetings and trade fairs in co-located settings. In a corporate context, FDIs of cluster firms challenge the previous atomistic interpretation of multinational corporations in terms of their locational decisions of new FDI affiliates. In a global-cluster network, multinational corporations are less adequately viewed as strictly hierarchical organizations, but as corporate networks that are embedded in and link with various cluster networks. In a city-region context, in turn, FDI linkages of cluster firms in manufacturing and/or producer services generate global city-region networks, within which various cities are connected and various clusters are embedded.

To test the global cluster network and global city-region hypotheses, this paper investigates the spatial patterns of about 300 FDIs from Canada to China between 2006 and 2010. After identifying clusters and classifying city-regions in a way comparable between the two countries, we find that the results of FDI linkages from Canada to China are consistent with the hypotheses developed. First, in both manufacturing and producer services, cluster firms from Canada are more likely to set up FDI affiliates inside - rather than outside - existing Chinese clusters, thus forming global cluster networks. Second, in these global cluster networks, FDI cases from telecommunications, finance, computer equipment and auto parts industries in Canada are connected to similar or closely related industrial clusters in China. In combination, these two findings support the global cluster-network hypothesis, implying that global cluster networks are formed through FDI linkages between clusters in similar or closely related technologies. Third, we find that different city-region networks are generated through these FDI linkages across different industries. FDIs exhibit a pattern from global city to global city/manufacturing centre in manufacturing industries, and from global city to global city in the finance and insurance industry. The connection between global cities in finance FDIs from Canada to China supports Sassen's (2001) global-city model. Fourth,

global cluster networks and city-region networks share the same centres for all industry groups studied. Together, the third and fourth findings point at the global city-region hypothesis, suggesting that city-regions are connected by FDIs of cluster firms both in manufacturing and producer services, within which cluster networks are embedded.

Due to a lack of large amounts of disaggregated data on FDI cases, the global cluster-network and city-region-network hypotheses have only partially been empirically tested in this paper. However, encouraged by recent case studies on cluster connection and interaction and supported by the findings about FDI linkage patterns from Canada to China, we expect that global cluster networks will become more manifest and visible over time as the internationalization of cluster firms proceeds. Because of specific knowledge that is "in the air" of clusters, we expect that more cluster firms need to establish linkages with other clusters characterized by similar or closely related technologies and "be there" in order to keep up with - and benefit from - industry dynamics at the global scale. Through this, clusters in similar fields would connect with each other. The analysis of FDI patterns from Canada to China calls for further quantitative research about the global patterns of cluster dynamics to extend our knowledge beyond the narrow cluster boundaries and be able to produce generalisations. The global cluster-network hypothesis also requires more qualitative investigations of how codified and tacit knowledge is transferred across clusters through expatriate managers, immigrant entrepreneurs, and other transnational professionals to explore why (or why not) cluster or non-cluster linkages are created. All this emphasizes the need for a broader future agenda of research on cluster networks and spatial FDI dynamics in the global economy.

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Table 1 Frameworks of Trans-Local Economic Connectivity

Scale	Conceptual frameworks	Key drivers of trans-local connectivity	Main arguments	Limitations
Individuals	Transnational community	Emigrant engineers/ entrepreneurs	- They provide a significant mechanism for external knowledge transfer/learning	- Focus on few immigrant groups - Lack of corporate dimension
Firms	Global value chains/ production networks	Multinational headquarters/ global buyers/ global producers	- Local clusters as nodes of multinational corporations - External learning of cluster firms depends on value chain governance	- Focus on vertical interactions - Focus on input-output relations - Spatial relations only secondary
Clusters	Global pipelines	Trade fair attendees, business travel, etc.	- Trans-local pipelines provide crucial growth resources - Temporary clusters lead to pipeline generation/extension	- Focus on intra-cluster relations - Global linkages vaguely conceptualized - Durable networks unexplored
City-regions	Global cities	Global producer servicers	-They are concentrated in global cities - They exercise control/power along the urban hierarchy	- Focus on input-output relations - Focus on the top group of global cities

Table 2 FDIs From Canada to China by Industry Group, 2006-2010

(Source: Extracted from Asia Pacific Foundation of Canada, 2006-2010)

Industry group	FDI cases, number
Manufacturing	79
Mining	72
Finance and insurance	31
Telecommunication and software	29
Agriculture	24
Utilities	12
Education	12
Administration and support, waste management and remediation services	9
Professional, scientific and engineering services	7
Transportation	6
Cultural industry	4
Wholesale trade	4
Arts, entertainment and recreation	3
Accommodation and food services	3
Construction	2
Health care and social assistance	1
Real estate	1
Total	299

Table 3 Identified Canadian Clusters with FDIs in China by City-region and Industry, 2006-2010

(Source: Based on data from Asia Pacific Foundation of Canada, 2006-2010; Statistics Canada, 2006)

Identified cluster by city-region and industry	NAICS industries included	Establish-ments, number	Employees, number	LQ of establish-ments	LQ of employ-ment
Calgary finance	522112; 522130; 522220; 522310; 523	5091	18827	1.1	1.0
Calgary oil and gas	2111;541330;541360;541620;5629	8846	80800	4.5	5.8
Edmonton petro-engineering	3241; 541330; 541360; 2111	1773	13470	1.4	1.3
Hamilton auto parts	3361; 3362; 3363; 3365; 3369; 333511; 3336; 335312; 335315; 335910	98	6624	1.5	1.8
Kitchener auto parts	3361; 3362; 3363; 3365; 3369; 333511; 3336; 335312; 335315; 335910	112	11472	2.4	3.8
London auto parts	3361; 3362; 3363; 3365; 3369; 333511; 3336; 335312; 335315; 335910	86	13530	1.9	5.1
Montreal clothing	315	1318	19995	3.6	3.4
Montreal computer equipment	334; 335910	496	15376	1.5	1.4
Montreal finance	522112; 522130; 522220; 522310; 523	11152	47831	1.2	1.1
Montreal furniture	337	1059	13959	1.5	1.1
Montreal metal products	331; 332	1417	36062	1.1	1.0
Montreal motion pictures	512	3015	19768	1.9	2.5
Montreal performing arts	711	3609	14085	1.8	1.3
Montreal pharmaceuticals	325410; 339110; 621510; 541710	1280	32506	1.4	1.9
Montreal software	5112	230	7699	1.2	1.6
Montreal telecommunications	517	391	20087	1.1	1.8

Ottawa computer equipment	334; 335910	188	12444	1.9	3.9
Ottawa software	5112	155	5327	2.6	3.9
Toronto auto parts	3361; 3362; 3363; 3365; 3369; 333511; 3336; 335312; 335315; 335910	796	47554	1.1	1.2
Toronto computer equipment	334; 335910	907	24837	1.5	1.3
Toronto finance	522112; 522130; 522220; 522310; 523	23256	127859	1.2	1.7
Toronto motion pictures	512	6077	21072	1.9	1.7
Toronto pharmaceuticals	325410; 339110; 621510; 541710	1754	38880	1.0	1.4
Toronto plastic	326	801	40025	1.4	1.5
Toronto producer servicers and corporate control functions	541110; 541190; 541212; 541611; 541612; 541619; 541810; 541820; 551113; 551114; 561110	58226	345486	1.4	1.7
Toronto software	5112	646	12108	1.7	1.5
Toronto telecommunications	517	769	22029	1.2	1.2
Vancouver computer equipment	334; 335910	247	8512	0.9	1.1
Vancouver pharmaceuticals	325410; 339110; 621510; 541710	897	14202	1.2	1.2
Vancouver producer services and corporate control functions	541110; 541190; 541212; 5416; 541810; 541820; 5511; 5611	23516	103542	1.3	1.2
Vancouver software	5112	297	8066	1.8	2.5
Vancouver telecommunications	517	294	12311	1.0	1.7

Notes: NAICS = North American Industry Classification System; LQ = Location quotient

Table 4 Identified Chinese Clusters with FDIs from Canada by City-region and Industry, 2006-2010

(Source: Based on from Asia Pacific Foundation of Canada, 2006-2010; National Bureau of Statistics of China, 2004, 2005)

Identified cluster by city-region and industry	CICS industries included	Establish-ments, number	Employees, number	LQ of establish-ments	LQ of employ-ment
Beijing information, communication and software	G	3500	334102	n.a.	4.9
Beijing lease and producer services	L	38383	628099	n.a.	5.7
Beijing pharmaceuticals	368; 27	268	41612	3.9	0.9
Beijing scientific research and geophysical research	M	15716	400982	n.a.	2.9
Beijing telecommunication equipment	401	134	28840	4.3	0.8
Changzhou auto parts	372; 2911; 3940	148	16873	1.0	1.0
Chengdu finance	J	2625	77000	n.a.	1.2
Chongqing auto parts	372; 2911; 3940	230	105790	2.8	1.5
Daqing oil	3612; 710; 790; 2511	83	120376	29.6	17.6
Guangzhou auto parts	372; 2911; 3940	161	44612	1.0	0.8
Guangzhou finance	J	2951	107900	n.a.	1.3
Jinan information, communication and software	G	335	8513	n.a.	1.0
Nanjing information, communication and software	G	801	120000	n.a.	1.3
Shanghai automation equipment	4111	81	11321	3.7	4.6
Shanghai auto parts	372; 2911; 3940	563	139469	1.1	1.4
Shanghai finance	J	787	182400	n.a.	1.6
Shanghai information, communication and software	G	1500	94800	n.a.	1.3
Shanghai lease and producer services	L	31148	458700	n.a.	3.1
Shanghai medical equipment	368	117	17654	2.8	3.4
Shanghai metal products	34	1388	159053	1.7	1.9
Shanghai plastic and rubber	2651; 2652; 291;	1335	180086	1.4	1.7

	30				
Shenzhen information, communication and software	G	1444	140000	n.a.	2.1
Shenzhen telecommunication equipment	401	179	146168	6.9	15.2
Shijiazhuang pharmaceuticals	368; 27	41	46795	2.3	8.7
Suzhou computer manufacturing	404; 405; 406	663	385224	2.7	13.0
Suzhou information, communication and software	G	550	38300	n.a.	1.1
Tianjin finance	J	3179	50400	n.a.	1.0
Weifang auto parts	372;2911;3940	141	28678	1.3	1.8
Wuhan auto parts	372; 2911; 3940	106	41483	2.4	0.9
Wuxi bicycles	374; 3940; 2912	68	17675	1.4	4.5
Yantai gold mining	921; 3321	70	57404	11.6	34.6

Notes: CISC = China Industry Classification System; LQ = Location quotient; n.a. = not available

Table 5 Types of City-regions with FDI Activities by Country, 2006-2010

Type of city-region	Number (percentage) of identified city cases in Canada	Number (percentage) of identified city cases in China
Global city (GC)	1 (3%)	2 (2%)
Regional control centre (RCC)	7 (18%)	22 (24%)
Manufacturing city (MC)	14 (37%)	32 (35%)
Resource centre (RC)	1 (3%)	6 (7%)
Rural and other cities (RO)	15 (40%)	29 (32%)
Total	38 (100%)	91 (100%)

Table 6 Origins and Destinations of FDI-based Cluster Networks from Canada to China by Cluster Status and Industry Group, 2006-2010

	All industries		Manufacturing		Telecommunications		Finance and insurance	
TO / FROM	Cluster	Non-cluster	Cluster	Non-cluster	Cluster	Non-cluster	Cluster	Non-cluster
Cluster	44	22	14	8	23	0	7	6
Non-cluster	30	203	12	45	5	1	4	14
Chi square (P value)	79.91 (.0000)		13.04 (.0003)		3.97 (.0463)		3.3 (.0692)	
Degrees of freedom (df)	1		1		1		1	
N	299		79		29		31	

Table 7 FDI-based Cluster Networks from Canada to China by Cluster Industry, 2006-2010

Cluster industry in Canada (FDI origin)	Cluster industry in China (FDI destination)	FDI linkages, number
Telecommunications and software clusters		**23**
	Information, communication and software clusters	19
	Telecommunication equipment clusters	1
	Computer manufacturing clusters	1
	Non-clusters	2
Finance clusters		**13**
	Finance clusters	7
	Non-clusters	6
Pharmaceutical clusters		**9**
	Pharmaceutical clusters	4
	Non-clusters	5
Computer equipment clusters		**7**
	Telecommunication equipment clusters	4
	Computer manufacturing clusters	1
	Software clusters	1
	Medical equipment clusters	1
Auto parts clusters		**6**
	Auto parts clusters	4
	Non-clusters	2
Motion picture clusters		**3**
	Non-clusters	3
Producer services clusters		**2**
	Lease and business service clusters	1
	Non-clusters	1
Paper publishing clusters		**1**
	Non-clusters	1
Petro-engineering clusters		**1**
	Non-clusters	1
Metal manufacturing clusters		**1**
	Non-clusters	1
Total		**66**

Table 8 FDI-based Cluster Networks from Canada to China Embedded in City-Region Networks by Industry Group, 2006-2010

Industry Group		FDI origin (Canada)		FDI destination (China)	
		Primary centre (Percentage of links in networks)	Secondary centre (Percentage of links in networks)	Primary centre (Percentage of links in networks)	Secondary centre (Percentage of links in networks)
All industries	Cluster links	Toronto (50%)	Vancouver (33%)	Beijing (27%)	Shanghai (26%)
	Total links	Toronto (41%)	Vancouver (37%)	Beijing (18%)	Shanghai (11%)
Manufacturing	Cluster links	Toronto (73%)	Vancouver (14%)	Shanghai (23%)	Beijing (19%)
	Total links	Toronto (49%)	Vancouver (22%)	Shanghai (13%)	Beijing (14%)
Telecommuni-cations	Cluster links	Vancouver (70%)	Ottawa (17%)	Shenzhen (36%)	Beijing (36%)
	Total links	Vancouver (55%)	Ottawa (14%)	Shenzhen (34%)	Beijing (34%)

Figure 1 Nested Model of Global Cluster Networks

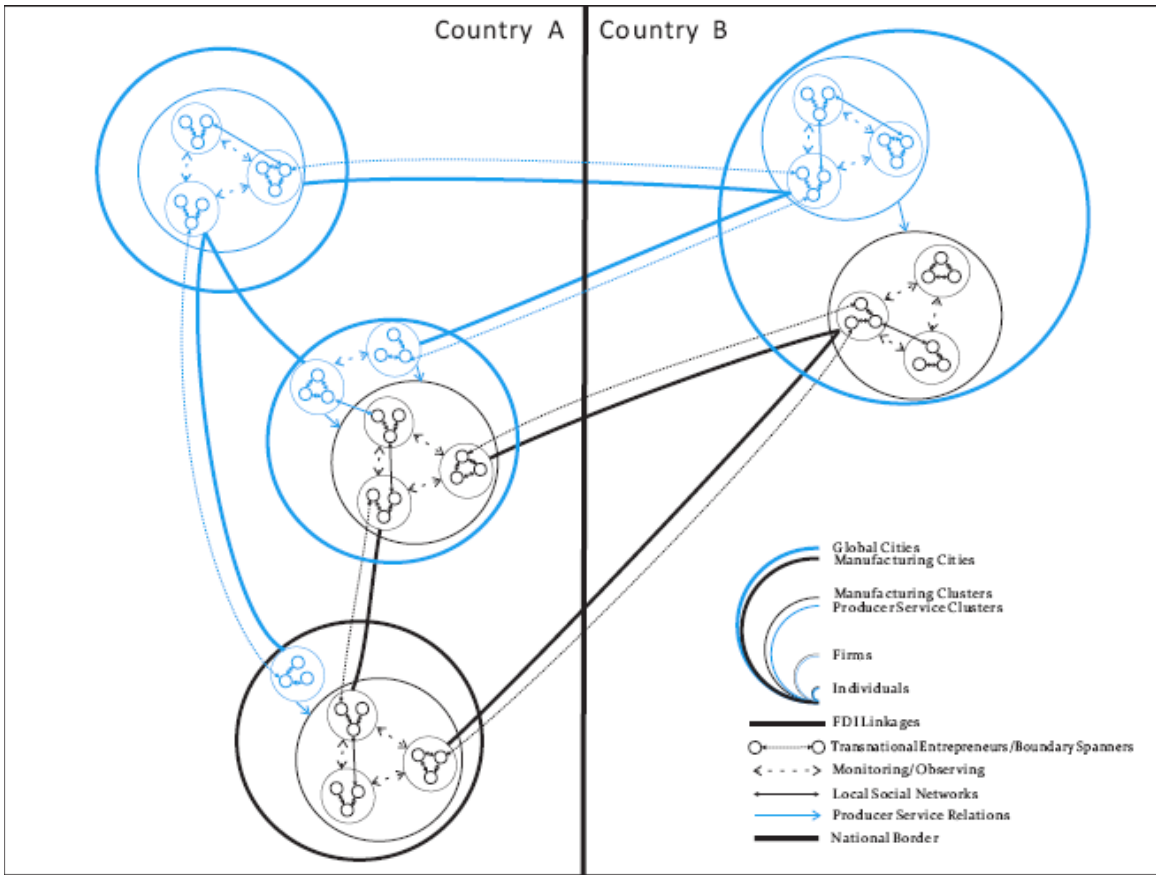
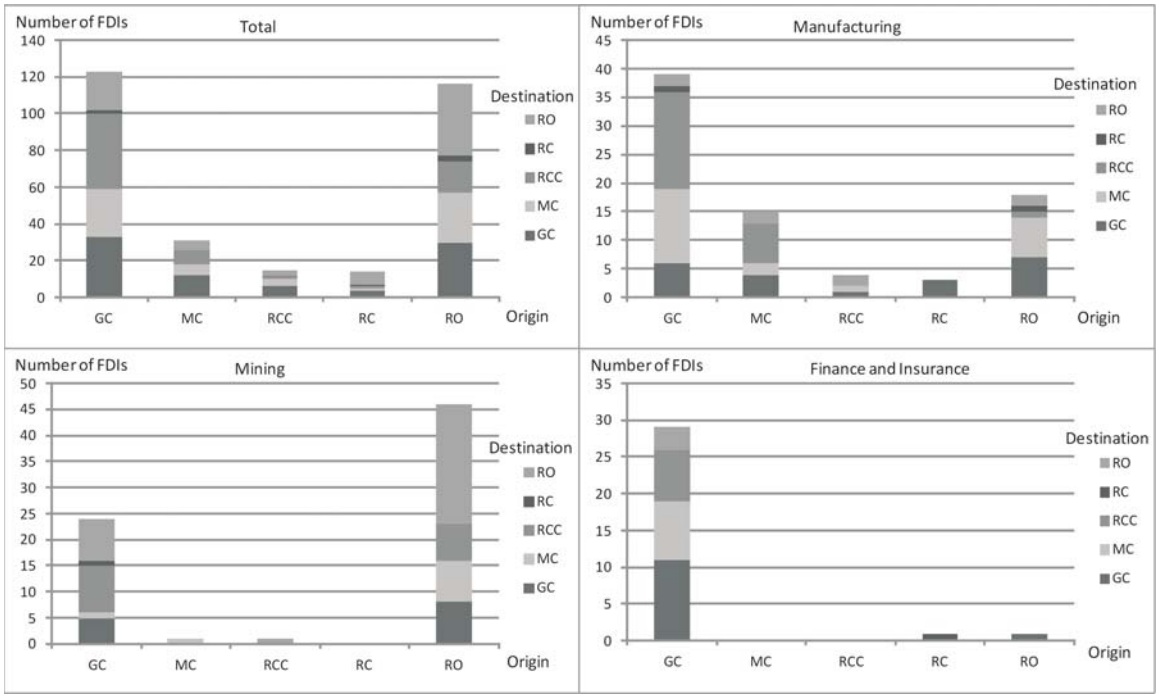


Figure 2 FDI-based City-Region Networks from Canada to China by Industry Group, 2006-2010



Note: GC = Global city; MC = Manufacturing city; RCC = Regional control centre; RC = Resource centre; RO = Rural and other city