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European Cities and Foreign Investment Networks

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Abstract

Although one of the core questions in the study of multinational enterprises (MNEs) has been typically that of *where* their different operations take place, the spatial dimension of MNE investments and functions is still relatively underexplored in the literature. This paper investigates the networks formed by Foreign Direct Investment (FDI) by applying network analysis techniques drawn from the world city network literature. Data is extracted from the *fDi Markets* database to describe and analyse the geography of FDI flows between a set of 3,500 cities and towns within the European Union (EU) Member States and their neighbourhood. The paper identifies hierarchical patterns of relations between different types of locations, and gains a finer-scaled appreciation of sectoral and functional specialisations of different regions within Europe.

1. Introduction

The literature on the economic and innovation performance of cities and regions has reached a consensus on the idea that spatial proximity, density and localised processes should be placed into a broader context by accounting for a other typologies of potential proximity relations between local (and non-local) agents (e.g. Huber, 2011; Uyarra, 2011; Crescenzi et al., 2016a). In order to maximize their innovative output cities and regions cannot rely exclusively on local knowledge assets, but should benefit from a combination of "local buzz" (Storper and Venables, 2004) and "global pipelines" (Bathelt et al., 2004) or, more generally, global networks. The latter are non-spatially bounded linkages that channel and diffuse new and valuable knowledge across space. For the development of these links geographical proximity constitutes "neither a necessary nor a sufficient condition" (Boschma, 2005, 62), while other non-spatial juxtapositions – i.e. cognitive, organisational, social and institutional proximities – play a crucial role as complements and/or substitutes of geographical closeness (e.g. Crescenzi et al., 2016a; D'Este et al., 2013).

The connections allowed for by the interaction of various proximities take different forms. A highly significant role in this respect is attributed to multinational enterprises (MNEs) that tap into pools of knowledge outside their place of origin, creating locational portfolios of complementary, place-specific assets (e.g. Cantwell, 2009; Malecki, 2010). The multiple embeddedment of subsidiaries within a MNE network across different geographies and in the local economy enables them to act as conduits for multidirectional knowledge flows between places (e.g. Meyer et al., 2011; Iammarino and McCann, 2013).

Rather surprisingly, in spite of the ground-breaking insights provided long ago by scholars such as Stephen Hymer and Raymond Vernon, international business and economic geography have not yet systematically identified the distinctive geography of MNE investment networks (McCann and Mudambi 2004; Iammarino and McCann, 2016). Notwithstanding the relevance of MNEs as global knowledge transmitters, a still limited scholarly attention has been devoted to the analysis of the position of cities and city-regions within such networks with respect to both the sectoral and functional dimensions of MNE operations.

This paper contributes to filling this gap by looking at the position of European cities in the continental networks formed by inflows and outflows of greenfield and brownfield Foreign Direct Investment (FDI) among the corresponding countries involved in the process of economic integration to different extents and degrees.[1] Starting from the early classical literature on MNEs, the paper applies network analysis techniques drawn from the world city network

[1] As discussed in Section 3 below, the dataset does not include Merger & Acquisition, thus our representation of city networks is limited to new greenfield investment projects.

literature (e.g. Friedmann, 1986; Alderson and Beckfield, 2004; Datu, 2014) to data extracted from the *fDi Markets* database to describe and analyse the geography of FDI flows between a set of 3,500 cities and towns within European Union (EU) members and the European Neighbourhood Policy (ENP) countries. Beyond producing a hierarchy of locations, we extend the analysis to disaggregate geographical networks by industrial sector, and according to flows relating to different stages of the value chain, as classified by Sturgeon (2008; see also Crescenzi et al., 2014). The heterogeneity across MNEs in terms of internationalization strategies is conducive to differentiated attitudes towards the formation of networks (e.g. Greenaway and Kneller, 2007). In addition, MNEs differ in terms of accumulation of technological capabilities as well as in their attitude toward cooperation and embeddedness into the regional or urban environment (Cantwell and Iammarino, 1998, 2003; Crescenzi et al. 2016b). The proposed methodology will make it possible to identify hierarchical patterns of relations between different types of locations, and gain a finer-scaled appreciation of sectoral and functional investment location patterns in different regions within Europe. We focus on specialised relations between different parts of the periphery of the European economy (i.e. interperipheral ties) with implications for strategic development policies in such peripheral regions. Furthermore, the link between the city-region position in investment networks and the degree of economic integration at the continental level allows us to develop a new taxonomy of Europe's leading investment cities.

2. The study background

2.1. Theoretical foundations: MNEs, urban hierarchies and global cities

In the current phase of globalisation, geographical specificity at the sub-national and sub-regional level has become increasingly significant for the strategy, organisation and performance of multinational enterprises, and in turn MNEs have become progressively more important for the economic growth and development of places (Iammarino and McCann, 2013; 2015). Over the last few decades MNEs have in fact experienced much faster and deeper transformations than other firm types (i.e. small- and medium-sized or large multi-plant uni-national firms) due to their bridging role across diverse geographical, technological and institutional systems. The emergence of a new set of relationships between MNE organisation and control of intra-firm and inter-firm networks, and the role of cities and city-regions as sources of inputs, knowledge and power, have led to increasingly differentiated geographies across all parts of the world (Iammarino and McCann, 2013).

Amongst the first generation of scholars who developed the early classical model of the MNE, both Stephen Hymer and Raymond Vernon are seminal contributors, in that they were the first two commentators aware of the likely long-run evolution of the relationships between MNE organisation and economic geography. Vernon's notion of the product life-cycle (PLC) (Vernon, 1966), which has since played a key part in the international business literature, was originally understood as a phenomenon operating at the sub-national level in which core cities and regions played different roles from peripheral regions (Vernon 1959). Vernon understood that a close mapping between technological and geographical structures was likely to be a natural outcome of MNE investment choices (Iammarino and McCann, 2015).

Stephen Hymer (1970, 1972), on the other hand, was the first to suggest that the pyramidal structure of corporate control should translate directly into a hierarchical structure of geographical locations – i.e. such a hypothesis being known as Hymer's 'correspondence principle' (1972). Some of these locations are heavily dependent on others, underlying the uneven spatial structure of economic development. Hymer noted that the simplest production activities tend to be relatively evenly spread internationally according to the attractiveness of resources such as labour, markets and raw materials: this phenomenon, re-echoing Vernon's PLC (1966), diffuses industrialization across less advanced economies. More complex activities, on the other hand, tend to be concentrated in fewer city-regions, as they require primarily white-collar labour, as well as sufficient communication and information systems: MNEs from different industries locate in the same cities or regions, thereby giving rise to a strong spatial and functional concentration at the sub-national level. Activities more connected to political power and lobbying will be, as suggested by Hymer, even more geographically clustered, as they need to be close to sufficient supplies of highly specialized human capital and services, capital markets, media and governments: the provision and exploitation of these high profile service relationships require strong connectivity, both locally and with the rest of the world.

Hence, the highest level functions of the leading MNEs are almost all located in the major 'global cities' of the world or macroregion considered, which themselves are "surrounded by regional subcapitals" (Hymer, 1970, 446). In the particular case of Europe, Hymer explicitly envisaged – as major global cities home to MNE core headquarter functions and high level strategic planning – London, Paris, Bonn, and Moscow (1972, 124). From these highest levels, Hymer foresaw that a geographical hierarchy would characterize the spread of MNE operations, with 'intermediate' and 'lower-level' activities distributed across lower tier urban centres.

Much of the later international business literature has explicitly or implicitly borrowed from Hymer's analysis (see, for all, Dunning and Pitelis, 2008). Curiously, however, in spite of a few studies (e.g., Young et al., 1994; Bailey and Driffield, 2002; Pitelis, 2002, 2005; Kottaridi, 2005) acknowledging and building up upon both Hymer and Vernon's key insights, the international business and economic geography literatures have largely overlooked the *ante litteram* relevance attributed to the interplay between spatial, and particularly urban, industrial/technological and functional structures underlying the locational choice and the geography of MNEs.

The 'correspondence principle' proposed by Hymer (1972) has seemingly evolved in the establishment of a direct relationship between the centralization of political and financial power within the MNE and their spatial concentration in a few truly global cities in the world economy. The increasing relative dominance of these global cities appears to be associated with strong transnational regulatory institutions and high density of information technology assets (e.g. Sassen, 2002; Derudder et al., 2003; Button et al., 2006; Taylor et al., 2010); their importance as major nodes within international networks is also reinforced by their role as hubs within the global transportation systems (e.g. Burghouwt, 2005; Leinbach and Capineri, 2007; Ni and Kresl, 2010).

At the same time, in response to the organisational and technological requirements of global value chains and knowledge networks management, control has increasingly been decentralised within the corporation and across geography, involving a wider range of spatial locations. In other words, while power (i.e. political and institutional linkages, finance, lobbying, alliances, etc.) has certainly tended to agglomerate in global cities, control over MNE functions and operations – including strategic ones such as the generation of new technology and innovation – is gradually delocalised in second, third and even lower tier cities and regions.

2.2 Foreign Investment and regionalism in Europe

Institutional and technological environments have changed radically since the late 1980s. The modes of international investment, the organization and management of intra-firm vertical and horizontal relationships for production and knowledge generation, the types of affiliation linkages, the diversification and distribution of functions, the integration of subsidiary objectives into the overall goals and strategy of the MNE, have all gone through substantial and rapid changes. These new organizational modes have occurred both within MNEs and involving external firms, often SMEs, which are connected through contractual relations to the global production and innovation networks led by large corporations (Iammarino and McCann, 2003).

Indeed, it has been shown that, rather than pure globalisation, clear trends towards global regionalism have emerged, with integration processes taking place between large groups of bordering advanced, transition and emerging economies (e.g. Rugman, 2005; Guy, 2009, 2015; Kohn and Brouwer, 2014).

This global regionalism is also characterised by a slicing up and recombination of global value-chains in which establishments and groups of activities are 'unbundled' (Baldwin, 2011) primarily across groups of neighbouring economic systems. These regionalism tendencies offer greater rewards to MNEs than ever before from exploiting the possibilities for better subsidiary-specific location matching, as well as coordination between dispersed MNE units and functions (Crescenzi et al. 2014). At the same time, higher demands for timeliness, greater requirements for high frequency transactions, and increased preferences for customization and variety, all tend to raise the distance costs associated with knowledge-related transactions (McCann 2007), and thereby the opportunity costs of sub-optimal MNE affiliate locations.

Some recent evidence indicates that, in the cross borders co-location of the different stages of the value chain of MNE affiliates in the context of the European Union, MNE headquarters do not display any pull effect over the location of any other MNE function (e.g. Defever 2006; Ascani et al. 2016b). Goerzen et al. (2013) have shown that *competence-exploiting* and *competence-creating* (Cantwell and Mudambi, 2005) activities of MNEs follow very different spatial patterns: while the first tend to agglomerate in global cities, the latter, far more valuable for local economic development, tend instead to concentrate in metropolitan less *core* regions, giving rise to geographical hierarchies based on functions rather than on firm counts or industry. These differing patterns also suggest that the relationships between MNE affiliates and the geography of knowledge networks and spillovers are likely to be far more varied and nuanced than the simple stylised linkages popularised in the traditional regional and urban economics and economic geography literature (Iammarino and McCann, 2003, 2015).

When looking at the geography of FDI in the EU and its associated and neighbouring countries[2], it is immediately apparent a strong core-periphery pattern at the national and supra-national level. The EU-15 countries account

[2] See Table A.1 in Appendix A for the definition of the European countries involved to a different extent in the continental integration processes.

for approximately 60% of all inward investments in the area[3], with the United Kingdom, France and Germany representing more than one third of all EU inward FDI. Around these central poles of attraction some of the 'new' member states (NMS) also play an important role. While Central and Eastern NMS attract approximately 21% of all investments in the area under analysis, Poland and Romania alone account for more than 40% of the projects localised in the NMS. Beyond the highly integrated core of the EU, other economies are progressively emerging as destinations for FDI such as Turkey or Serbia among the accession or candidate countries (ACC). The role of the European Neighbourhood Policy (ENP) countries remains relatively marginal in comparative terms, accounting for 20% of the investments outside the EU-15 and 8% of total intra-area investments. However, among the ENP-East, Ukraine emerged as a relevant investment pole before the 2008 economic downturn, as well as Morocco among the ENP-South countries. Russia is by far the largest non-EU FDI attractor in the area: accounting for approximately 20% of all FDI outside the 'core' of the EU-15, Russia receives approximately the same number of new investment projects as France or Germany.

With the 2004 and 2007 eastward enlargements, the European Neighbourhood Policy and other regional and multi-lateral cooperation initiatives (e.g. Eastern Partnership; the Euro-Mediterranean Partnership; the Black Sea Synergy) the EU has tried to reinforce its area of influence in the entire region. The significant increase in trade flows and labour mobility has been accompanied by a generalized increase in FDI among all economies involved. However, at the national level, the existence of a polarised system of FDI flows remains apparent, with the 'core' of the EU on the one side, and Russia on the other.

3. Cities and city-regions in FDI networks: data and method

3.1 Data

[3] *fDI Markets* data.

The dataset used for this study comprises the originating (or 'sender') locations and destination (or 'receiver') locations of a large number of decisions to undertake new greenfield investment projects between countries within Europe and its surrounding neighbourhood. Data is drawn from *fDi Markets-Financial Times Business*, comprising records of individual foreign investment 'projects' across all sectors and classified by main business function, occurred among EU-28 member countries, current and potential EU membership candidates, members of the EFTA and EEA, and participants in the European Neighbourhood and Common Spaces policies. The database, that for the purpose of this paper covers the period between 2003 (starting year of data collection) and 2008 (pre-crisis), includes all cross-border greenfield and brownfield investment.[4] Foreign firms' operations are identified by Financial Times analysts through a wide variety of sources, including nearly 9,000 media sources, project data from over 1,000 industry organizations and investment agencies, and data purchased from market research and publication companies. Furthermore, each project is cross-referenced across multiple sources and more than 90 percent of investment projects are validated with company sources. In addition, Crescenzi et al. (2014) and Ascani et al. (2016a) show that investment decisions recorded in *fDi Markets* are highly correlated with other macro-level data on FDI from UNCTAD, IMF and the World Bank.

3.2 Network position

The dataset, comprising sender and receiver locations for each investment decision within the EU and its neighbourhood, was transformed into one single square location network matrix using Ucinet (Borgatti et al., 2002), to be referred to herein as the 'entire neighbourhood' network. Data relating to investment projects coming from outside the European neighbourhood was not

[4] In this database joint ventures are tracked only when they lead to new operations, whereas Mergers & Acquisitions (M&A) as well as other equity investment are not included. Overall, the inclusion in the dataset is conditional on the fact that investment projects generate new employment or capital investment. Given the relevance of M&A in Europe, the representation of spatial FDI networks here reported is inevitably limited by the dataset used.

included in this operation. Filtered subsets of the data were transformed into separate square location network matrices for each sector (herein 'sectoral' subnetworks) and each function (herein 'functional' subnetworks). The sectors present in the dataset and thus used for this study are listed in Table A.2 in Appendix A. The classification of value chain stages used here is the same as that used in Crescenzi et al. (2014), where more details can be found, and which is an adaptation of a scheme presented by Sturgeon (2008) for occupations. This classification separates value chain activities into five stages as summarised in Table A.3 in Appendix A, alongside a measure of the degeneracy of each resulting matrix.

The identification of topologically viable networks, as well as the identification of the position of each location within the hierarchy of locations comprising each network, was achieved through the analysis of the degeneracy of each network according to a method set out in Datu (2014) following Kitsak et al. (2010a,b). This method centres on the calculation of the "*k*-shell decomposition" of each network according to the algorithm developed by Seidman (1983). The algorithm recognises that any network may be decomposed into several layers, numbered from the periphery to the core like the layers of an onion, each of which is herein called a "*k*-shell". The number *k* of any *k*-shell identifies the minimum number of connections to other locations within that *k*-shell accruing to every location within that same *k*-shell, regardless of the number of connections to peripheral locations outside that *k*-shell. For example, every location within the 14th *k*-shell of a network has *at least* 14 connections to other locations within the 14th *k*-shell. And nested within may be a *k*-shell where $k = 26$, signalling that every location within that *k*-shell has *at least* 26 connections to other locations within that 26th *k*-shell.[5] The algorithm thus identifies to which *k*-shell each location in the network belongs, providing a simple as well as intuitive means of identifying each location's position within the overall concentric hierarchy of the network. The

[5] To think of it another way, the number *k* identifies the minimum number of "inward" (from the inner layers) connections a location has, regardless of the number of "outward" (towards more peripheral layers) connections it has.

number of k-shells found within any network is a measure of the overall degeneracy (or resilience, or complexity) of the network, represented by the letter k. As Seidman (1983) demonstrated mathematically in his original specification, networks with less than three k-shells are conventionally too degenerate, or in other words too sparse, fragmented or fragile, to be analysed mathematically in much depth. Such networks are considered to be topologically unviable, and where a sectoral or functional network is found to have such a low number of k-shells, it is dropped from further analysis.[6]

To reiterate, the number k indicating which k-shell each location is found in for a given network is thus used as a way of measuring the position of each location within the hierarchy of each network. Each location is assigned a value k within the overall network, and within each sectoral, functional and sectoral-functional network where applicable: these values are used to assess the usefulness of network position in describing and explaining the geography of FDI networks in Europe.

4. Results: the network cores

Tables 1-6 report the locations found within the core (i.e. locations with $k \geq 3$) of

[6] The k-shell decomposition analysis is an extremely useful method for city network analysis for several reasons. First, it has been shown by the methodological literature (e.g. Kitsak et al., 2010a,b) to identify more accurately than other common node-level algorithms the group of cities that wields the most influence over the network as a whole. Second, it captures very succinctly all other classes of cities in the network—that is, it efficiently and simultaneously identifies all classes of cities from the innermost core to the outermost periphery of the network. Third, it provides an in-built test of significance, allowing us to discard networks where $k < 3$ by having shown that they do not bear meaningful further analysis. Fourth, it provides a clear-cut distinction between the cores and the peripheries of any network, marking clearly as core any locations where $k = 3$ or higher, and marking clearly as peripheral any locations where $k = 1$ or 2. And finally, it begins to provide sensible comparisons of the influence of a given location within various networks, including networks of very different levels of complexity.

the overall network, and within each sectoral and functional subnetwork.[7] Each row in each table represents a k-shell, with the more inner k-shells (represented by larger values of k) towards the top, and the more outer k-shells (represented by smaller values of k) towards the bottom. Locations in the innermost k-shell are displayed in bold. The peripheral k-shells (k = 1 or 2) are not reported.

The columns represent each location's institutional position in relation to the EU. Towards the left are the EU-15, followed by the EU-25, etc.; towards the right are the various territories peripheral or external to the European Union system such as countries identified in the European Neighbourhood Policy (whether active participants or not) or the Common Spaces Policy.

Individual outliers are also reported. Outliers are locations whose outdegree, indegree or total degree are at least half that of the location with the highest reported outdegree, indegree or total degree. Because of the extreme Poisson-like distribution of degree values, very few locations fall in these top halves of reported ranges, and with few exceptions they are all found in the innermost core of each subnetwork. All outliers have been underlined; in addition outliers on the outdegree measure have been presented in allcaps, outliers on the indegree measure have been presented in italics, and outliers on the total degree measure have been doubly outlined. For example, in the topmost row of Table 1 — the core of the overall network — six outliers are identified. London and Paris are the only two outliers on the outdegree measure; they are also the only two outliers on the indegree measure. In addition, four outliers on the indegree measure have been identified — Madrid, Budapest, Bucharest and Moscow.

[7] We present here selected core network representations: the overall network (Tab. 1); Food & Tobacco (Tab. 2), Software & IT services (Tab. 3), and Automotive OEM (Tab. 4) for sectoral subnetworks; and Manufacturing (Tab. 5), and Research & Innovation (Tab. 6) for functional subnetworks.

Table 1: The core of the overall network

k	*EU15*	*EU25*	*EU27*	*EU28*	*EEA*	*EFTA*	*Overseas*	*Candidate*	*ENP (active)*	*ENP*	*Common spaces*
23	**Amsterdam, Antwerp, Athens, Barcelona, Berlin, Bonn, Brussels, Cologne, Copenhagen, Dublin, Dusseldorf, Frankfurt, Hamburg, Helsingborg, Helsinki, *LONDON*, Luxembourg, Lyon, *Madrid*, Milan, Munich, *PARIS*, Rotterdam, Ruhr, Stockholm, Stuttgart, Vienna**	**Bratislava, *Budapest*, Krakow, Prague, Riga, Tallinn, Vilnius, Warsaw**	***Bucharest*, Sofia**		**Oslo**	**Geneva, Zurich**		**Istanbul**	**Kyiv, Tel-Aviv**		***Moscow*, St Petersburg**
22	A Coruña										
21	Goteborg, Lille, Manchester, Rome, Turin	Katowice, Ljubljana, Lodz, Wroclaw			Reykjavik	Basel	Hamilton	Belgrade			
20	Edinburgh, Lisbon	Poznan		Zagreb					Baku		
19	Bordeaux, Porto, The Hague, Treviso, Valencia, Windsor, Wolfsburg, Zaragoza		Varna			Zug					Novosibirsk
18	Flensburg, Ghent, Utrecht								Cairo, Casablanca		Nizhny Novgorod, Yekaterinburg
17	Florence, Klagenfurt, Malmo	Gyor	Timisoara								
16	Bilbao, Birmingham, Cambridge, Fischamend, Frankfurt an der Oder, Glasgow, Heilbronn, Mannheim, Marseille, Seville		Cluj Napoca, Plovdiv			Schindellegi		Ankara	Algiers, Odesa		
15	Cardiff, Herzogenaurach, Liege, Malaga										
14	Aarhus, Arnhem, Bristol, Graz, Hanover, Linz, Nantes, Nuremberg, Palma de Mallorca, Toulouse	Brno, Gdansk, Kaunas, Plzen	Brasov, Constanta, Ruse					Izmir	Lviv, Tunis	Minsk	Krasnodar, Samara
13	Bremen, Heidelberg, Leuven, Mulheim, Newcastle upon Tyne, Trieste, Wiesbaden	Klaipeda	Iasi						Chisinau, Kharkiv, Tbilisi		Kaliningrad, Kazan, Rostov on Don
12	Aberdeen, Antibes, Bologna, Chertsey, Cork, Gouda, Grenoble, Hemel Hempstead, Leicester, Liverpool, Montebelluna, Newbury, Padua, Salzburg, Valles, Vicenza		Ploiesti			Lausanne, Vevey			Amman, Beirut		
11	Amersfoort, Belfast, Caen, Darmstadt, Eindhoven, Kempten, Leeds, Lund, Lunen, Maastricht, Nottingham, Oxford, Reading, Rennes, Roskilde, Southampton, Strasbourg, Swindon, Thessaloniki, Venlo, Walldorf, Watford, Wels	Nicosia	Arad, Sibiu		Stavanger, Vaduz				Dnipropetrovsk, Donetsk	Tripoli	
10	Aalst, Amstetten, Brighton, Cordoba, Dresden, Hagen, Le Havre, Osnabruck, Slough, Verona	Kosice, Ostrava	Targu Mures		Bergen			Skopje	Yerevan		Maluga, Omsk, Tver

Legend: Each row represents the number of *k*-shell in descending order (i.e. from more inner *k*-shells at the top to more outer *k*-shells towards the bottom). Locations in the innermost *k*-shell (i.e. cores) are displayed in bold. All outliers are underlined: in addition, outliers on the outdegree measure are in allcaps, outliers on the indegree measure are in italics, and outliers on the total degree measure are doubly outlined.

Note: For k smaller than 10 the full table is available upon request from the authors.

Table 2. The core of the food & tobacco subnetwork (S02)

k	*EU15*	*EU25*	*EU27*	*EU28*	*EFTA*	*Candidate*	*ENP (active)*	*Common spaces*
4	**Amsterdam, Athens, Barcelona, Brussels, Cologne, Dublin, DUSSELDORF, Hamburg, HEILBRONN, Helsinki, Lille, Linz, LONDON, Mulheim, PARIS, RUHR, Stockholm**	***Budapest*, Krakow, Ljubljana, Poznan, Prague, Tallinn, Vilnius, Warsaw**	**Brasov, *Bucharest*, Constanta, Deva, Pleven, Sofia, Targu Mures, Timisoara**		**Vevey**	**Belgrade, Istanbul**	**Kyiv**	***Moscow*, *St Petersburg***
3	Madrid, Munich, Neu Isenburg, Valles, Vienna, Weybridge	Pecs, Riga	Arad, Blagoevgrad, Cluj Napoca, Glati, Iasi, Pernik, Ploiesti, Plovdiv, Ruse, Satu Mare, Sibiu, Suceava, Varna, Veliko Turnovo	Bjelovar, Osijek, Rijeka, Zagreb	Basel		Kharkiv	Omsk, Rostov on Don, Samara

Legend: Each row represents the number of *k*-shell in descending order (i.e. from more inner *k*-shells at the top to more outer *k*-shells towards the bottom). Locations in the innermost *k*-shell (i.e. cores) are displayed in bold. All outliers are underlined: in addition, outliers on the outdegree measure are in allcaps, outliers on the indegree measure are in italics, and outliers on the total degree measure are doubly outlined.

Table 3. The core of the software & IT services subnetwork (S03)

k	*EU15*	*EU25*	*EU27*	*EEA*	*EFTA*	*Overseas*	*Candidate*	*ENP (active)*	*Common spaces*
7	**Amsterdam, Barcelona, Berlin, Bordeaux, Brussels, Cambridge, Copenhagen, Dublin, Dusseldorf, Edinburgh, Frankfurt, Helsinki, *London*, Lyon, Madrid, Milan, Munich, *PARIS*, Reading, Ruhr, Stockholm, Utrecht, Vienna, Walldorf**	**Budapest, Prague, Warsaw**	**Bucharest**	**Oslo**	**Zurich**	**Hamilton**		**Tel-Aviv**	**Moscow**
6	Hamburg, Leuven, Lisbon		Sofia						
5	Antibes, Athens, Belfast, Cork, Lille, Lund, Luxembourg, Newcastle upon Tyne, Porto, 's-Hertogenbosch	Krakow, Vilnius, Wroclaw		Porsgrunn	Geneva			Kyiv	St Petersburg
4	Bath, Cologne, Frankfurt an der Oder, Ghent, Glasgow, Linkoping, Malmo, Manchester, Newbury, Nuremberg, Rome, Rotterdam, The Hague	Riga			Zug		Belgrade, Istanbul	Cairo, Casablanca	
3	Alton, Antwerp, Bilbao, Darmstadt, Kunzelsau, Maidenhead, Nimes, Odense, Oxford, Saarbrucken, Slough, St Albans, Stuttgart, Toulouse, Turin, Uppsala, Valencia, Zaragoza	Bratislava, Bruno, Ljubljana			Basel, St Gallen			Tunis	

Legend: Each row represents the number of *k*-shell in descending order (i.e. from more inner *k*-shells at the top to more outer *k*-shells towards the bottom). Locations in the innermost *k*-shell (i.e. cores) are displayed in bold. All outliers are underlined: in addition, outliers on the outdegree measure are in allcaps, outliers on the indegree measure are in italics, and outliers on the total degree measure are doubly outlined.

Table 4: The core of the Automotive OEM subnetwork (S14)

k	*EU15*	*EU25*	*EU27*	*Candidate*	*Common spaces*
4	GOTEBORG, London, Lyon, *Madrid*, MUNICH, PARIS, STUTTGART, Turin, Vienna, WOLFSBURG	*Budapest*, Prague	*Bucharest*, *Sofia*		*Moscow*, St Petersburg
3	Brussels, Sodertalje	Bratislava, Gyor	Cluj Napoca	Belgrade, Stara Pazova	Kaluga

Legend: Each row represents the number of *k*-shell in descending order (i.e. from more inner *k*-shells at the top to more outer *k*-shells towards the bottom). Locations in the innermost *k*-shell (i.e. cores) are displayed in bold. All outliers are underlined: in addition, outliers on the outdegree measure are in allcaps, outliers on the indegree measure are in italics, and outliers on the total degree measure are doubly outlined.

Table 5 : The core of the manufacturing (function) subnetwork (Fn4)

k	*EU15*	*EU25*	*EU27*	*EU28*	*EEA*	*EFTA*	*Overseas*	*Candidate*	*Potential*	*ENP (active)*	*ENP*	*Common spaces*
10	Amsterdam, Athens, Barcelona, Berlin, Brussels, Dublin, Dusseldorf, Frankfurt, Hamburg, Helsinki, LONDON, Luxembourg, Madrid, Milan, Munich, PARIS, Rotterdam, Stockholm, VIENNA, Windsor	*Budapest*, Katowice, Prague, Tallinn, Warsaw	*Bucharest*, *Sofia*					Istanbul		Tel-Aviv		*Moscow*, *St Petersburg*
9	Copenhagen	Krakow, Vilnius								Kyiv		
8	Lisbon	Poznan, Wroclaw	Varna			Zurich		Belgrade				
7	A Coruña, Antwerp, Cologne, Helsingborg, Manchester, Mannheim, Nantes, Palma de Mallorca, Porto, Rome, Ruhr, Seville, Stuttgart, Utrecht, Valencia, Wolfsburg, Zaragoza	Bratislava, Gdansk, Gyor, Lodz, Riga	Brasov, Ploiesti, Plovdiv, Ruse, Timisoara	Zagreb	Oslo	Basel, Geneva		Ankara, Izmir		Baku		Kaluga, Yekaterinburg
6	Aalst, Bologna, Ghent, Gouda, Heidelberg, Klagenfurt, Lille, Lyon, Turin, Valles, Watford, Wiesbaden	Brno, Ljubljana	Cluj Napoca, Constanta, Stara Zagora				Hamilton	Skopje		Cairo, Odesa, Tangier		Nizhny Novgorod, Novosibirsk, Rostov on Don, Tula
5	Aachen, Amersfoort, Arnhem, Belfast, Bergamo, Birmingham, Bordeaux, Caen, Edinburgh, Frankfurt an der Oder, Gerlingen, Goteborg, Grenoble, Hanover, Immingham, Iphofen, Linz, Malaga, Malmo, Nottingham, Padua, Toulouse, Waterford	Klaipeda, Nitra, Ostrava, Plzen	Burgas, Targu Mures			Vevey, Zug		Antalya, Bursa		Algiers, Casablana, Dnipropetrovsk, Marrakesh, Oran, Tbilisi		Krasnodar, Tver
4	Aalborg, Alicante, Ancona, Antrim, Bilbao, Breda, Bristol, Cordoba, Cork, Darmstadt, Florence, Friedrichshafen, Genk, Glasgow, Granada, Heerlen, Leeds, Liege, Louvain-la-Neuve, Merseburg, Nordborg, Nuremberg, Oyonnax, Rouen, Salzburg, Sheffield, Sines, Slough, Tarragona, The Hague, Thessaloniki, Trieste, Verona, Viana do Castelo, Vicenza, Zaldibia	Bialystok, Bielsko Biala, Kostrzyn, Lublin, Miskolc, Szombathely, Tatabanya, eszprem	Arad, Blagoevgrad, Calarasi, Craiova, Oradea, Satu Mare, Sibiu, Turda	Osijek	Reykjavik	Oftringen		Gaziantep, Kragujevac, Manisa	Zenica	Kharkiv, Tunis, Zaporizhia	Tripoli	Chelyabinsk, Cherepovets, Kaliningrad, Kazan, Khanty-Mansiysk, Naberezhnye Chelny, Ryazan, Tomsk, Vsevolozhsk, Yaroslavl
3	Aberdeen, Allendorf, Ansfelden, Aviles, Bad Homburg, Beringen, Besançon, Billund, Bonn,	Celje, Debrecen, Dunaujvaros, Eger, Gorizia (Slovenian side),	Botevgrad, Dej, Dobrich, Giurgiu,	Karlovac, Varazdin		Berne, Bulle,		Indija, Leskovac,	Sarajevo, Tirana,	Agadir, Cherkasy, Chisinau, Jijel,	Damascus, Latakia,	Arzamas, Bor, Gatchina, Omsk,

k	EU15	EU25	EU27	EU28	EEA	EFTA	Overseas	Candidate	Potential	ENP (active)	ENP	Common spaces
	Bregenz, Bremen, Brescia, Bruchsal, Budenheim, Burgos, Bussi sul Tirino, Cadiz, Cambridge, Cardiff, Castellon de la Plana, Chartres, Clermont Ferrand, Cumbernauld, Deventer, Dijon, Ditzingen, Dresden, Dunkirk, Eindhoven, Faulquemont, Forbach, Fos-sur-mer, Galway, Goppingen, Graz, Guadalajara, Gutersloh, Haguenau, Heidenheim an der Brenz, Herzogenaurach, Hof, Hull, Ingelheim am Rhein, Karlsruhe, Knokke Heist, Leicester, Leipzig, Leuven, Lippstadt, Liverpool, Livorno, Logstor, Marseille, Martorell, Modena, Moerdijk, Mons, Moura, Naarden, Naas, Ohlsdorf, Oxford, Paderborn, Pamplona, Plymouth, Portsmouth, Reims, Riba Roja de Turia, Roeselare, Rubi, Saint-Nazaire, Salamanca, Southampton, Stokke on Trent, St Polten, Swindon, Thionville, Toledo, Trelleborg, Turku, Ulm, Valladolid, Venlo, Vigo, Villach, Vilsbiburg, Weybridge, Ypres	Grodzisk Mazowiecki, Jelgava, Kaunas, Kazincbarcika, Kechnec, Kolin, Kosice, Krotoszyn, Legnica, Liberec, Mlada Boleslav, Nyaregyhaza, Parnu, Puchov, Rakvere, Sarvar, Suwalki , Szczecin, Szekesfehervar, Tarnow, Tartu, Trun, Trnava, Trutnov, Walbrzych, Zory	Ihtiman, Kostinbrod, Pazardzhik, Pleven, Slatina, Suceava			Lausanne		Novi Sad, Pristina, Sakarya, Zrenjanin	Tuzla	Lviv, Rabat, Suez, Taba, Yerevan	Minsk	Orekhovo Zuyevo, Podolsk, Samara, Serpukhov, Stupino, Tolyatti, Tosno, Tyumen, Ulyanovsk, Voronezh, Yelabuga

Legend: Each row represents the number of *k*-shell in descending order (i.e. from more inner *k*-shells at the top to more outer *k*-shells towards the bottom). Locations in the innermost *k*-shell (i.e. cores) are displayed in bold. All outliers are underlined: in addition, outliers on the outdegree measure are in allcaps, outliers on the indegree measure are in italics, and outliers on the total degree measure are doubly outlined.

Table 6: The core of the research & innovation (function) subnetwork (Fn2)

k	EU15	EU25	EU27	EEA	EFTA	Candidate	ENP (active)	Common spaces
4	Amsterdam, Antwerp, *Barcelona*, Copenhagen, Dublin, Helsinki, LONDON, Lyon, *Madrid*, Milan, MUNICH, *PARIS*, Stockholm, Walldorf	*Budapest*, *Prague*, Wroclaw	*Bucharest*		Geneva		Tel-Aviv	*Moscow*
3	Antibes, Belfast, Bonn, Bristol, Brussels, Cambridge, Dijon, Frankfurt, Goteborg, Hamburg, Hanover, Malmo, Nantes, Newbury, Porto, Rotterdam, Stuttgart, Toulouse, Valles			Oslo	Zurich	Istanbul	Kyiv	

Legend: Each row represents the number of *k*-shell in descending order (i.e. from more inner *k*-shells at the top to more outer *k*-shells towards the bottom). Locations in the innermost *k*-shell (i.e. cores) are displayed in bold. All outliers are underlined: in addition, outliers on the outdegree measure are in allcaps, outliers on the indegree measure are in italics, and outliers on the total degree measure are doubly outlined.

4.1 Innermost core locations

By looking at Table 1 we can see that 45 cities appear in the innermost k-shell (k = 23) of the overall network. They are located predominantly in the EU15 countries, but are found in several other groups of countries as well. One is not surprised to discern a strong national primate city effect here: the economic capitals of most EU countries are present, as well as the economic capitals of important candidates (e.g. Istanbul in Turkey), ENP neighbours (e.g. Tel Aviv in Israel), and CSP countries (Moscow in Russia).[8] The major exception is Germany which is represented by nine cities, though this is expected since the country does not have a particular economic primate city. These cities are the core of the European foreign investment network: MNEs are forming functional relationships actors EU cities that overcome the barriers of the lack of geographical and institutional proximity. These links support the increasing integration of the 'core' of the European city-system and its immediate neighbourhood with a large periphery at its functional margins.

Within the 'core' of the foreign investment networks it is possible to identify an additional layer with three predominant global capitals that are simultaneously at the centre of the networks of all industrial sectors. Of the 45 cities in the core of the overall network, only three appear in the innermost k-shell of all 11 sectors: London, Moscow and Paris. In these cities the combination of density, absolute size and connectivity can sustain multiple-specialisation, generating a cumulative virtuous circle with foreign investment. While Germany is not part of this urban 'triad' (due to its dispersed urban hierarchy), it is interesting to notice that Paris and London are at opposite ends of the institutional spectrum with respect to Moscow. This suggests a bipolar regional economy with Western

[8] Geographical FDI data tend to be biased toward capital cities given that FDI are usually recorded with reference to the the location of the headquarters. This bias is well known both in the literature on the economic geography of MNEs and in that on global city networks (e.g. Derudder et al., 2003; Iammarino and McCann, 2015). Although *fDi Markets* accurately reports the location of each function, this geographical bias cannot be resolved entirely as it is intrinsic in the process of data collection.

Europe at one end, and the Russian capital at the other.

When looking at the functional nature of the investments connecting the various cities, Hymer's prediction of a strong concentration of more sophisticated functions in a limited set of locations is fully confirmed. Only twelve cities (out of 45 in the overall network) appear in the innermost *k*-shell of all five functional subnetworks used here; Paris, London and Moscow are joined by Amsterdam, Bucharest, Budapest, Dublin, Helsinki, Madrid, Munich, Prague and Stockholm. Most of these are within the EU-15; there are no EEA or EFTA members, EU candidate or potential candidates, or ENP countries here. This brings out Bucharest, Budapest and Prague as the three most important multifunctional cities in the institutional middle zone between the EU15 and Russia. These three are also important multisectoral cities, being in the innermost *k*-shell of eight, nine and ten of our 11 sectors respectively. Yet other cities in these institutionally "intermediary" positions are also important multisectoral and multifunctional cities. For example, Kyiv is in the innermost *k*-shell of eight out of 11 sectoral subnetworks, though in only two out of five functional subnetworks. St Petersburg is in the innermost *k*-shell for seven sectors and three functions, Warsaw and Sofia both for six sectors and four functions, and Tallinn for five sectors and four functions. Istanbul is in the innermost *k*-shell for four out of 11 sectors and three out of five functions. The different degrees of political, institutional and economic integration among European countries tend to preserve a multiplicity of hubs in investment networks. Activities more connected to political power do tend to cluster in a limited number of central locations but, given the political fragmentation of (part of) Europe, a number of these centres are still present in investment networks.

Some of 45 core cities identified in the overall network are less 'central' than others. It is possible to be in the innermost core of the overall network without being in the innermost *k*-shell of many sectors and functions. Krakow is not in the innermost *k*-shell of any functional subnetworks. And it is along with Antwerp, Bratislava, Helsingborg, Luxembourg, Oslo, Rotterdam and Stuttgart in the innermost k-shell of only one out of the 11 sectoral subnetworks. A relative specialisation in just one sector along with enough diversification to participate in other sectors at lower levels would appear to be enough to bring a city into the innermost core of the overall network. Even so, Helsingborg is in the innermost k-shell for the consumer products sector but does not appear at all (not even in the peripheral k-shells $k = 1$ or 2) for the financial services, business services, hotels and tourism, and communications sectors. Stuttgart is in the innermost core of the automotive OEM sectoral subnetwork but does not appear at all in the food and tobacco, textiles, real estate, and consumer products subnetworks. This structure of the networks and of the intersections between functional and sectoral sub-networks reflects the concentration of highest level functions in major cities with a set of 'regional' sub-capitals for specific sectors or functions.

Tables 2, 3 and 4 provide some additional insights on the network structure of some key sectors. Networks of investments in low tech sectors (such as food & tobacco – Table 2) tend to be sparser with a smaller number of centres and more reduced overall connectivity (in line with Vernon's PLC). Cities in the 'new' Member States of the EU-27 tend to occupy relatively more relevant positions in this type of sectors confirming the ubiquitous nature of lower-level functions. Indeed, previous research has found that, by contrast, the software & IT services subnetwork (Table 3) is more diversified, with a stronger core (more concentration) but a larger number of other lower-order 'clubs'. In this context, outside the EU-15 only the most advanced cities can play a significant role in investment networks. The automotive subnetwork is also an interesting case (Table 4): given the underlying geography of this sector, only a few highly specialised locations are involved in FDI networks. The majority of these locations are highly distinctive of this particular industry (e.g. Stuttgart or Turin) while others (e.g. Paris or London) are equally central in other networks. Some specialised centres are emerging also outside the EU-15 with Bucharest, Budapest and Sofia playing an increasingly central role together with Moscow outside the EU.

Tables 5 and 6 focus on the functional dimension of the investment and look at manufacturing production and R&D & Innovation respectively. Manufacturing investment shows the most sophisticated network structure among all functions. The manufacturing core of the area under analysis is highly interconnected with key central locations outside the EU. Below the most central, highly connected cities (K=10) we can observe a complex hierarchy of other relevant nodes. In contrast, and as expected, R&D activities involve a substantially smaller number of locations that are, however, less intensely inter-connected by investment flows vis-a-vis other functions. The dominance of global cities – associated with the density of communication and technological assets (Sassen 2002) – is apparent in the R&D network, supporting evidence on strong MNE agglomerative patterns in R&D operations, even vis à vis domestic firms (e.g. Cantwell and Iammarino, 2003; Alfaro and Chen, 2014). However, a constellation of other innovation centres/clusters not necessarily located in major cities is also present: successful university cities, clusters, innovation hubs establish vital external connections via foreign investments (e.g. Bathelt et al., 2004; Crescenzi et al.2016b).

4.2 Individual outlier locations

Overall outliers

Two truly 'global' cities rule over all the others in the overall network: Paris and London, the only outliers in the network by total degree, and the only outliers by outdegree. Their role is multisectoral and multifunctional. Of the 11 sectors considered here, Paris is a total degree outlier in ten of them and an outdegree outlier in eight of them; London a total degree outlier in nine sectors and an outdegree outlier in six; no other location is a total or outdegree outlier in more than two sectors. Both London and Paris are total and outdegree outliers in all five functional categories used in this study, while no other location is a total or outdegree outlier in more than one function.

While Paris and London are also outliers by indegree, another four cities are outliers on this measure: Moscow, Bucharest, Budapest and Madrid. The meaning of such a picture can be intuited immediately: while much foreign direct investment is deployed by businesses in Paris and London from the core region of Western Europe, a high proportion is also deployed into a very small number of what we might broadly conceive as 'peripheral focal points' (or 'regional sub-capitals' to follow Hymer, 1970): Madrid to the southwest, Budapest in Central Europe, Bucharest to the southeast, and Moscow to the northeast of the overall area observed here. This to some extent modifies the interpretation given earlier, i.e. that the European economy is a bipolar one, with Moscow at one end balancing London and Paris at the other. Rather, by considering overall outliers, Moscow is somewhat subordinate to the investment decisions being made in London and Paris, just like many other locations in the overall network.

Nevertheless, these four peripheral focal points are also multisectoral and multifunctional. Moscow is an indegree outlier in nine of the 11 sectors isolated here, Bucharest in six, Budapest in five, but Madrid only in two. By comparison, Paris and London are indegree outliers in eight and seven sectors respectively. Moscow is an indegree outlier in all five of the functional subnetworks studied here, Bucharest and Budapest each in three, but Madrid only in one function; by comparison, Paris is an indegree outlier for four functions, London for two. The emergence of these 'regional sub-capitals' reflects the possible signs of de-localisation of control functions in favour of second or third tier cities.

Sectoral outliers

The identification of outliers provides clearer indications of the specialisations of individual cities than does the identification of the innermost k-shell for each sectoral and functional subnetwork. Looking at Table 7, apart from Paris and London, 25 other cities are outliers by total, out- or in- degree measures in any sectoral subnetwork (disregarding indegree outliers for the transportation and hotels and tourism subnetworks since these are too numerous to be considered robust).

Table 7. Sectoral outliers

Location	*k*	*Total degree*	*Outdegree*	*Indegree*
A Coruña	22	Textiles	Textiles	
Amsterdam	23	Transportation		
Barcelona	23		Textiles	Consumer products
Bonn	23	Transportation	Transportation	
Brussels	23	Hotels and tourism	Textiles, hotels and tourism	
Bucharest	23	Real estate		Food and tobacco, real estate, communications, automotive OEM
Budapest	23			Food and tobacco, real estate, communications, automotive OEM
Dublin	23			Financial services
Dusseldorf	23	Food and tobacco	Food and tobacco	
Flensburg	18		Textiles	
Goteborg	21	Automotive OEM	Automotive OEM	
Heilbronn	16	Food and tobacco	Food and tobacco	
Helsingborg	23	Consumer products	Consumer products	
Helsinki	23	Communications	Communications	
London	23	Financial services, food and tobacco, software and IT services, textiles, real estate, business services, consumer products, hotels and tourism, communications	Financial services, food and tobacco, textiles, real estate, business services, communications	Financial services, software and IT services, textiles, business services, consumer products, communications
Madrid	23			Communications, automotive OEM

Location	*k*	*Total degree*	*Outdegree*	*Indegree*
Moscow	23	Financial services, communications		Financial services, food and tobacco, textiles, business services, consumer products, communications, automotive OEM
Munich	23	Automotive OEM	Automotive OEM	
Paris	23	Financial services, food and tobacco, software and IT services, textiles, business services, consumer products, transportation, hotels and tourism, communications, automotive OEM	Financial services, food and tobacco, software and IT services, textiles, consumer products, hotels and tourism, communications, automotive OEM	Financial services, software and IT services, textiles, business services, consumer products, communications
Ruhr	23	Food and tobacco	Food and tobacco	
St Petersburg	23			Food and tobacco
Sofia	23			Real estate, automotive OEM
Stockholm	23	Textiles	Textiles	
Stuttgart	23	Automotive OEM	Automotive OEM	
Vienna	23	Financial services, real estate	Financial services, real estate	Communications
Windsor	19		Hotels and tourism	
Wolfsburg	19	Automotive OEM	Automotive OEM	

Functional outliers

Table 8 shows that 12 cities are outliers in at least one function (disregarding indegree outliers for research & innovation, and logistics & distribution subnetworks since these are too numerous to be considered robust).

Table 8. Functional outliers

Location	*k*	*Total degree*	*Outdegree*	*Indegree*
Amsterdam	23	**Fn5**: logistics and distribution, customer and after-sales services	**Fn5**: logistics and distribution, customer and after-sales services	
Bonn	23	**Fn5**: logistics and distribution, customer and after-sales services	**Fn5**: logistics and distribution, customer and after-sales services	
Bucharest	23			**Fn4**: manufacturing, firm infrastructure
Budapest	23			**Fn4**: manufacturing, firm infrastructure
Dusseldorf	23		**Fn3**: sales and marketing, technical services	
London	23	**All five** functional subnetworks	**All five** functional subnetworks	**Fn1**: headquarters, business services; **fn3**: sales and marketing, technical services
Moscow	23			**Fn1**: headquarters, business services; **fn3**: sales and marketing, technical services; **fn4**: mfg., firm infrastructure
Munich	23	**Fn2**: research and innovation, human resource management	**Fn2**: research and innovation, human resource management	
Paris	23	**All five** functional subnetworks	**All five** functional subnetworks	**Fn1**: headquarters, business services; **fn3**: sales and marketing, technical services
St Petersburg	23			**Fn4**: manufacturing, firm infrastructure
Sofia	23			**Fn4**: manufacturing, firm infrastructure
Vienna	23	**Fn4**: manufacturing, firm infrastructure	**Fn4**: manufacturing, firm infrastructure	

There are some functional twin cities visible in the list above. London and Paris are twin outliers as decision-makers in all five functions. Amsterdam and Bonn are twin outliers as decision-makers with regards to Fn5: logistics and distribution, customer and after-sales services. But perhaps most interestingly, Bucharest, Budapest, St Petersburg and Sofia are twin (or quadruplet) cities as destinations of investment decisions with regards to Fn4: manufacturing and firm infrastructure. This suggests that while cities such as London and Paris (and Moscow — at the two poles of our bipolar European economy) are both drivers and destinations of investment decisions related to highly cognitive functions, cities such as Bucharest, Budapest, St Petersburg and Sofia fulfil a role primarily as destinations of investment decisions related to production functions.

Non-outlier innermost-core locations

Remarkably, once we have set aside all locations in the innermost core of the overall network with outlier roles in one section or one function or another, we still have 24 cities left over. The cities previously listed as either sectoral or functional outliers have agglomerative phenomena occurring in their economies causing large numbers of investment decisions to be made or destined within them, regardless of how many or how few partner locations they interact with. In contrast, the 24 cities left over enjoy positions in the innermost core of the network not because of internal agglomerative phenomena of the same kind but because of the geographic diversity of their partnerships. These are Antwerp, Athens, Berlin, Bratislava, Cologne, Copenhagen, Frankfurt, Geneva, Hamburg, Istanbul, Krakow, Kyiv, Luxembourg, Lyon, Milan, Oslo, Prague, Riga, Rotterdam, Tallinn, Tel-Aviv, Vilnius, Warsaw and Zurich. These cities do not attract large numbers of investment decisions, but they do attract investment decisions from large numbers of locations, and in particular those in the innermost core of the overall network and of each subnetwork.

The most remarkable of these is Prague, which manages to be in the innermost core of the overall network as well as in those of ten out of 11 sectors and all five functions; yet it is a degree outlier in none of them (disregarding its non-robust indegree measures). This is quite a feat, given that it requires the city to have formed investment partnerships with a large number of innermost core locations in each sectoral and functional subnetwork, without attracting large numbers of decisions in any of them in particular. Almost as remarkable are Kyiv, in the innermost core of eight sectors and two functions yet outliers in none of them; Milan, in the innermost core of seven sectors and four functions; Warsaw in the innermost core of six sectors and four functions; Berlin and Tallinn both in five sectors and four functions; and Istanbul in four sectors and three functions.

5. A speculative hierarchical taxonomy of Europe's leading investment cities

This analysis has brought to light a number of typologies of cities and city-regions worth further reflection, as follows:

Europe's investment global cities

Paris and **London** are clearly Europe's capitals for foreign direct investment decisions, being in the innermost core of all 11 sectors and all five functions, and being total degree and outdegree outliers in the overall network, in every functional subnetwork, and in almost every sectoral subnetwork. They are surrounded by a number of other highly multisectoral and multifunctional cities throughout the EU15, including Amsterdam, Dublin, Helsinki, Madrid, Munich, Stockholm and Vienna.

Europe's second pole or global city

Paris and London are followed closely in importance by **Moscow**, also in the innermost core of all 11 sectors and all five functions, and being the largest indegree outlier (after Paris) in the overall network. It is also an indegree outlier in the most number of sectoral subnetworks (nine out of 11) and the most number of functional subnetworks (all five).

Europe's intermediaries or 'regional sub-capitals'

A number of cities illuminate the space between these two poles, with discernible differences in importance between them. **Bucharest** and **Budapest** stand out as overall indegree outliers, as well as being in the innermost core of all functional and almost all sectoral subnetworks, as well as indegree outliers on the important "production" function Fn4: manufacturing and firm infrastructure. **St Petersburg** and **Sofia** are also indegree outliers on this important production function, though they are not in the innermost cores of quite as many sectoral and functional subnetworks. By contrast, **Prague** is in the innermost cores of all functional and almost all sectoral subnetworks, though a (robust) outlier in none of them. Below Prague are **Kyiv**, **Warsaw**, **Tallinn** and **Istanbul**, also in the innermost cores of quite a number of sectoral and functional networks though a (robust) outlier in none of them.[9]

6. Conclusions

Global and macro-regional urban centres are locations which not only exhibit significant agglomeration advantages, but also primarily interact with other similar cities in other parts of the world or within the same macro-region, rather than with smaller urban centres and regions within their national boundaries. Indeed, Hymer's 'correspondence principle' is still a crucial connection between the centralization of power and decentralisation of control within the modern MNE, and the increasingly differentiated spatial hierarchy in contemporary

[9] The interpretation of our findings for countries in the eastern part of the European Continent, as is intended in the present study, should be cautious, particularly given the time frame of analysis. The strong historically driven core-periphery patterns of economic activities in this area may have been particularly affected by M&A trends in most recent years.

economic systems. On the other hand, Vernon's crucial observation of the strong relationship between industry life cycles and spatial shifts helps explain different geographical orders and the increasing specialisation of places.

The centralisation of political and economic power is certainly concentrated in a few first tier cities, as indicated by Hymer. However, the emphasis on the role played by the presence of MNEs and their investment networks in making cities 'global' has probably been overstated, largely neglecting the crucial evolution of the relationship between corporate power and control. Such complex networks – and the variety of spatial typologies that arise from our taxonomy above – seem to offer a rather more differentiated picture of the geography of the MNE than that provided by the location of headquarters of large corporations, which has consistently shown the strongest agglomerative pattern (e.g. Alfaro and Chen, 2014). This analysis has indicated that, in the light of both Hymer's and Vernon's legacy, the geography of MNEs' networks cannot be understood without recourse to detailed and bundled considerations of organization, technology and innovation, institutional context, and political and financial power of modern multi-product and multi-technology MNEs.

The analysis of investment networks among European cities has unveiled a complex structure built around three global players: London and Paris at the centre of the European Union and Moscow, geographically European but politically and institutionally separated from the core of the Continent. The extended core of the network revolves around these three pillars with different degrees of centrality and functional integration. The consolidation of regional sub-capitals is accompanied by the emergence of a large periphery involved only to a very small extent into investment networks. In the cities and metropolitan areas belonging to the periphery, cognitive lock-in situations and limited exposure to non-redundant knowledge are more likely. The limited contribution of foreign investors to the local economy can hamper long term development trajectories in these areas, often simultaneously disadvantaged by geographical/physical peripherality.

Understanding the structure of investment networks and identifying the position of cities and regions in this context has significant implications for public policies. The analysis of the factors of disadvantage that can hamper local economic development in the 'periphery' of Europe cannot be limited to purely geographical/spatial factors. Exclusion from investment networks is a relevant form of 'non-spatial peripherality' that might persistently curb the development prospects of certain localities. Therefore, local economic development strategies may need to address this additional/alternative form of structural disadvantage in order to unlock local economic potential. Other forms of non-localised networks (e.g. linked to migration/labour mobility) to be possibly leveraged by local and urban development policies are also strongly influenced by the evolution of investment networks. Following the preliminary descriptive exploration attempted in this paper, our agenda for future research includes the conceptual and empirical analysis of the drivers and impacts of global investment networks in Europe and beyond.

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Appendix A

Table A-1. Countries covered in the analysis and their status with reference to the European Union

Pos.	*Definition*	*Territories appearing in the data*
1	EU15 (before 2004)	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom (15)
2	EU25 (2004 NMS)	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia (10)
3	EU27 (2007 NMS)	Romania, Bulgaria (2)
4	EU28 (2013 NMS)	Croatia (1)
5	Outermost regions (within EU)	Canary Islands (1)
6	EEA (and EFTA) members	Iceland, Liechtenstein, Norway (3)
7	EFTA members outside EEA	Switzerland (1)
8	Microstates using the Euro	Andorra, Monaco (2)
9	Overseas countries and territories (outside EU)	Bermuda (UK), British Virgin Islands (UK), Cayman Islands (UK), Curação (NL), Greenland (DK) (5)
10	EU membership candidates (ACC)	Macedonia, Montenegro, Serbia, Turkey (4)
11	Potential candidates (give the status of ACC in 2014)	Albania, Bosnia and Herzegovina (2)
12	Self-governing territories (outside EU)	Guernsey, Isle of Man, Jersey (3)
13	European neighbourhood policy (ENP), active participants	Algeria, Armenia, Azerbaijan, Egypt, Georgia, Israel, Jordan, Lebanon, Moldova, Morocco, Tunisia, Ukraine (12)
14	European neighbourhood policy (ENP), non-active	Belarus, Libya, Syria (3)
15	Common spaces agreement	Russia (1)

Table A-2: Sectoral subnetworks

Net.	*Sector*	*Dec.*	*Unique pairs*	*Main comp.*	*Loc.*	*Main comp.*	*K*
fDi	Entire network	15,427	10,468	10,301	4,097	3,781	23
S01	Financial services	1,331	991	989	423	419	9
S02	Food and tobacco	1,293	1,078	1,014	873	753	4
S03	Software and IT services	1,082	852	835	425	391	7
S04	Textiles	1,038	823	777	501	416	6
S05	Real estate	979	704	684	408	371	7
S06	Business services	902	675	657	341	306	7
S07	Consumer products	901	778	726	543	447	5
S09	Transportation	563	533	510	384	341	4
S10	Hotels and tourism	474	408	391	265	232	5
S11	Communications	469	397	382	264	236	4
S14	Automotive OEM	384	290	276	231	203	4

Table A-3: Functional subnetworks

Net.	*Core activities*	*Support activities*	*Dec.*	*Unique pairs*	*Main comp.*	*Loc.*	*Main comp.*	*K*
Fn1	Headquarters	Business services	2,279	1,571	1,552	658	620	11
Fn2	Research and innovation	Human resource management	557	479	439	362	290	4
Fn3	Sales and marketing	Technical services	5,534	4,110	4,051	1,630	1,515	15
Fn4	Manufacturing	Firm infrastructure	5,594	4,434	4,200	2,931	2,502	10
Fn5	Logistics and distribution	Customer and after-sales services	1,463	1,282	1,201	906	753	6

Source: Crescenzi, Pietrobelli and Rabellotti (2014)