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Global networks, cities and economic performance: Observations from an analysis of cities in Europe and the US

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Abstract
The network paradigm has been highly influential in spatial analysis in the globalization era. As economies across the world have become increasingly integrated, so-called global cities have come to play a growing role as central nodes in the networked global economy. The idea that a city's position in global networks benefits its economic performance has resulted in a competitive policy focus on promoting the economic growth of cities by improving their network connectivity. However, in spite of the attention being given to boosting city connectivity little is known about whether this directly translates to improved city economic performance and, if so, how well connected a city needs to be in order to benefit from this. In this paper we test the relationship between network connectivity and economic performance between 2000 and 2008 for cities with over 500,000 inhabitants in Europe and the US to inform European policy.

Introduction

Globalization and city networks are two faces of the same coin. As economies across the world have become increasingly integrated, 'global cities' have been seen more and more as dominant economically competitive nodes in the networked global economy (Sassen, 1991; Castells, 1996). They are the places where transnational networks of firms can source concrete assets, a large pool of diverse specialized labour, global business services, communication and transportation infrastructures, etc. They are the places where global firms connect with each other, where face to face contact, relationship building and tacit knowledge transfer take place, and where distance between one global player and another is effectively eliminated. Drawing on Porter's internationally influential ideas on the "competitiveness" of (big) cities (1990, 1995, 1998) and Storper's (1997) work on regional development dynamics in globalization, Scott (2001) predicted that highly connected global cities would in future be the places in the world where massive expansion of "leading sectors of capitalism" with global reach and "powerful endogenous growth mechanisms" would occur (p. 820). According to Florida such cities are the "real engines of the global economy" (2008, p. 42). Moreover as Sassen (1991) argued, globalization goes hand in hand with the ongoing concentration of strategic network functions, resulting in increasing agglomeration of global commanding functions in global cities. Hence, it would seem that to the classic competitive advantages of large cities must be added their role as interconnected nodes in a globally networked and integrated economy.

A whole body of literature has developed around this general idea, linking the organization of the transnational network enterprises which now characterize global and globalizing cities to the city competitiveness narrative which emerged in the US, which has been so influential in urban policy circles internationally. The improved 'connectivity'[i] of cities in global networks is often seen as a means of addressing economic development problems and improving the competitiveness of cities in a global context (Camagni, 1993; Capello, 2000, p.1925; WEF, 2010). European Union (EU) spatial strategy has specified a series of 'gateway' cities which connect Europe to the global economy (European Commission, 1999) and, for a decade, the 'Lisbon' economic growth agenda has prioritised the need to boost the connectivity of cities in Europe in general, to the networked economy (European Council, 2000; European Commission, 2009a; Pain, 2011). The relationship between a city's connectivity and its economic performance tends to be taken as given, however we argue here that despite the enthusiasm for strategies to boost international attractiveness in general, and city global network connectivity in particular, there has been a void in empirical assessment of the specific relationship between city economic performance and connectivity. The precise aim of this paper is therefore to address the analytical gap in city network analysis by establishing the level of correlation between network connectivity and city economic performance measured by city level Global Domestic Product (GDP) and growth. By achieving this, we can address the following important question: is there evidence of a correlation between global network connectivity and a city's economic performance? Drawing on the answer to this question, we will in the conclusion discuss the policy implications of our results.

In this paper we address this question by analyzing the correlation between city network connectivity and economic performance systematically in Europe and also in the US between 2000 and 2008 for cities with more than 500,000 inhabitants. The large database and analysis we draw on are outputs from a major two year and a half year European Spatial Planning Observation Network (ESPON) funded study investigating the territorial implications of globalization, and the role of European cities in this, for EU spatial and economic development policy. But while the empirical focus is on European large and medium-sized cities, similar analyses are generated for US cities in order to test whether the results are specific to the EU context or whether they can also be observed in a much more integrated market with a similar urbanization and development level. The EU focus of the analysis is policy-driven in the sense that we intend to inform urban policies in Europe where we are more aware of the urban stakes. However, we do believe that the comparison with the US is useful to assess whether our results hold in a different, but, to some extent, comparable context.

City connectivity and economic performance: some theoretical considerations

In several fields of urban and economic geography, theorization of the network paradigm has emerged as a consequence of late twentieth century processes associated with the globalization phenomenon (Friedmann and Wolff, 1982; Sassen, 1991; Castells, 1996; Veltz, 1996). The network paradigm starts from the assumption that economic globalization profoundly reshapes the spatial pattern of the economy and gives decisive advantages to the most connected places through different types of networks (economic, social, transport etc.). Here, the old paradigm of territories and nation-states is replaced by a new paradigm of places, flows and networks. The basic argument is thus that the rising relevance of connectivity in the world system should increase spatial polarization in favour of global cities (Friedmann, 1986; Neal, 2011; Ma and Timberlake, 2013; David *et al*., 2013). In other words, cities which are more connected globally will benefit from higher growth rates. We synthesize here some of the major arguments to explain why connected cities should have an economic advantage.

Friedmann (1986, p. 73) in particular argues that "the driving force of world city growth is found in a small number of rapidly expanding sectors". Because of their specialization in key growing functions and sectors of globalization, such as international finance, global transport and communication or high level business services, world cities will grow faster than other types of territories. Sassen (1996, 2001) develops the same line of argument but focuses more specifically on high level services. In her view, metropolitanization is the result of "the massive trends toward spatial dispersion of economic activities at the metropolitan, national and global level, which we associate with globalization, [which] have contributed to a demand for new forms of territorial centralization of top-level management and control operations" (Sassen, 1996, p. 631). According to this perspective, global cities are improving their economic performance because of their capacities to gain a central position in the global networks constructed by the practices of financial and linked business and professional firms in the 'advanced producer services'. As elaborated mainly in the urban economic geography literature, centralising tendencies are the result of an ongoing need for high-level inter-firm as well as intra-firm tacit knowledge transfer, relationship-building, trust and cooperation, essential to global 'wholesale' business transactions and global markets competition (Pryke, 1991; Amin and Thrift, 1992; Pryke and Lee, 1995; Porteous, 1999; Andersen *et al.*, 2000; Gertler, 2003; Taylor *et al.*, 2003). The capacity to improve a city's global network centrality is therefore seen as relying on the existence of dense intra-urban global networks and multiple agglomeration effects in strategic functions (Rozenblat and Pflieger, 2010). In this respect, metropolitanization and globalization are seen as two sides of one ball.

Literature has also insisted on the importance of knowledge flows through social networks. From this perspective, "global cities act as key conduits for the inward and outward knowledge flows widely regarded as being essential for national competitiveness" (Dijkstra *et al*., 2013, p. 336). Hence, it is argued that in the era of global communication, concrete social relations and face-to-face contacts, which tend to be located in global cities, remain essential for access to the most vital information (David *et al*., 2013). Basically, this is the argument developed by Braudel (1985) in his analysis of capitalism, defined as the top-layer of the economy, an area of monopolies rather than markets (Arrighi, 1994; Van Hamme and Pion, 2012). In this top layer, transnational personal network relations and trust are decisive in obtaining high-value information and knowledge, and in controlling the commercial circuits that allow high-level profits to be made. While this is a basic feature of capitalism, it may have been reinforced in the era of globalization and deregulation. In the latest 2014 draft of the London Plan, the dense clustering of economic sectors, such as specialised financial and business services, remains a key component of strategy to support London's global position and "connected economy" (GLA, 2014, p. 127).

Building on the collective of seminal theoretical works in this literature, a body of related empirical research has emerged focusing on measuring city connectivity and its determinants. Taylor and collaborators in particular have drawn on Sassen's (1991, 1994) conceptualization of the rise of the new role of global cities as a consequence of the simultaneous dispersion and concentration of advanced producer services and Castells' (1996) theorization of a 'space of flows' produced by their organisational networks that operate within and between cities on a global scale (Taylor, 2001, 2004, 2012). Castells' identification of producer services as key conduits for flows in city networks, together with Sassen's insights into their use of cities as strategic sites for a new space economy, drew attention to their significant role in the emergence of globally interconnected places that are manifestations of global resources and capital. Notably, Castells' network theory was an input to the EU 'Lisbon' 2000 economic agenda now incorporated in EU2020 strategy (European Council, 2000; Pain, 2008, p.3; European Commission, 2010). In brief, Castells drew attention to the role of global business networks in generating *inter-city* relations and flows, and hence city network connectivity, at a worldwide scale, however this connectivity defied measurement until the late nineteen nineties (Beaverstock *et al*., 2000b; Taylor *et al.,* 2002). The basic idea behind Taylor's subsequent innovative quantitative analysis was to build a matrix of the relations *between* cities generated by the organizational practices of global firms in the principle advanced producer services sectors critical to Friedmann's process of 'world city' formation (1986): banking/finance, insurance, accountancy, law, advertising, communication and computer services etc. The different sizes and business command and control functions of their offices across the world are computed to show the connectivity that these confer on cities in an interlinked 'world city network'[ii] (Beaverstock *et al*., 2000a; Taylor, 2001, 2004, 2012).

Starting from this analytical framework, many researchers in the city networks field have expanded the range of analysis, describing other types of city relations to empirically assess city position in global networks (Timberlake and Smith, 2012). Following the seminal works of Smith and Timberlake (1995; 2001), authors such as Derudder and Witlox (2005) have focused in particular on airline linkages, notably because they "facilitate face-to-face business meetings, tourism and the movement of high value/low bulk goods" (Neal, 2012, p. 2695). In parallel, a large body of literature has developed on maritime networks (Jacobs *et al*., 2010) which, in Europe at least, overlap poorly with other types of global networks identified in the literature (Ducruet, *et al.,*2014). Alternative methodologies have also been proposed, most notably by incorporating the organisational and financial links between multinational network enterprises (Alderson, *et al.*, 2004; Rozenblat, 2008). Short's attention to the 'black holes and loose connections in the global urban network' (2004) and Robinson's concern for cities of the global South that are simply 'off the map' (2002), afford evidence of notable scholarly impatience with the swathe of research prioritizing the network connectivity of economically advanced world cities. But it is argued here that when it comes to understanding the exact relationship between city connectivity and the city economy, there is a lack of robust empirical evidence.

While global connectivity is supposed to be one of the key inputs to urban economic performance today, the city network literature does not offer empirical evidence and analyses to support this. The theoretical and empirical studies of city networks are concerned with understanding city connectivity and its changing dynamics rather than how these might impact on city economic performance. Taylor's world city network analysis for example does not attempt to measure a city's myriad inter and intra-city flows nor its gross economic performance (Taylor, 2006). To our knowledge, Neal (2011, 2012) has been the only author to explicitly assess the relationship between network connectivity and city economic performance. He starts also from the argument already developed that "a city's economic fortunes are closely tied to its position in networks of interurban exchanges" (Neal, 2011, p.167). However, his research shows the direction of causality to be unclear. Using airline linkages within the US, Neal attempts to disentangle whether the position in networks creates jobs (which he calls "structural advantage hypothesis", and which is the basic argument developed by the network paradigm) or whether jobs create networks (the "flow generation hypothesis"), through a demand-based argument. He concludes that centrality, in the US context, drives employment, though the strength of this relationship changes over time (Neal, 2011) and according to spatial context. In the European context, David *et al*. (2013) find little evidence that city position in networks drives economic performance.

Yet while the link between connectivity and economic growth is still unproven empirically, this relationship is still widely *assumed* to exist by policy makers pursuing global network connectivity as a territorial economic strategy. Although the city network model does not in itself infer a competition between cities as economic entities, territorial-political efforts to increase international attractiveness, notably through direct inward investment by global firms, illustrate how the city network paradigm has become a central plank in the competitive economic strategies of 'urban growth coalitions' (Molotch, 1976; Logan and Molotch, 1987; Harvey 1989; Brenner, 1998; Wei and Leung, 2005). Political regimes have come to associate city economic performance with territorial 'position', or rankings, in a hierarchy of world or global cities (Brenner, 1998; Brenner and Theodore, 2002; Olds and Yeung, 2004), as exemplified by strategy to make Europe "the most competitive and dynamic knowledge-based economy in the world" (European Council, 2000) by exploiting the role of its major "gateway cities" in global networks (European Commission, 2009 a, b, 2010, 2011; Pain, 2011). In the UK for example, a 2008 Policy Briefing document from think-tank, the National Endowment for Science, Technology and the Arts (NESTA), states that "Globalisation is changing. New economies and centres for innovation are emerging and capital, ideas, goods and people are moving more freely between them. The more connected a place is, the more successful it can become, enabling it to tap in to new sources of innovation." (NESTA, 2008, p. 1). The document goes on to assert that, to achieve this, places require "Access capacity - the capacity to link and connect to international networks of knowledge and innovation (through global academic, corporate or virtual networks)." (2008, p. 2). Linked research commissioned and led by NESTA includes UK-wide GaWC city network analyses, reflecting the view that such capacity has, from the 1950s onward, played "a major role in bridging economic development gaps between places" (Mahroum *et al*., 2008, p. 100). On the other side of the world in the same year, the New South Wales Government Department of Planning, Australia, commissioned GaWC researchers to undertake a 2008 Sydney city network analysis for presentation at its major international 'World Metropolis Congress' and in the first of its series of '9th World Congress' publications entitled, '*Connecting Cities - Networks'* (Johnson *et al*., 2008).

To further illustrate this point, we develop here a few examples of local urban projects aiming at reaching higher international visibility and attractiveness for foreign firms and investors. It is true that such policies rarely refer to the objective of improving the position of cities in global city networks explicitly because this concept is less familiar to local politicians who better understand the notion of boosting city economic performance through "internationalization policies". As an example, in the case of Brussels, an International Development Plan, whose main objectives and projects have been integrated in the PRDD (Plan Regional de Développement Durable, that is the strategic plan for Brussels), has initiated a shift in urban policies by focusing on "international development projects" with the explicit objective of being attractive for international visitors as well as investors, real estate developers, creatives or researchers (Vancriekingen and Decroly, 2009; Van Hamme and

Vancriekingen, 2012). Similarly, in the UK, the redrafted London Plan, 2014, focuses on sustaining the city's economic growth by promoting London "as a pre-eminent global business location". Z/Yen Group 'Global Financial Centres' and Mastercard 'Worldwide Centres of Commerce' rankings are referred to as measures of London's economic position and global competitiveness (GLA, 2014, p. 20).

A number of authors has critiqued internationalization projects mobilized for example by the design of flagship 'starchitect' buildings or the organization of major competitive events like the Olympic Games, with the implicit aim of boosting the global connectivity of parts of city "where key structures of the global economy are located" (Sassen, 2007, p. 205). For example, in the case of the Olympic Games event staged in Athens in 2004, Beriatos and Gospodini contend that "Although not explicitly stated by either the state or the Organizing Committee of Olympic Games 2004, different points of view converge in that the strategy underlying Athens' candidacy and the city's preparation for Olympics 2004 was to enlarge the city's development prospects and put Athens on the map as a major metropolitan center in southeast Europe" (2004, p. 192). Amongst others, Swyngedouw *et al.*, have drawn attention to the 'new urban policy' evident from the large-scale neo-liberal city development projects being implemented in Europe (2002).

The purpose of this paper then is to explore the relationship between city connectivity and GDP performance *empirically*, using the unique database for European and US city network connectivity compiled in our ESPON study. The intention is not to address the complexity of all urban economic processes in globalization but to provide some first answers about the assumed, but as yet unproven, specific relationship between network connectivity and city level economic performance, informing urban empirical and theoretical approaches and territorial policy.

Data and method

In the framework of the major two and a half years European Spatial Observation Network (ESPON) funded project studying the impact of networks and flows in globalization on the European territory, a unique database on cities has been built which includes indicators of social and economic structures, connectivity level and performance for European and US cities, with a population size of more than 500,000 inhabitants. All indicators have been collected at the city-region (functional city) level[iii]. In Europe, we have used the Large Urban Zones (LUZ) provided by the Urban Audit. While the basic idea is to consider the "influence area" of core cities through daily commuting, exact definitions differ across Member States. Moreover, in order to collect more relevant indicators, we have been obliged to use the NUTS3 proxies of LUZ, that is the NUTS3 that best fit the LUZ area defined by the Urban Audit[iv] (IGEAT, 2010). However, in most cases, spatial delimitations only differ in the margins of the functional cities (LUZ), without affecting the measures used in this paper, whether these are structural data (the level of education for example) or absolute indicators such as the number or value of connections, because major hub functions are nearly always included within the LUZ area (ports, airports, or advanced producer services mostly locate in the functional limits of the city)[v]. In the US, the delimitation of Metropolitan Areas has been provided on the same principle, but in a much more homogenous way throughout the US territory. The Office of Management and Budget (OMB) has defined a 'Core Based Statistical Area' throughout the country. Metropolitan Areas include all counties which send more than 25% of their workers to the core area. This definition is also used by the US census Bureau and the Bureau of Economic Analysis which makes the collection of data for US metropolitan areas easy. Delimitations are thus roughly comparable between Europe and the USA as long as we use Large Urban Zones and Metropolitan Areas. On this basis, we have built two databases, one for Europe and one for the US, covering all functional cities with more than 500,000 population.

As far as connectivity indicators are concerned, we assigned all cities included in the dataset to their correspondent European NUTS3 regions and US Metropolitan Areas, in order to link the connectivity indicators to the other regional information. In line with the literature on global networks, we use several indicators to assess the position of cities in global networks:

- Gross City Connectivity (and Standardized Connectivity)[vi] in advanced producer services (2000 and 2008) refers to the value of the connections interlinking a given city to other cities worldwide generated by the office command and control functions of global firms; all values are ratios of the most connected city in the world city network.
- gross air connectivity (1999, 2008) includes total overseas air connections of European and US cities;
- gross maritime connections (1996, 2006) are calculated the same way.

The exact indicator used in the regressions is the number of extra-continental (and neighbourhood[vii]) connections. By doing this, we intend to distinguish really global connections from local, national and continental ones. Global cities have by definition a global reach in their network connectivity and truly global connections cannot be considered to be of exactly the same nature as linkages within an integrated national or continental market. From the theoretical section, we derive that cities with greater global reach would have a decisive competitive advantage over those with predominantly national and local linkages. So, for example, the difference between Warsaw and Lodz is that the former is the real global hub for Poland while Lodz has limited direct linkages with the rest of the world. At a higher level, a similar difference appears between Warsaw and London. However, it is also true that overseas connectivity relies on local, national and continental connectivities, making global and overseas connectivity highly correlated. In consequence, using global or overseas connectivity barely affects the results.

Using the database, we have undertaken statistical analyses with economic performance as the dependent variable and connectivity in different networks as independent variables to test whether the network position of cities is important to explain their economic performance during the 2000's. We have three different network indicators: the gross city connectivity and the number of air and maritime connections. These indicators are first introduced separately to avoid collinearity issues. We define economic performance (our dependent variable) in two different ways: the GDP per inhabitant in the second half of the 2000's and the growth of GDP during the years 2001-2008 prior to the fully-fledged global economic and financial collapse in late 2008. A series of control variables is used (see Annex 1 for the description of indicators). These variables are usual in the regional or urban competitiveness literature (see for example Martin *et al*., 2006 and IGEAT, 2010), related to human capital (level of education), the economic specialization of the city (the share of the different sectors in the economy) and its accessibility (related to physical infrastructures):

- the economic structures, that is the share of manufacturing, construction, transport and trade, finance and other business services and other services in employment, or total added value. The structural composition of employment in cities can have a strong impact on their dynamics since sectors have different growth rates at a national or a global level;
- the level of education measured by the share of tertiary educated in the active population. Workforce qualification is generally considered decisive in explaining differences in regional growth because in the so called knowledge-based economy, manual employment has been destroyed and the labour market requires very qualified workforce. This process is considered to be more intense in large cities (Van Hamme et al., 2011);
- the accessibility by combining air and road accessibility of each NUTS3 area in the EU. The accessibility of a city is defined by the accessibility of the NUTS3 area equivalent to the core city. Accessibility is considered as vital for growth, notably because of the access to larger markets it allows;
- a dummy has been added to distinguish Central and Eastern newcomers in the EU to the West European countries, because dynamics are known to be very different in these parts of Europe (David *et al*., 2013).

As for regressions on GDP growth, we also consider as control variables GDP per inhabitant at the starting date and population growth during the period under consideration. We leave aside governance factors and other forms of so-called soft factors (cultural and institutional infrastructures, "quality of life" etc.), because of the difficulty of quantifying such factors in a systematic way. These analyses are undertaken separately for US and European cities because the data and delimitations are not perfectly comparable. Moreover, whilst we can consider Europe or the US to be coherent regional economies, with more predominant internal relations than relations with the rest of the world, together, they do not constitute such a coherent economic area as to justify the treatment of US and European cities in the same analysis.

Endogeneity is likely to be a crucial issue when it comes to evaluate the impact of network measures on economic performance. In the first set of regressions, we compare the connections measured in the year 2000 with the GDP per capita measured in 2008. Although the network measure is predetermined compared to GDP per capita, we see these regressions as providing information on the correlation between those variables. Indeed, it is likely that these two measures represent two different faces of the same coin: wealthier cities attract network connections because they are wealthier and they become wealthier because they have more connections… When looking at the impact of network connections measured in 2000 on GDP growth between 2001 and 2008, we intend to interpret these links as causal and believe that endogeneity is not an issue for several reasons. First, we compare the level of network connections that is the result of a long run process on economic performance measured in the short run. Second, reverse causality could be seen as a threat in our estimations. On the one hand, we do not believe that the level of network connections could be the result of the anticipated short run growth. Indeed, network connections are relatively stable over time[viii], as the result of a long run process. On the other hand, we have explicitly tested reverse causality by regressing the short run growth of network connections (between 2000 and 2008) on the initial GDP per capita. To perform this test, we use the growth of network connections over the period as the dependent variable while the GDP per capita measured in 2000 is one of the independent variables. We have found no evidence in favour of such a reverse causality and so we do not show the tables.

Results

We propose four sets of regressions using GDP per inhabitant in 2008 or economic growth between 2001 and 2008 as the dependent variables on both the European Union and the USA. For each set, we use different specifications; the results provided in the core of the text use exactly the same specifications for the US and the EU but we also provide some complete tables with alternative specifications in the appendix, in particular models for the EU adding controls for the country, capital cities and accessibility. For each set of regressions, we introduce our three measures of connectivity separately (Gross city, air and maritime connectivity), because of their high level of collinearity, and together in a final model to be explicated very carefully.

Looking at regressions on the level of GDP per inhabitant in 2008 for both the US and the EU, some significant relationships appear (Tables 1 and 2). In both regressions, the connectivity in advanced producer services is associated with a high level of GDP per inhabitant (43.553 for the EU and 43.933 for the US), while it is not the case for the other two measures of connectivity, except maritime connectivity in the US (35.665). In Europe, this result holds when accessibility (variable "airmulti" in Annex 2) is introduced as a control variable but not when regressions are controlled for capital (see Annex 3) and/or country (see Annex 4). This is readily understandable since capital cities tend to capture, in some parts of Europe at least, a large part of global connectivity at the country level: capitals are national gateways making connectivity in advanced producer services very related to the status of capital. Looking to control variables, classical competitiveness indicators appear as significant in both Europe and the US: the share of other services that is mostly services to the population (education health, administration etc.) appears in all models as significantly and negatively related to the GDP per inhabitant, while the level of education has a positive correlation with it. In Europe, when accessibility is introduced, it is also related to the level of GDP per inhabitant.

Because economic development in cities is such a complex and systemic process, we should interpret these results with care. The correlations observed in this model are the result of long historical processes, and we cannot say whether accessibility, the level of education and connectivity in advanced producer services, explain differences in GDP per capita in European cities because these variables are all part of a complex systemic process of development (Jacobs, 1961) that also includes the multi-scale embeddedness of cities.

Table 1. Per Capita GDP and network measures in Europe

	Per capita GDP 2008				
Share agricult. 2001	-505.95	-476.99	-514.03	-487.89	-433.16
	(4.06)**	(3.92)**	(4.09)**	(3.76)**	(3.37)**
Share energy. & manuf. 2001	36.02	106.25	41.31	47.41	112.83
	-0.42	-1.23	-0.48	-0.51	-1.22
Share construct. 2001	-765.01	-553.99	-758.61	-697.58	-459.08
	(2.71)**	-1.95	(2.68)**	(2.33)*	-1.54
Share finance 2001	446.28	384.5	431.77	466.63	409.66
	(3.84)**	(3.35)**	(3.64)**	(3.74)**	(3.29)**
Share other sectors 2001	-532.4	-405.14	-521.16	-516.52	-386.57
	(5.19)**	(3.75)**	(5.00)**	(4.63)**	(3.37)**
Higher educ.	247.95	196.2	243.95	250.98	188.99
	(4.62)**	(3.57)**	(4.50)**	(4.51)**	(3.31)**
1 if Western country	5687.07	6097.99	5731.19	5453.12	6035.86
	(4.83)**	(5.29)**	(4.85)**	(4.29)**	(4.85)**
GaWC stand. extra EU 2000		43.55			61.54
		(3.08)**			(3.32)**
Flights extra EU 99			0.442		-1.304
			-0.66		-1.55
Port extra EU 96				0.553	-3.658
				-0.06	-0.38
Constant	21728.6	17375.31	21694.9	20213.46	15490.09
	(3.15)**	(2.53)*	(3.14)**	(2.69)**	(2.09)*
R^2	0.78	0.79	0.78	0.78	0.79
N	161	161	161	153	153

* p<0.05; ** p<0.01

Standard deviations in parenthesis

Variables described in appendix 1

Table 2. Per Capita GDP in 2008 and network position for US cities

	Per capita GDP 2008				
Share energy. & manuf.2000	-269.276	-179.369	-165.881	-147.024	-82.855
	-1.26	-0.85	-0.75	-0.7	-0.39
Share construct. 2000	-648.275	-282.922	-29.87	-509.803	13.82
	-1.24	-0.54	-0.05	-1.01	-0.03
Share finance 2000	727.27	597.927	625.695	713.165	488.589
	(2.06)*	-1.74	-1.69	(2.11)*	-1.37
Share other sectors 2000	-669.565	-552.453	-634.064	-603.988	-467.244
	(3.17)**	(2.64)**	(2.96)**	(2.96)**	(2.21)*
Higher educ.2000	2194.584	1892.645	2169.215	2136.822	1854.44
	(4.34)**	(3.77)**	(4.03)**	(4.40)**	(3.52)**
GaWC stand. Extra-US 2000		56.381			90.043
		(2.58)*			(2.40)*
Flights extra US 99			1.976		-3.96
			-1.41		-1.7
Port extra US 96				40.083	28.696
				(2.80)**	-1.66
Constant	44281.708	40627.723	40254.382	39705.266	36851.451
	(3.20)**	(3.02)**	(2.86)**	(2.97)**	(2.75)**
R^2	0.58	0.61	0.58	0.62	0.64
N	86	86	77	86	77

p<0.05; ** p<0.01

Standard deviations in parenthesis

Variables described in appendix 1

To advance a step further in unravelling the relationship between city development and position in global networks, in the next regressions, we use the economic growth per capita between 2001 and 2008 as the dependent variable (see Tables 3 and 4).

In all specifications, connectivity measures never impact significantly on the economic growth of cities in both Europe and the US. In other words, city economic growth does not appear to be as strongly related to participation in global networks, and in particular to connectivity in advanced producer services, as might be supposed. Regarding other variables, the results in Europe appear perfectly in line with the usual expectations of the urban competitiveness literature: the share of other services (low level "services" mostly) negatively impact on city economic growth (-0.002), while the level of tertiary education has a positive impact (0.001). The initial level of GDP per inhabitant has a negative impact on growth, suggesting processes of convergence despite the fact that regressions are controlled for the western vs. eastern location of a city. Also, when introduced, both accessibility and the status of capital have a positive impact on city economic growth (see Annexes 2 and 3). Finally, when fixed countries' effects are introduced, the model appears more powerful (R^2 of 87% instead around 70%) but most other variables are found not significant (Annex 4). For the US (Table 4), some results are less expected: the share of construction positively impacts on city growth, which can probably be explained by the real estate bubble of the period considered; in contrast, manufacturing and, less expected, also the share of finance and business services, have a negative impact on growth.

Table 3. Per Capita GDP growth over the period 2001-2008 in Europe

	Per capita GDP growth 2001-08				
Share agricult. 2001	0	0	0	0	0
	-0.21	-0.25	-0.16	-0.37	-0.3
Share energy. & manuf. 2001	0	0	0	0	0
	-0.3	-0.1	-0.31	-0.45	-0.11
Share construct. 2001	0.001	0.001	0.001	0.001	0.001
	-0.94	-1.15	-0.95	-0.98	-1.2
Share finance 2001	0	0	0	0	0
	-1.15	-1.18	-1.15	-0.86	-0.89
Share other sectors 2001	-0.002	-0.002	-0.002	-0.002	-0.002
	(5.16)**	(4.56)**	(5.15)**	(5.12)**	(4.58)**
GDP pc 2000	0	0	0	0	0
	(5.31)**	(5.41)**	(5.14)**	(5.20)**	(5.18)**
Population 2000	0	0	0	0	0
	-0.76	-1.41	-0.38	-0.65	-0.88
Higher educ.	0.001	0.001	0.001	0.001	0.001
	(7.49)**	(6.79)**	(7.47)**	(7.48)**	(6.74)**
Pop. growth 01-07	-0.386	-0.38	-0.388	-0.395	-0.394
	(3.70)**	(3.65)**	(3.69)**	(3.63)**	(3.60)**
1 if Western country	-0.023	-0.021	-0.023	-0.022	-0.02
	(4.89)**	(4.30)**	(4.86)**	(4.37)**	(3.81)**
GaWC stand. extra EU 2000		0			0
		-1.24			-1.27
Flights extra EU 99			0		0
			-0.2		-0.45
Port extra EU 96				0	0
				-0.83	-0.92
Constant	0.084	0.079	0.083	0.088	0.083
	(3.68)**	(3.45)**	(3.63)**	(3.56)**	(3.31)**
R^2	0.7	0.7	0.7	0.7	0.7
N	160	160	160	152	152

* p<0.05; ** p<0.01

Standard deviations in parenthesis

Variables described in appendix 1

Table 4. Per capita GDP growth over the period 2001-2008 in the USA

	Per capita GDP growth 2001-2008				
Share energy. & manuf. 2000	-0.13	-0.14	-0.13	-0.12	-0.12
	(4.84)**	(4.73)**	(4.52)**	(4.30)**	(3.95)**
Share construct. 2000	0.17	0.18	0.21	0.15	0.19
	(2.42)*	(2.43)*	(2.77)**	(2.12)*	(2.43)*
Share finance 2000	-0.15	-0.15	-0.16	-0.14	-0.15
	(3.18)**	(3.19)**	(3.13)**	(2.96)**	(3.02)**
Share other sectors 2000	0.02	0.02	0.02	0.02	0.02
	-0.73	-0.63	-0.6	-0.85	-0.68
GDP pc 2001	0	0	0	0	0
	-1.57	-1.6	-0.89	-1.42	-0.87
Population 2000	0	0	0	0	0
	(2.26)*	-1.34	(2.00)*	-0.87	-1.41
Higher educ.2000	-0.18	-0.18	-0.17	-0.17	-0.16
	(2.54)*	(2.43)*	(2.14)*	(2.43)*	(2.01)*
Pop. growth 01-08	-0.56	-0.57	-0.55	-0.51	-0.51
	(4.69)**	(4.58)**	(4.53)**	(4.25)**	(3.96)**
GaWC stand. extra US 2000		-0.002			-0.002
		-0.39			-0.29
Flights extra US 99			0		-0.001
			-1.13		-1.3
Port extra US 96				0.004	0.004
				-1.76	-1.78
Constant	7.32	7.37	7.59	6.98	7.26
	(4.11)**	(4.11)**	(4.09)**	(3.95)**	(3.93)**
R^2	0.49	0.49	0.52	0.51	0.54
N	86	86	77	86	77

p<0.05; ** *p*<0.01

Standard deviations in parenthesis

Variables described in appendix 1

Discussion

These results are important because they seem to contradict the previously widely held expectation of the importance of connectivity as a factor in city economic growth in the globalization era. How should we interpret this finding?

First, some theoretical approaches take the view that metropolitanization should be considered a complex process of structural changes in global cities, rather than a purely quantitative one (Sassen, 2001) which would assume higher growth in the most connected metropolitan areas. In other words, in global cities, the reorientation toward the most strategic functions and sectors, has certainly resulted in growing prosperity for highly qualified wealthy classes working in these economic areas, though it has not necessarily produced economic growth for the city as a whole, except in the most global cities such as London and New York, where the intensity of the processes described are particularly high.

Second, the period considered might have a significant impact on the results. Some studies (European Commission, 2009b; David *et al*., 2013) have shown that the biggest metropolitan areas or first national cities, which have on average better connectivity, had better economic performances in the 1990's suggesting a slowing down of the importance of EU metropolitanization processes in the 2000's. World city network analysis has noted a connectivity shift during the globalization process of the 2000's with many cities, especially those in the Pacific Asia region, catching up with the connectivity of the US and the EU and also overtaking the rank order position of some US and EU cities (Pain *et al.*, 2012). This connectivity spurt may be a consequence of major metropolitanization coupled with improved economic performance, highlighting that the causality nexus from networking into economic growth implied by the city competitiveness narrative may be blind to a potential reverse causality; i.e. that city economic performance might foster the development of global network connectivity.

Thirdly then, the high importance of connectivity, especially in advanced producer services, may have been overestimated as a general factor of urban economic growth in contemporary globalization. Levels of inter-city connectivity may simply be indicators of city economic vibrancy. The specific local characteristics of cities, such as labour and service markets and political environment, are not directly accounted for in city network analysis but we suggest that they should be of critical relevance in informing effective economic development policy.

One possible explanation for distinctions in the relationship between city connectivity and GDP revealed by our analysis is that network economies in the biggest four or five global cities studied are less relevant for other cities of more limited size and with lower agglomeration of international functions. Hence, while truly global cities have been able to capture value at a global scale, most notably through their financial functions (Taylor *et al.*, 2003), growth mechanisms are different for other cities for which the impact of connectivity might be more restricted. In all these cities, economic performance is clearly also related to other factors, such as the level of education of the labour force, which has a significant impact on economic growth in European cities. In addition, we must underline that most global as well as globalizing cities still have relatively closed economies, which largely rely on regional, national, or macro-regional markets, as noted by Krugman (1996) in his comparison of Chicago at the end of the XIXth century and Los Angeles at the end of the XXth century. In a service economy, nations and even big cities are in practice relatively closed economies because, despite growing openness in most economic sectors, economic activity is at the same time also shifting more and more toward local services which are not easily off-shored (Van Hamme, 2012). In this context, factors of growing productivity in local services can be expected to have an important impact on a city's economic growth. However, the complex dialectical relation between city "external" global functions and the "internal" economy has yet to be properly understood, despite some interesting results from Porter for US cities on this subject. Porter's (2006) analysis suggests that the share of specialization in non local services is less important than the nature of this specialization, i.e. the share of high added value sectors in city economies, such as advanced producer services. The degree to which global connectivity will be related to the gross economic success of a city depends on how important the non-local is within a city economy. But this still tells us nothing about the sense of causality between city position in the global division of labour and the specific internal structural characteristics of cities. As stated by Jacobs (1970), it is the diversity and vibrancy of the local economic component within big cities which is productive of economic growth. Such local capacities may be necessary to benefit from global network connectivity.

Fourth, these results tell us nothing about the impact of connectivity on the economic growth of the EU and of the US as a whole. Indeed, major gateway cities may have a decisive role in allowing US or European territories to sustain their performance in the global economy. Our results provide a necessary empirical foundation to inform wider spatio-economic analysis. Nevertheless, though increased competitiveness, as measured by GDP, accrues to more complex, truly 'global' cities like London which benefit from a central position and supreme connectivity in global networks, there is no evidence of the general applicability of this relationship for other cities. These results have important implications in policy terms.

Conclusions

In this paper, we have asked whether global network connectivity has a demonstrable effect on a city's economic performance.

We have tested whether city connectivity is related directly to city economic performance. We can find no generalised relationship between city connectivity, for example through networks of firms in advanced producer services, and the level of GDP per capita in European and US cities or their level of city economic growth between 2001 and 2008. These results suggest that while global network connectivity is certainly important for a few global cities, the exact impact for others is uncertain. For example, London and New York may have experienced higher growth due to their high concentration of global gateway functions but the capacity to capture a higher share of added value associated with these functions may be specific to a limited number of world cities with a truly 'global' network role. It evidently has not worked this way for all other European and US cities in the recent past and so we cannot be clear in what ways their network position is impacting on their economic performance in practice. The results have some important policy implications at both European and local scales which we would like to discuss more in depth now.

At the European scale, the importance of urban concentration has recently been underlined as dictating the prosperity of the European economy in EU2020 strategic objectives. The European Commission has developed the line of argument that: "metropolitan areas play an important role in sustaining the EU's global competitiveness" (European Commission, 2011, p.16). In the context of globalization, the network connectivity of Europe's cities is seen as determining the economic competitiveness of the EU as a whole[ix] because they connect the European territory to the global economy. Thus it seems as though the "city network paradigm" has become implicitly linked to the narrative of the competitiveness literature and the "new economic geography" (Martin, 2008), and to discourse surrounding the trade-off between city agglomeration and balanced spatial development and territorial equity. We argue that there is a need for caution in assuming that increasing the network connectivity of all European cities will automatically translate to improved EU economic growth. The results from our analysis do not of course prove one way or the other whether there is a direct relationship between city-level connectivity and growth at national or the EU-wide scales, however to know how city connectivity in Europe has changed and how city performance has changed relative to this is, we argue, a critical first step in informing necessary wider analysis[x] and informed policy responses.

At a local scale, as discussed at the outset of this paper, in Europe, the US, and across the world, urban policies since the latter years of the twentieth century, have increasingly focused on improving the international position of cities to boost territorial competitiveness. Indeed, scientific considerations around network connectivity and internationalization have been translated into a normative urban policy narrative. Yet our results do not support the assumption that increasing connectivity will *by itself* result in better city economic performance. An open policy question that remains to be answered is whether and how the swathe of cities that are not supremely connected in global networks, can boost their growth in an increasingly competitive economy.

We conclude that theoretical economic growth narratives and policies focusing simply on improving the competitive position of cities in global networks are compromised by the absence of an in-depth understanding of diverse local city economies, functions, roles and network relations. For example, they do not take into consideration the importance of structural and historical features (path dependence) in explaining differential economic performance. Furthermore, they do not take into consideration the uncertain impact that increased global network connectivity would have on the performance of a city's economy as a whole, which is the underlying focus of urban policies focusing on internationalization. Nevertheless, global connectivity is an indicator of economic activity in the part of the urban economy which relates to non-local services and it is therefore a barometer of a city's participation in a transnational space of flows, in a global economic context. Hence the results are not indicative of the *un*importance of the connectivity of globalizing cities as a potential contributor to overall performance at wider EU or US economy levels. Rather our results highlight the relational complexity of city network economies and the need for policy to engage with this complexity instead of assuming that international attractiveness is a straightforward economic development 'fix' at city and wider territorial levels. Finally, in terms of policy-related research we emphasize the need to build on our results by integrating theoretical and analytical perspectives within and beyond the network paradigm and the competitiveness narrative in order to better inform economic and spatial policy.

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Annex 1. Indicators and sources

Name	Indicator	Source in the EU	Source in the US
GDP pc 2000(1)	The Gross domestic product per inhabitant, 2000 for EU, 2001 for US	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	US Bureau of Economic Analysis (BEA)
GDP growth	Growth of GDP, 2001 to 2008	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	US Bureau of Economic Analysis (BEA)
Population 2000	Population, 2000	Eurostat, regional data	US Census Bureau data
Share agricult. 2000(1)	The share of agriculture in total GDP (EU only, 2001)	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	
Share energy. & manuf. 2000(1)	The share of extraction, manufacturing and energy in total GDP (EU, 2001) or employment (USA, 2000)	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	US Bureau of Economic Analysis (BEA)
Share construct. 2000(1)	The share of construction in total GDP (EU, 2001) or employment (USA, 2000)	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	US Bureau of Economic Analysis (BEA)
Share finance 2000(1)	The share of financial and business services in total GDP (EU, 2001) or employment (USA, 2000)	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	US Bureau of Economic Analysis (BEA)
Share other sectors 2000(1)	The share of other services in total GDP (EU, 2001) or employment (USA, 2000)	Eurostat, own evaluations by affecting NUTS3 data to functional cities in Europe	US Bureau of Economic Analysis (BEA)
Higher educ.	Share of tertiary diploma in the active population (2001 in Europe; 2000 in the US)	Eurostat Census data; Eurostat Labour Force Survey; own calculations, 2001	US Census Bureau data, 2000; US Bureau of Economic Analysis (BEA) on the base on inquiries, 2005-2009
GaWC stand. extra EU (US) 2000	The number of connections of EU (or US) cities in networks of big firms of high level business services, with Non EU or Non US cities (2000, 2008)	Globalization & World Cities Network (GAWC), 2000	
Flights extra EU (US) 99	Number of flights connecting each city to non European and non neighbourhood cities (not in NAFTA for US cities) (1) (1999, 2008)	OAG (Official Airline Guide), 1999, 2008	
Port extra EU (US) 96	Number of connections with ports not in Europe or in its direct neighbourhood (not in NAFTA for US cities) (1) (1996, 2006)	Lloyd's Marine Intelligence Unit (LMIU), 1996, 2006	
Accessibility 2001	Indicator of accessibility at NUTS 3 level, affected to core cities, in 2001	Spiekermann & Wegener, Urban and Regional Research (S&W), 2001, 2006	
Pop. growth 01-07(8)	Population growth between 2001 and 2007 (EU) or 2008 (US)	Eurostat, Regional data	US Census Bureau data
1 if Western country	Dummy indicating if the city is located in Central and Eastern new member States		

Notes:

(1) European neighbourhood includes former USSR except, Western Balkans, Turkey, Syria, the Jordan, Israel, occupied territories and Northern Africa

Sources:

EUROSTAT: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database (Date last accessed 12.06.14).

Globalization and World Cities (GaWC): http://www.lboro.ac.uk/gawc/ (Date last accessed 12.06.14).

Lloyd's Marine Intelligence Unit (LMIU): http://securecontent.informa.com/NASApp/cs/ContentServer?pagename=informaGroup%2Fhome&peName=INFORMA_EL0014&MarketSectorCode=ALL&DirectoryID=20001062163 (Date last accessed 12.06.14).

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US (United States) Census Bureau: http://www.census.gov/data.html (Date last accessed 12.06.14).

Annex 2. Growth of GDP per head 2001-2008 and network position for European cities, with control for accessibility

	Per capita GDP growth 2001-08				
Share agricult. 2001	0	0	0	0	0
	-0.39	-0.36	-0.39	-0.48	-0.44
Share energy. & manuf. 2001	0	0	0	0	0
	-0.58	-0.17	-0.58	-0.8	-0.46
Share construct. 2001	0.001	0.002	0.001	0.002	0.002
	-1.29	-1.5	-1.28	-1.61	-1.76
Share finance 2001	0	0	0	0	0
	-0.5	-0.52	-0.5	-0.08	-0.04
Share other sectors 2001	-0.002	-0.002	-0.002	-0.002	-0.002
	(5.25)**	(4.64)**	(5.23)**	(5.35)**	(4.81)**
GDP pc 2000	0	0	0	0	0
	(5.63)**	(5.73)**	(5.46)**	(5.81)**	(5.75)**
Population 2000	0	0	0	0	0
	-1.13	-1.7	-0.75	-1.2	-1.33
Higher educ.	0.001	0.001	0.001	0.001	0.001
	(7.69)**	(6.97)**	(7.66)**	(7.88)**	(7.13)**
Accessibility 2001	0	0	0	0	0
	-1.77	-1.79	-1.75	(2.48)*	(2.39)*
Pop. growth 01-07	-0.383	-0.377	-0.383	-0.396	-0.392
	(3.69)**	(3.64)**	(3.67)**	(3.70)**	(3.65)**
1 if Western country	-0.023	-0.021	-0.023	-0.022	-0.02
	(4.95)**	(4.35)**	(4.90)**	(4.45)**	(3.88)**
GaWC stand. extra EU 2000		0			0
		-1.28			-1.13
Flights extra EU 99			0		0
			-0.05		-0.12
Port extra EU 96				0	0
				-0.89	-0.96
Constant	0.08	0.075	0.08	0.082	0.078
	(3.51)**	(3.28)**	(3.48)**	(3.34)**	(3.15)**
R^2	0.71	0.71	0.71	0.71	0.72
N	160	160	160	152	152

* $p<0.05$; ** $p<0.01$

Standard deviations in parenthesis

Variables described in appendix

Annex 3. Growth of GDP per head 2001-2008 and network position for European cities, with control for accessibility and capital cities

	Per capita GDP growth 2001-08				
Share agricult. 2001	0	0	0	0	0
	-0.9	-0.86	-0.8	-0.91	-0.8
Share energy. & manuf. 2001	0	0	0	0	0
	-0.43	-0.52	-0.48	-0.12	-0.22
Share construct. 2001	0.002	0.002	0.002	0.002	0.002
	-1.86	-1.9	-1.85	(2.03)*	(2.03)*
Share finance 2001	0	0	0	0	0
	-0.87	-0.86	-0.84	-0.35	-0.31
Share other sectors 2001	-0.002	-0.002	-0.002	-0.002	-0.002
	(4.65)**	(4.37)**	(4.58)**	(4.60)**	(4.37)**
GDP pc 2000	0	0	0	0	0
	(6.20)**	(6.01)**	(6.12)**	(6.17)**	(5.97)**
Population 2000	0	0	0	0	0
	(2.13)*	-1.92	-1.84	(1.99)*	-1.79
Higher educ.	0.001	0.001	0.001	0.001	0.001
	(6.32)**	(6.10)**	(6.24)**	(6.40)**	(6.16)**
Accessibility 2001	0	0	0	0	0
	(2.20)*	(2.18)*	(2.24)*	(2.63)**	(2.64)**
Pop. growth 01-07	-0.399	-0.396	-0.395	-0.403	-0.397
	(3.95)**	(3.91)**	(3.89)**	(3.84)**	(3.74)**
1 if Western country	-0.018	-0.017	-0.017	-0.018	-0.017
	(3.79)**	(3.61)**	(3.62)**	(3.61)**	(3.31)**
1 if capital city	0.013	0.013	0.014	0.012	0.012
	(3.04)**	(2.77)**	(3.08)**	(2.49)*	(2.28)*
GaWC stand. extra EU 2000		0			0
		-0.46			-0.28
Flights extra EU 99			0		0
			-0.53		-0.49
Port extra EU 96				0	0
				-0.47	-0.47
Constant	0.062	0.061	0.062	0.064	0.064
	(2.70)**	(2.65)**	(2.71)**	(2.58)*	(2.56)*
R^2	0.72	0.72	0.72	0.73	0.73
N	160	160	160	152	152

* p<0.05; ** p<0.01

Standard deviations in parenthesis

Variables described in appendix 1

Annex 4. Growth of GDP per head 2001-2008 and network position for European cities, with control for accessibility and fixed effects for countries

	Per capita GDP 2008				
Share agricult. 2001	-173.405	-193.937	-166.258	-164.259	-167.947
	-1.32	-1.46	-1.23	-1.21	-1.2
Share energy. & manuf. 2001	-88.215	-77.484	-88.547	-85.578	-77.749
	-1.01	-0.88	-1.01	-0.9	-0.82
Share construct. 2001	-1,180.855	-1,115.448	-1,182.319	-1,135.042	-1,057.312
	(4.33)**	(3.98)**	(4.32)**	(3.98)**	(3.60)**
Share finance 2001	310.95	278.375	317.033	302.256	276.337
	(2.45)*	(2.13)*	(2.45)*	(2.17)*	-1.89
Share other sectors 2001	-617.187	-605.649	-619.274	-617.526	-620.192
	(5.07)**	(4.95)**	(5.06)**	(4.62)**	(4.62)**
Higher educ.	291.856	283.348	293.007	277.763	274.161
	(3.51)**	(3.39)**	(3.50)**	(3.17)**	(3.12)**
Accessibility 2001	27.245	21.566	27.772	35.968	27.97
	-1.44	-1.09	-1.45	-1.73	-1.26
1 if Western country	14,795.143	14,527.161	14,799.295	14,767.324	14,461.189
	(3.22)**	(3.16)**	(3.21)**	(3.19)**	(3.11)**
GaWC stand. extra EU 2000		12.494			18.982
		-0.99			-1.14
Flights extra EU 99			-0.126		-0.578
			-0.25		-0.89
Port extra EU 96				-8.167	-9.13
				-1.11	-1.22
Constant	22,353.270	22,858.260	22,161.556	22,235.695	22,617.844
	(3.01)**	(3.07)**	(2.96)**	(2.81)**	(2.82)**
R^2	0.91	0.91	0.91	0.91	0.91
N	161	161	161	153	153

* p<0.05; ** p<0.01

Standard deviations in parenthesis

Variables described in appendix 1

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[i] As networked nodes in the global economy, cities are part of a spatially dynamic cross-border urban system in which they are interconnected by diverse links and flows supported by informational, communication and transportation developments.

[ii] The world city network is formally represented by a city-by-firm matrix $\mathbf{V}_{ij}$, where $v_{i,j}$ is the 'service value' of city i to firm j; for detailed information about the construction of the model see Taylor, 2004.

[iii] Functional cities intend to capture the scale at which urban economies really work. They are generally approximated through employment pool.

[iv] The basic idea is to consider that a large urban zone can be approximated by a NUTS3 area when more than 70% of the population of this NUTS3 area resides in the LUZ. The NUTS classification is a hierarchical

classification of territories across the EU and near neighbours (Norway, Switzerland, Turkey). NUTS 3 corresponds for example to *Kreise* in Germany or *Departement* in France. It is not totally homogeneous because of its reliance on pre-existing national administrative divisions.

[v] A complete comparison has been made with other delimitations of Functional Urban Areas (Latts *et al*., 2011) showing some differences: the list of LUZ with more than 500000 inhabitants is larger especially in Eastern Europe where many cities are near this population treshold; when the same city is considered, FUA and LUZ do correspond relatively well, depending on the treshold used to include a NUTS3 area within a Functional Urban Area or LUZ. So it is true that there are significant differences in the list of cities but not so much based on their exact approximations in NUTS3. Our conviction is that there is no good solution to this issue of city delimitations in Europe because, in any case, commuting areas are still defined heteregeneously across Europe and the allocation to NUTS3 remain unsatisfactory. In any case, we use stable defintions in our study and we believe that differences in the margins of the city do not affect our statistical results because of their limited weight in the Functional Urban Area.

[vi] To measure Gross City Connectivity in advanced producer services, a universe of *m* advanced producer services firms located in *n* world cities is defined. The importance of the office of firm *j* in city *i*, which is known as the service value of a firm in a city, is *vij*. Service values for all firms in all cities define a service value matrix. The assumption is that the more important the office is in a given city, the more connections it will generate with other offices in a firm's network in other cities. The advanced producer services connectivity conferred on a city is therefore generated by the connections between the offices of firms in a given sector. $Ra = \Sigma\, rai$ is the gross interlock connectivity, which defines the integration of a city in the network. However, to make the results more readily interpretable, they are converted to proportions of the largest connectivity recorded in the given universe of cities. If the largest connectivity is designated *L*, the city network connectivity is given as: $Ca = Ra / L$. The GaWC interlocking city network model is explained in full detail in Taylor, 2004. A Standardized Connectivity index allows direct city network connectivity comparisons to be made across the years 2000 and 2008. The index is calculated after standardizing the values of connectivity flows between the cities included in the dataset. The standardization method is explained in more detail in Working Paper 3 of the ESPON Project Final Report, pp. 2-3.

[vii] The European neighbourhood includes the former USSR except, the Western Balkans, Turkey, Syria, Jordan, Israel, the occupied territories and Northern Africa. The US neighbourhood includes the NAFTA as well as the Caribbean and Central America.

[viii] The relative stability of this connectivity measure has been carefully investigated for the 2000-04 period by Taylor and Aranya (2008).

[ix] This relationship has been a recurring theme in the case of London (see for example, London Economics, 2009; Oxford Economics, 2011).

[x] While a large economic competitiveness literature has addressed the theoretical relationship between external network economies and growth (for example, Bathelt *et al*., 2004; Breschi and Lissoni, 2003; Coe and Bunnell, 2003; Moodysson *et al*., 2005; Breschi and Lenzi, 2011), in an absence of flow data there has until now been a dearth of empirical analysis investigating the correlation between the connectivity of networked cities and territorial economic performance.