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The Rise of Second-Rank Cities: What Role for Agglomeration Economies?

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Abstract *In the last 15 years, empirical evidence has emerged about the fact that European first-rank cities have not always led national economic performance, and when they did, the difference between first- and second-rank cities in explaining national growth has not been significant. A recent work [Dijkstra, L., Garcilazo, E. & McCann, P. (2013) The economic performance of European cities and city regions: Myths and realities,* European Planning Studies*, 21(3), pp. 334–354] claims that second-rank cities have in fact outperformed first-rank cities, becoming the main driving forces in national economic performance. In the debate that emphasizes the role of second-rank cities in national growth, a simplified view of the role of agglomeration economies is provided; they are taken for granted in small- and medium-sized cities and only in large cities will the problem of a downturn in urban returns to scale emerge. In this paper, a more complex view is assumed, claiming that the oversimplified interpretation that urban economic performance simply depends on the exploitation of agglomeration economies and that these agglomeration economies merely depend on urban size alone should be abandoned. Some already existing theoretical frameworks in urban economics can help in recalling the role of possible bifurcations in the development path of cities, linked to the capability to attract or develop new and higher-order functions, increase internal efficiency and reach scale economies through cooperation networks with other cities (the city-network theory). All these elements work as conditions for fully exploiting agglomeration economies and ways to overcome urban decreasing returns.*

1. Introduction

The interest in the role of cities in explaining national economic performance is not at all new and has always been at the basis of urban economics theory and economic geography studies. In the 1990s, thanks to seminal contributions (Glaeser *et al*., 1992; Krugman, 1991), a resurgence of interest in cities and in their role in national economic performance was registered, followed by more recent studies, especially on the North American reality (Glaeser, 2008; Henderson, 1974, 1985, 1996; Rosenthal & Strange, 2004; Sassen, 2002; Scott, 2001).

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This revival of interest in the role of cities in explaining national economic performance is not merely driven by an academic fashion (Henderson, 2010), but finds concrete evidence of real changes in the role of large cities in driving national economies (Nijkamp & Kourtit, 2011, 2012). For a long time, in the last 20 years of the last century, large European cities (but not only European) benefitted from two main favourable exogenous factors that enhanced their generalized performance: the emergence and consolidation of the ICT paradigm, that was quickly utilized to re-launch urban activities after the previous de-industrialization period, and the birth of the European Single Market project by president Jacques Delors in 1985, which generated an enormous inflow of FDI into large gateway cities in all European countries (Camagni, 2001). On the other hand, the economic crisis of more recent years mostly hit large and capital cities, natural loci of core economic and financial activities. This implies that second-rank cities have proved to be the most resilient areas to economic downturn in advanced economies.

The evidence of a scarcity of public resources sharpened the debate on the contribution that each territory can provide to national competitiveness, encouraging a comparison between the efficiency displayed by capital cities vs. second-rank cities in exploiting public investment for growth. It is in fact well known that large cities are expensive machines, requiring large social overhead capital investments and exhibiting expensive real estate markets and high-rise, capital-intensive buildings. Second-rank cities, once endowed with some necessary preconditions for a modern development—namely international links, high-education and cultural facilities—may well exhibit higher public resources efficiency and better quality of life conditions than first-rank cities, being in a condition to find appropriate specialization niches inside the international division of labour.

The vast academic and policy debate over the last years has generated some important empirical studies comparing the role of second- vs. first-rank cities in explaining national economic competitiveness (Glaeser, 2011). While much US literature celebrated the role of large metro areas in fostering economic growth, there is common evidence that in Europe, over the last two decades, second-rank cities have often outperformed first-rank cities, or, even when first-rank cities grew faster, the difference with respect to second-rank cities has been negligible. In fact, in several countries, second-rank cities have been identified as the main driving forces in national economic performance (Dijkstra *et al*., 2013; Parkinson *et al*., 2014).

In this literature, there is a simplified view of the role of agglomeration economies; they are taken for granted in small and medium-size cities and only in large cities will the problem of a downturn in urban returns to scale eventually emerge.

Here, a more complex view is assumed. In fact, this paper adds to the existing literature the idea that urban economic performance does not only depend on the exploitation of agglomeration economies and that, in turn, agglomeration economies do not only depend on urban size alone. Some existing theoretical frameworks in urban economics can help recall the role of possible bifurcations in the development path of cities, linked to the capability to attract or develop new and higher-order functions (the SOUDY model, Camagni *et al*., 1986), increase internal efficiency and reach scale economies though cooperation networks with other cities (the city-network theory, Camagni, 1993; Conti & Dematteis, 1995). All these elements work as conditions for fully exploiting agglomeration economies and ways to overcome urban decreasing returns.[1]

This paper aims at inspecting the conditions leading second-rank cities in the EU in some periods to outperform with respect to larger metro areas. Urban rank is defined according to the cities' physical (population) size; in particular, first-rank cities are defined as those cities (LUZ areas) with a population larger than 1 million inhabitants. Second rank cities are instead identified as those LUZ areas with a number of inhabitants in a range from 1 million to 200,000 inhabitants. In both cases, data used to define the classes refer to 2011.[2]

The interpretation assumed in this work is that cities may experience a halt in their growth path and even a decline irrespective of their size class, in the absence of these conditional factors. These factors are not really quantitative in nature, but rather qualitative and some quantum jumps in their endowment are needed at specific intervals if agglomeration economies have to fully generate their beneficial effects. The quality of activities hosted, the quality of production factors, the density of external linkages and cooperation networks, the quality of urban infrastructure—in internal and external mobility, in education, in public services—are all enabling factors allowing a long-term 'structural dynamics' process (in the language of dynamic modelling) through what could easily be called a process of urban innovation in each urban category.

The paper thus departs from most existing literature, by decomposing the black box of agglomeration economies, and their impacts on long-run urban performance, into their main determinants, as well as by better qualifying the commonplace finding that agglomeration economies/diseconomies would be the only determinants of urban dynamics.

The paper is structured as follows. Section 2 briefly presents the recent debate on the rise of the second-rank cities, and highlights the existing conceptual toolbox that allows overcoming the traditional view of the role of agglomeration economies in urban growth. Section 3 presents a descriptive analysis on the economic performance of the different size classes. Section 4 presents the conceptual model and the rich database on which the model is estimated. Section 5 contains the results of the econometric estimates, while Section 6 concludes.

2. The Theoretical Explanations for the Rise of Second-Rank Cities: Testable Assumptions

Against the much celebrated triumph of (large) cities (Glaeser, 2011), recent empirical evidence has been presented on the fact that in the EU the last two decades witnessed a relatively comparable performance across cities of first and second rank. Within this recent debate, agglomeration economies are called upon to explain the relatively better performance of second-rank cities, while diseconomies of scale are identified as the cause of the limited success of large ones (Dijkstra *et al.*, 2013). The explanations provided for such a phenomenon are not convincing, and risk an ex-post circular reasoning: a structural break—namely the limit between economies and diseconomies—is used to explain cyclical economic phenomena, with no interpretation of why it takes place exactly at a specific moment and in a particular place.

In the above reasoning, two problems are mixed together: a structural one and a cyclical one. The former deals with the existence of a theoretical explanation concerning the way and conditions for the different city-size classes to exploit increasing returns to urban scale (the how problem); the latter problem concerns the question whether different classes of urban size are better suited for expansion or crisis periods (the when). The how issue is logically propaedeutical and more interesting than the when issue, as descriptive evidence shows that there are some large cities still able to play a role in their national economies, and some second-rank cities still lagging behind, demonstrating that, for the same urban size, agglomeration economies seem to play a positive role for some cities and not for others.

Urban economists are called to give some more appropriate explanations to these phenomena. In our opinion, some relevant theoretical interpretations concerning increasing returns to urban scale—going beyond the use of a single, smooth function for the entire spectrum of city sizes, interpreting the capacity of cities to exploit agglomeration economies—are already available in urban economic theory, and deserve empirical demonstration.

The first explanation for the capacity of a city to overcome diseconomies of scale is contained in the so-called SOUDY (Supply Oriented Urban DYnamics) model (Camagni *et al.*, 1986). The model assumes that an "efficient" city-size interval exists separately for each hierarchical rank, associated with rank-specific economic functions. In other words, for each economic function characterised by a specific demand threshold and a minimum production size, a minimum and a maximum city size exists beyond which urban location diseconomies overcome production benefits typical of that function.

As Figure 1 shows, under these conditions, for each economic function and each associated urban rank, it is possible to define a minimum and a maximum city size in which the city operates under efficiency conditions (i.e. with net positive gains) (d_1–d_2 for the function—and centre—of rank 1; d_3–d_4 for the function—and centre—of rank 2; . . .). The higher the production benefits (profits) of the single functions (increasing with rank), the higher the efficient urban size interval associated to such function.

As each centre grows, approaching the maximum size compatible with its rank ("constrained dynamics"), it enters an instability area (e.g. in d_3–d_2 in Figure 1) where it becomes a potentially suitable location for higher-order functions, thanks to the achievement of a critical demand size for them. In dynamic terms, each city's long-term growth possibilities depend on its ability to move to higher urban ranks, developing or attracting

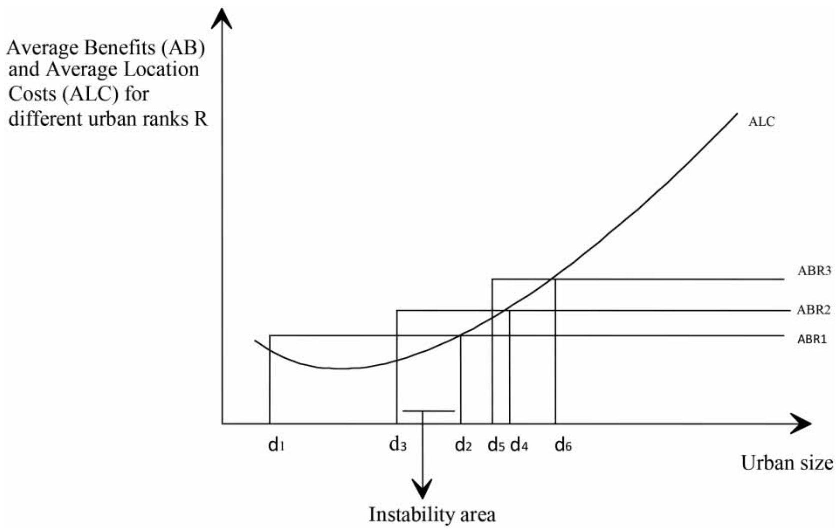

Figure 1. Efficient city size for different urban functions.
Source: Camagni *et al.* (1986).

new and higher-order functions ("structural dynamics"). This "jump" is not mechanically attained: it represents a true urban innovation and is treated as a stochastic process in the dynamic model.

The interest of this model resides in the fact that it overcomes some of the limits of the "optimal" city-size theory, by suggesting:

- the need to replace "optimal size" by a "range" within which the city size is "efficient",[3] i.e. where average production benefits exceed average location costs;
- the need to allow different "efficient" urban intervals according to the functions actually performed by the cities;
- the possibility of decoupling urban ranks from urban size. Differently from Christaller's approach, two cities of the same size (for example, size d_2 in Figure 1) can belong to two ranks (1 and 2 in the example), depending on their capacity to attract/develop higher functions.[4]

The second theory helpful in explaining the determinants of agglomeration economies that go beyond urban size is the city-network theory. Born in the field of industrial economics (Chesnais, 1988; Williamson, 1985), the concept of network behaviour—namely a cooperative organizational form, intermediate between internal and external growth of the firm, between "make" or "buy"—was transferred into urban economics providing a successful theoretical framework to overcome the limiting interpretative power of the traditional central-place model.[5] In fact, real city-systems in advanced countries have departed from the abstract Christaller pattern of a nested hierarchy of centres and markets, showing (Camagni, 1993):

- processes of city specialization and presence of higher-order functions in centres of lower order;
- horizontal linkages between similar cities, not allowed in the traditional model: e.g. the financial and headquarter networks among top world cities, or the art cities linked through tourist "itineraries" (so called "synergy networks"); the systems of specialised cities exploiting the advantages of the division of labour, like the Dutch Randstad or the network of medium-sized cities in the Veneto region ("complementarity networks") (Camagni & Capello, 2004).

In the new logic, other elements come to the fore—economies of vertical and horizontal integration, and network externalities similar to those emerging from "club goods". These elements provide the possibility for cities to reach increasing returns and scale economies through network integration—in the economic, logistic and organizational fields—with other cities.

In this sense, the concept of city networks recalls that of "borrowed size", which was launched by Alonso (1973) to explain a disconnection between size and function of smaller cities that were part of a megalopolitan urban complex:

> the concept of a system of cities has many facets, but one of particular interest . . . is the concept of borrowed size, whereby a small city or metropolitan area exhibits some of the characteristics of a larger one if it is near other population concentrations. (Alonso, 1973, p. 200)

According to this literature, "borrowed size" can easily explain why second-rank cities grow economically without a physical expansion: their location in polycentric urban systems substitutes for their individual physical size (Meijers & Burger, 2010), since borrowed size allows single cities to upgrade their economic functions without necessarily increasing their individual size. Externalities accrue to functionally connected urban areas, that thus reach economies of scale without incurring the costs associated with (excessive) urban size (Phelps *et al*., 2001; Veneri & Burgalassi, 2012; and, for a conceptual review, Parr, 2002). Conversely, a polycentric urban structure, whereby cities of average size can overcome the limits associated with sheer size, may be associated with limitations to the achievement of economies of scale whenever the threshold of given services cannot be dispersed in such a spatial arrangement (see for instance Burger *et al*., 2013, 2014).

An important difference, however, exists between the concept of borrowed size and that of city networks. The concept of city networks adds to that of "borrowed size" the idea that size can be borrowed not only thanks to physical proximity to larger centres, but also thanks to relationships and flows of a mainly horizontal and non-hierarchical nature among complementary or similar centres, located far from each other, with the aim of achieving network externalities (Camagni, 1993; Camagni & Capello, 2004; Capello, 2000).

These conceptual ideas help in explaining why cities of intermediate size are being increasingly looked upon as the places that could well host the growth of the years to come: limited city size, in fact, facilitates environmental equilibrium, efficiency of the mobility system and the possibility for citizens to retain a sense of identity, provided that a superior economic efficiency is reached through external cooperation with other cities, located in the same regions or distant but well connected. Urban productivity was empirically found to be much more closely related to urban connectivity—a concept similar to urban network relations—than to urban scale (McCann & Acs, 2011), thus supporting the global city argument but also the medium-sized cities' potentials.

The joint application of the SOUDY model and the city-network paradigm has relevant implications for urban efficiency and growth: size is not the only determinants of factor productivity and urban performance. The presence of high-order functions and integration inside city networks are also extremely important elements in the explanation of the competitive advantage of cities, allowing the boosting of productivity even in presence of limited urban size.

We expect functional specialization and city networks to play a prominent role in explaining the achievement and exploitation of agglomeration economies (or in avoiding agglomeration diseconomies) in second-rank cities.[6] Moreover, within second-rank cities, we expect best performing cities to be able to exploit increasing returns much more than the other cities.

Our research hypotheses are therefore the following:

(a) small- and medium-sized cities can also experience a halt or a decline in their growth pattern, since each city's long-term growth possibilities depend on its ability to move to higher urban ranks, developing or attracting new and higher-order functions;
(b) the best performing small- and medium-sized cities are able to postpone and overcome the appearance of decreasing returns, thus being able to fully exploit increasing returns to urban scale;
(c) the capability of best performing small- and medium-sized cities to exploit increasing returns depends on the development of higher valued functions and external cooperation networks;

(d) For second-rank cities, these growth-enhancing factors can be borrowed from closely located large urban areas.

3. Urban Economic Performance from 1996 to 2009: Second- vs. First-Rank Cities

This section presents a comprehensive picture of the medium-run trends for a sample of 136 EU metropolitan areas, dividing the trends between first-rank and second-rank cities. The two "uniform categories" of first- and second-rank cities are defined in terms of physical size, as usually done in the economic geography literature. As anticipated in Section 1, first-rank cities are defined as those cities (LUZ areas) with a population larger than 1 million inhabitants. Second rank cities are instead identified as those LUZ areas with a number of inhabitants in a range from 1 million to 200,000 inhabitants. In both cases, data used to define the classes refer to 2011.

Figure 2 presents the 1996–2009 time series for yearly gross domestic product (GDP) growth rates divided by urban rank. A first result is that a clear cyclical process characterized European economies. Figure 2 displays annual GDP growth rates on the main graph, while showing aggregate GDP growth rates in the bottom (first through third period) and top-right (fourth and last period) corner of the figure.

The main graph suggests a few relevant stylized facts for the EU economies in the surveyed period:

- the EU economy, following a worldwide trend, behaves cyclically. Two fast growth stages can be identified, running from 1995 to 2000 and from 2003 to 2007; between such

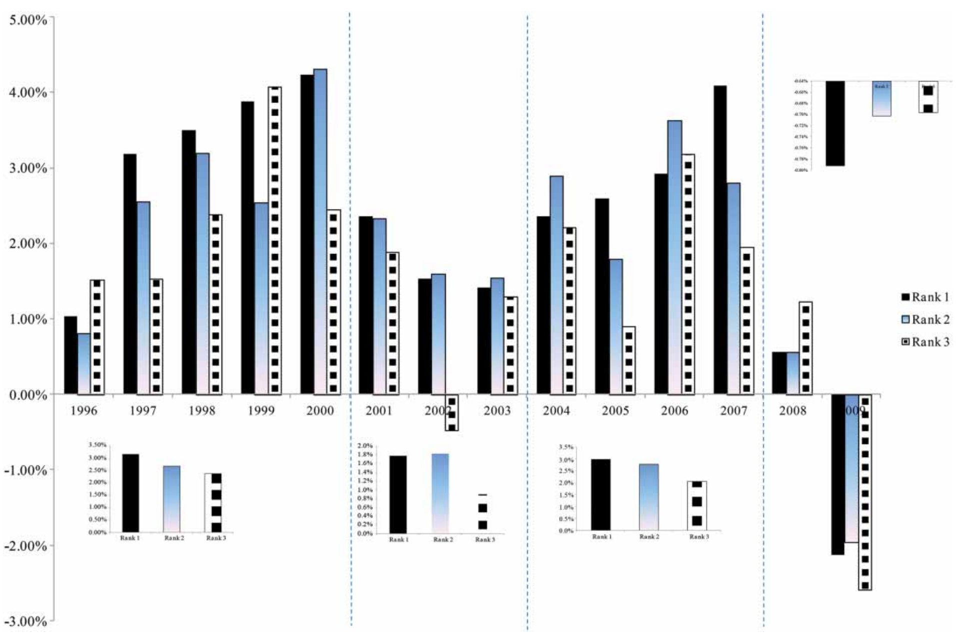

Figure 2. Annual GDP growth rates, 1996–2009, by city rank.
Note: In the boxes: period averages.
Source: authors' elaboration.

periods, three years of growth slowdown (2000–2003) can be identified. Finally, after 2007 EU data clearly show the appearance of the (currently ongoing) financial crisis, first marking a relevant growth slowdown in 2008, then showing the first signs of GDP contraction in 2009. In Figure 2, these periods are marked with vertical dashed lines;

- most interestingly, while in the fastest expansion periods rank 1 cities seem to drive economic growth (black-coloured bars in Figure 2), in slowdown times rank 2 cities (shaded colour in Figure 2) invert this trend and are at the forefront of the process of economic development. In Figure 2 this statement can be easily seen from the ancillary graphs at the bottom and top-right corner of the main chart, showing period average growth rates. Rank 2 cities grow in fact faster than rank 1 cities in the second period, and present a less pronounced decline in GDP in the fourth period;
- while this EU-wide trend is relatively visible with plain GDP growth data, the prevalence of rank 2 cities as engines of economic growth in recent periods emerges more clearly from the inspection of Figure 3(a)–(c). Figure 3, in fact, represents per capita GDP growth rates for the same four periods, showing that indeed in 8 of the last 10 years rank 2 cities outperformed rank 1 cities, thus contributing more to the overall country (and EU-wide) growth of productivity. This statement is again valid for both the second as well as for the last period above identified;
- while Figure 3(a) shows such trend for the whole EU27, Figures 3(b) and 3(c) break down this result by macro areas. Figure 3(b) shows data for productivity growth in the EU15, and Figure 3(c) for New Member States (henceforth, NMS). Because of the large portion of EU27 GDP produced by Western Countries, Figure 3(b) behaves quite similarly to the main EU27-wide trend, with rank 2 cities growing faster than rank 1 cities in the second and fourth period. Figure 3(c) shows instead that in most observed years rank 1 cities overperform with respect to rank 2 ones in NMS, with no clear trend of a rank 2 cities' reprise. Clearly, this may depend either on a strong prevalence of rank 1 cities in the process of wealth creation in NMS, or else on the relative lack of a well-structured, well-interconnected network of rank 2 cities in these countries.[7]

Graphical evidence does not find, however, unequivocal statistical support in classic *t*-tests for mean differences across groups, and this holds for all the four periods identified. This result strengthens the case for our empirical analyses, as it clearly shows that first-rank cities are not really leading national performance as superficially expected on the basis of their size and role in national economies, and points at the need to analyse the reasons why some second-rank cities have outperformed first-rank ones in the last 20 years. Thus, this work focuses on the two periods (2001–2004 and 2008–2009) when rank 2 cities grew faster than first-rank cities. In these periods, a dummy variable is calculated for second-rank cities, taking on value 1 if the metro area overperformed with respect to the country average GDP growth rate. The four periods identified in the data are shown in Table 1.

4. The Model and the Data Description

4.1. *The Estimated Model*

The research questions mentioned in Section 2 are addressed by estimating an aggregate urban production function in the traditional neoclassical form of average location benefits

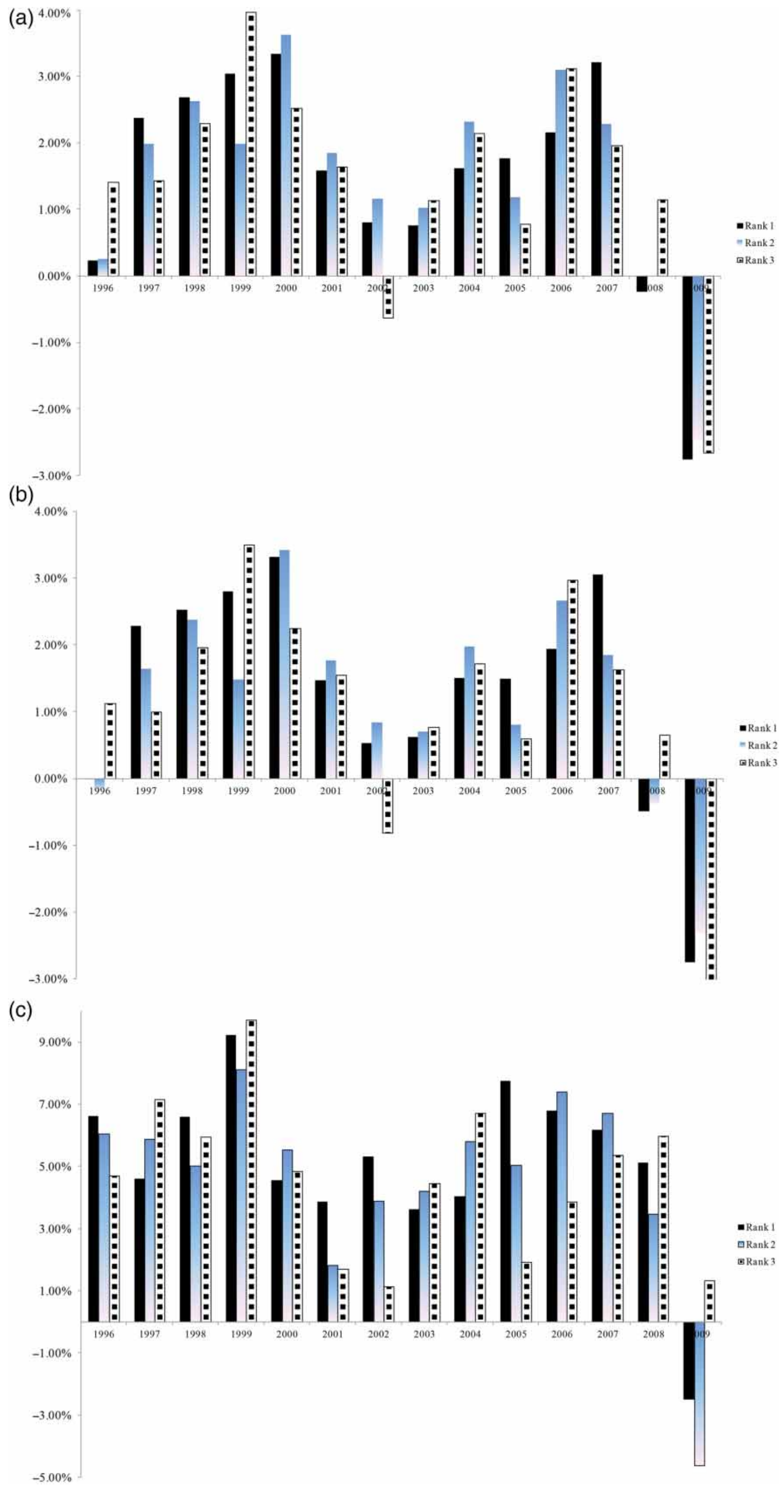

Figure 3. Annual per capita GDP growth rates, 1996–2009, by city rank.
(a) EU27. (b) EU15. (c) NMS.
Source: authors' elaboration.

Table 1. Periods observed in the data set used for the empirical analyses

Period	Label	Period observed in the dependent variable	Period observed in the explanatory variables
1995–2001	Growth	–	–
2001–2004	Slowdown	2004	Av. 1998–2002
2004–2008	Reprise	–	–
2008–2009	Crisis	2011	Av. 2002–2006

(henceforth, ALBs). ALB depend on the size of the city, measured through the absolute number of inhabitants, as most of the traditional literature developed (Catin, 1991; Marelli, 1981; Rousseau, 1995; Rousseau & Prud'homme, 1992; Segal, 1976; Sveikauskas *et al.*, 1988). In order to discern between increasing or decreasing returns to scale, a quadratic form is imposed on the ALB by introducing the square population term in the model. Moreover, networks and functions are expected to act on average benefits when they have achieved a certain critical mass of population, and this is captured by the interaction term between networks and functions, on the one hand, and population, on the other hand.

The basic model estimated therefore reads as follows:

$$\text{ALB} = \text{const} + \beta_1\text{Pop} + \beta_2\text{Pop}^2 + \beta_3\text{Pop}^*\text{Functions} + \beta_4\text{Pop}^*\text{Networks} + \varepsilon, \quad (1)$$

where "ALB" stands for average location benefit and "Pop" stands for population.

A specific indicator of net urban advantage has been used in this work, i.e. urban rent, measured through house prices per square metre.[8] Already used with the same purpose in other studies (Camagni & Pompili, 1991; Capello, 2002), this indicator is based on a crucial underlying hypothesis, i.e. that the differences in house prices between large and small cities measure their relative attractiveness (and thus their net localisation advantage), since they are the result of an evaluation made by the market of the "value" of these locations. For the same reason, the dynamics of urban house prices captures the changes in attractiveness of each location, and thus the dynamics of urban net advantage.[9]

According to this logic, urban rent is a useful indicator of advantages and costs of different urban sizes, and of the existence of an optimal city size. This latter is the size which allows the achievement of the maximum net agglomeration advantages, estimated by the market as an "equilibrium rent level". For urban areas larger than the optimal size, scale diseconomies would emerge, causing a relocation of residential and production activities, a decrease in city size and a consequent decrease in urban rent. In the same way, a city which is smaller than the optimal size would be characterised by lower rent levels, which would attract production and residential activities, causing an increase in city size and consequently an increase in urban rent.

The outperforming small- and medium-sized cities with respect to the national average have been identified, and a dummy created for them. In order to analyse specificities of the outperforming cities with respect to the average behaviour, the basic model has been estimated again by introducing the interaction terms between the independent variables and the outperforming city dummies, as follows:

$$\text{ALB} = \text{const} + \beta_1\text{Pop} + \beta_2\text{Pop}^2 + \beta_3\text{Pop}^*\text{Functions} + \beta_4\text{Pop}^*\text{networks} + \beta_5\text{Pop}^*D + \\ + \beta_6\text{Pop}^{2*}D + \beta_7\text{Pop}^*\text{Functions}^*D + \beta_8\text{Pop}^*\text{Networks}^*D + \beta_9 D + \varepsilon. \quad (2)$$

Equation (2) contains the interaction terms with D, which represents the relatively best performing cities with respect to the national average. An alternative version of model (2) entails the use of a measure of borrowed size, that aims at capturing the possibility that second-rank cities may have in fact borrowed the use of high-level urban functions and connectivity from large metro areas, irrespective of their own (relatively) small size. This implies that borrowed size partially substitutes functions and networks; if this is the case, an alternative model can be estimated, namely:[10]

$$\text{ALB} = \text{const} + \beta_1\text{Pop} + \beta_2\text{Pop}^2 + \beta_3 D + \beta_4 D^*\text{Pop} + \beta_5 D^*\text{Pop}^2 \\ + \beta_6\text{Borrowedsize} + \beta_7 D^*\text{Borrowedsize} + \varepsilon. \quad (3)$$

Before entering the estimation procedure, we present the database on which the model is estimated (Section 4.2).

4.2. *The Database*

In order to empirically test the research questions stated in Section 2, we assembled a novel data set which exploits the relatively recent release of metro area data from EUROSTAT. Table 2 summarizes the main sources of the data set assembled for the present analysis.

The European statistical institute provides in fact a detailed definition of metropolitan statistical areas in Europe. In particular, data on metro regions are based on an aggregation of NUTS3 administrative regions with at least 250,000 inhabitants, in turn based on LUZ. As such, the aim of such statistical classification is to "correct the distortions created by commuting" by "including the commuter belt around a city" (Dijkstra, 2009, p. 1).[11]

For these regions, we collected data on GDP in current prices and population from 1995 to 2009. As for the latter, because the early years (1995–2000) were missing from the data set, population in the NUTS3 regions forming metropolitan areas has been aggregated following the official EUROSTAT classification. Finally, GDP data has been deflated with the EUROSTAT country-specific deflator, to obtain GDP in constant 2005 prices (net of within-country price variations, which cannot at the present state be fully eliminated).

The data on GDP and population have been used to identify those cities that over—or underperformed with respect to the country mean (see the evidence presented in Section 3).

Next, the data necessary to estimate the models presented in equation (2) have been collected. As explained in Section 4.1, urban land rent represents our measure of average urban location benefits. Land rent is here measured with the price per square metre of an average quality apartment located in the Central Business District of each city in the sample. The data, collected for the years 2004 and 2011, have been deflated with the same country deflator used for correcting GDP price distortions, in order to refer to constant 2005 prices.

Moreover, data for high urban functions and city networks are also needed to test equation (2). For urban functions, the share of high-skilled professionals over the total population is used, from the micro database of EUROSTAT's labour force survey, aggregated at the

Table 2. The data set

Data	Indicator	Source of raw data	Years available
GDP	Constant 2005 € GDP	EUROSTAT	1995–2009
Population	Average yearly metro area population	EUROSTAT	1995–2009
Land rent	Prices of an average apartment in the city's CBD	EUROSTAT/Urban Audit, author's integration[a]	2004, 2011
High urban functions	Share of high-skilled professionals over total population[b]	Labour Force Survey	1995–2007 (average 1998–2002 and 2002–2006 have been calculated)
City networks	Number of FP 5 and 6 co-participations	CORDIS	1998–2002 (FP5) 2002–2006 (FP6)

Source: Authors' elaboration.

[a]House prices data have been integrated through single national sources.

[b]High-level functions are defined as the ISCO 88 category 1, encompassing "legislators, senior officials and managers". Micro data have been aggregated at NUTS2 level, and the value of the NUTS2 region is assigned to the metro area. A full list of ISCO professions is available at http://laborsta.ilo.org/applv8/data/isco88e.html.

NUTS2 level (see Table 1 for details). In order to measure urban networks, the approach used in Camagni *et al*. (2013) has been followed and urban networks are measured by the number of Framework Programme (henceforth, FP) 5 and 6 projects in which institutions of each surveyed city participated.[12] This indicator has the advantage of capturing collaborations and exchange of knowledge, irrespective of the geographical distance between network nodes. As such, they represent a good proxy for the capability of a city to engage in long-distance networks aiming at fostering scientific cooperation, and represent a comprehensive measure of the quality and thickness of external urban networks (Basile *et al*., 2012, p. 710).

Finally, borrowed size (viz. the accessibility of second-rank cities to functions and networks typical of large urban areas) is calculated as the population in first-rank urban areas discounted by distance from each second-rank city. Borrowed size (equation (3) above) is therefore defined as:

$$\text{Borrowedsize}_i = W\overline{\text{pop}} = \sum_{j=1}^{n} \text{pop}_j w_j, \quad \forall j \neq i, \tag{4}$$

where i and j represent respectively second- and first-rank cities, W is an nXn distance weight matrix between second- and first-rank cities (each entry in the matrix is equal to 0 if the two cities are second-rank or first-rank cities and equal to the inverse of the geographical distance in kilometres if the two cities are cities one of second- and one of first-rank), and $\overline{\text{pop}}$ represents the vector of first-rank city populations.[13]

5. An Interpretative Model of Urban Structural Dynamics of Small- and Medium-Sized Cities

5.1. *Outperforming Cities: Do Agglomeration Economies Play a Role?*

Table 3 reports the results of the estimates for the empirical model, and for equation (2). The results are presented in columns 1–4 for the second-rank cities of Western countries.

Table 3. Estimation results (random effects)

Dep. variable Model	Average urban benefits (Log urban rent) (1)	(2)	(3)	(4)
Constant term	−3.38	−0.72	−46.51	−40.42
	(27.12)	(22.52)	(29.62)	(28.87)
Metro area population	1.38	1.17	7.84*	7.06*
	(3.97)	(3.30)	(4.36)	(4.23)
Metro area population^2	−0.04	−0.04	−0.28*	−0.26*
	(0.14)	(0.12)	(0.16)	(0.16)
D (outperforming second-rank cities)	0.06	–	55.78*	51.29*
	(0.06)		(33.05)	(32.60)
D × metro area population	–	–	−8.47*	−7.76*
			(4.86)	(4.80)
D × metro area population^2	–	–	0.32*	0.30*
			(0.18)	(0.18)
Functions	–	0.33***	–	–
		(0.04)		
Networks	–	0.02	–	–
Functions × metro population	–	–	–	0.02***
				(0.001)
D × functions × metro population	–	–	–	0.01*
				(0.00)
Networks × metro population	–	–	–	0.003*
				(0.00)
D × networks × metro population	–	–	–	−0.004
				(0.003)
Number of obs.	158	158	158	158
Wald chi-square	6.51*	80.85***	27.20***	324.96***
Breusch–Pagan test (OLS vs. RE)	15.82***	7.05***	16.78***	7.01***
	(0.00)	(0.00)	(0.00)	(0.00)
R-squared (within)	0.07	0.29	0.13	0.37
R-squared (between)	0.04	0.43	0.06	0.44
R-squared (overall)	0.04	0.39	0.07	0.42
Robust standard errors	Yes	Yes	Yes	Yes

Notes: All variables are in log. Dependent variable: average urban benefits (Log urban rent). Functions and networks variables are expressed in logs.
Abbreviation: D—outperforming second-rank cities.
*Significance at 1%.
**Significance at 5%.
***Significance at 10%.

In fact, the model does not interpret the behaviour of all second-rank cities in Europe, testifying that Eastern European second-rank cities have still a very peculiar dynamics that has no similarities to those of advanced countries (see Section 3 for descriptive figures).

The results in columns 1–4 are obtained with random effects estimates. Fixed effects for single cities are conceptually refused in this exercise; besides, OLS estimates are statistically rejected, with the standard Breusch–Pagan test suggesting the appropriateness of random effects. Peculiarities for single cities in exploiting agglomeration advantages that do not depend on size, functions and networks neither exist, nor are expected to play a role. Also for western second-rank cities, the fit of the model is good (overall $R^2 = 0.42$).

The first column shows that the inverted U-shaped curve of the location benefit curve does not hold for the whole sample of second-rank cities in western countries, and the result does not change when functions (significant in absolute terms) and networks are added. Column 3 instead presents interesting results. When the size of the city is multiplied with a dummy representing the best outperforming second-rank cities, results become significant; while non-performing cities register a traditional inverted U-shaped form, implying an achievement of a threshold in terms of size-up to which decreasing returns are at work, fast-growing second-rank cities register decreasing returns up to a certain critical size, at which they start enjoying increasing returns. Lastly, column 4 shows the estimates for our conceptual equation (2); with the exception of the networks in outperforming large cities, the coefficients have significant and expected signs.[14]

Results are also presented in Figures. Figure 4 reports the ALB curve with respect to size. Many interesting messages are contained in this figure, namely:

- for the general sample, the curve shows an inverted U-shape relationship (the continuous curve in Figure 4). An optimal size exists, after which economies of agglomeration turn into diseconomies, and this is true also for small- and medium-sized cities, as expected according to our first assumption;
- when only the outperforming cities are analysed (dotted line in the figures), the ALB curve displays a U-shaped form, showing that increasing returns in size characterize best performing cities, i.e. agglomeration economies are associated with outperforming cities;
- outperforming cities turn diseconomies of scale that characterize cities of their size in the sample into economies, by increasing the level of functions; as Figure 4 shows, second-

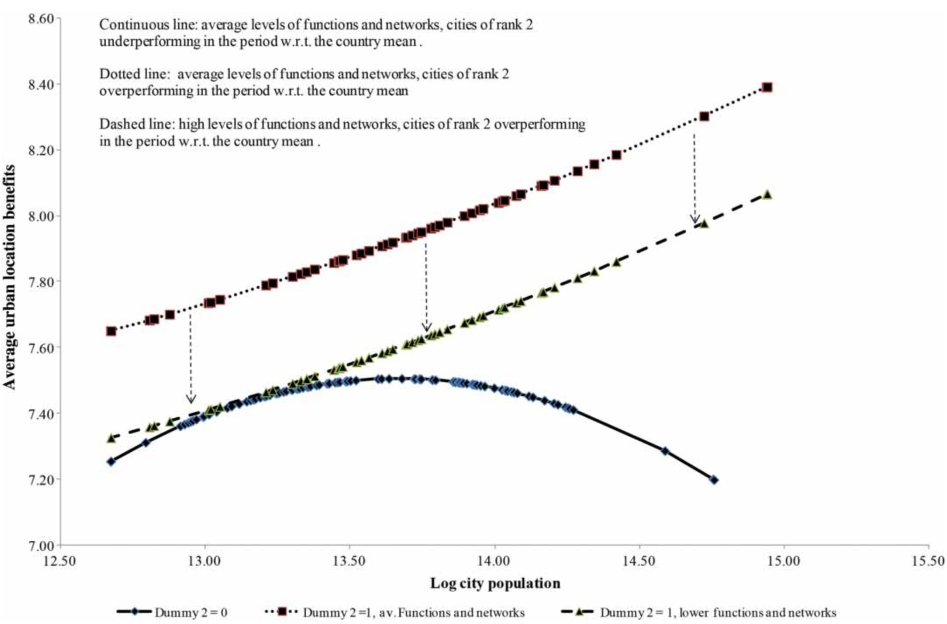

Figure 4. Average urban location benefit curve for second-rank cities.
Source: authors' elaboration.

Table 4. Optimal city size, critical size and level of functions for second-rank cities

Optimal city size (no. of inhabitants) (maximum point of the benefit curve function)	714,973
Critical size of outperforming cities turning diseconomies into economies of agglomeration (minimum point of the benefit curve function of outperforming cities)	296,559
Share of advanced functions and critical size necessary to outperforming cities to achieve the same level of urban benefit than the other cities	7.5% At a size of 545,000

Source: Authors' elaborations.

rank outperforming cities manage to achieve the bifurcation point from the average sample for lower levels of functions than first-rank cities (dashed line);

- higher intensities of high-value functions would shift the average location curve (as indicated for instance by the dotted line in Figure 4). This means that higher functions produce, ceteris paribus, higher location advantages.

Table 4 reports the optimal city size, the critical size at which, for outperforming cities, diseconomies turn into economies and the level of high functions necessary to achieve the same level of urban benefits of the other cities. Optimal second-rank city size is achieved at around 700,000 inhabitants, and requires a critical size of around 300,000 inhabitants.

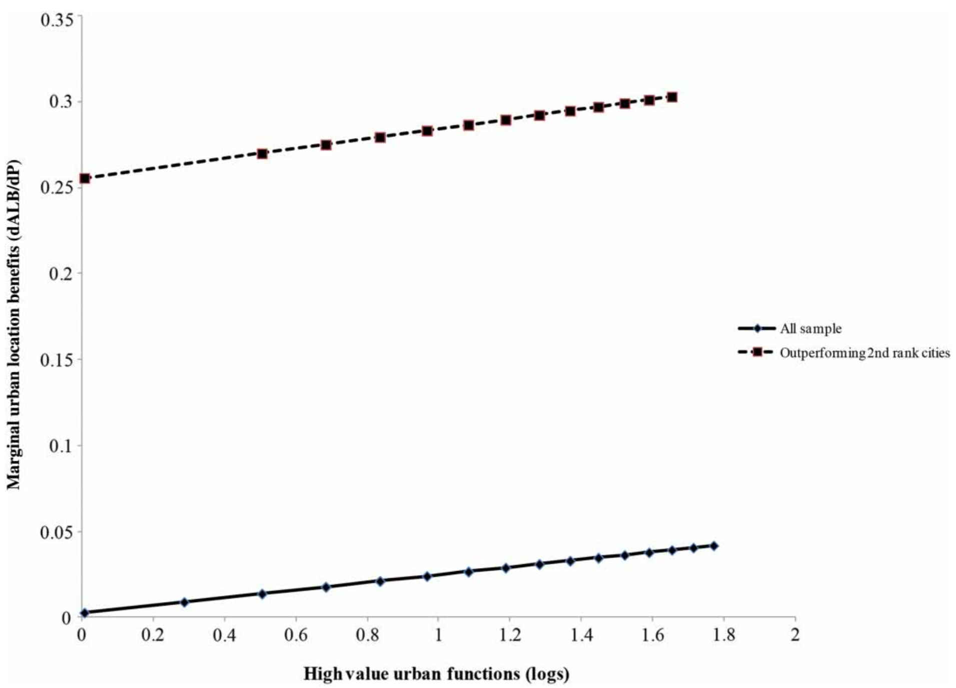

Figure 5. Marginal urban location benefits at different levels of high-value urban functions. *Source*: authors' elaboration.

As a final consideration, second-rank cities need 7.5% of employment in high-level functions and a size of 545,000 inhabitants. Therefore, small cities require a low intensity of high-level functions and a low size to gain increasing returns, as the SOUDY model theoretically explains.

Our second hypothesis has been confirmed. Outperforming cities are the ones that are able to turn decreasing returns to scale into agglomeration economies. Moreover, increasing returns of outperforming cities are associated with higher-level functions.

5.2. *Exploitation of Agglomeration Economies: Do Functions Play a Role?*

The role of high-value functions in increasing the ALB curve has been presented in Figure 4. Our interest in this part of the analysis is to show if functions determine the intensity of agglomeration economies (Figure 5).[15]

Figure 5 is helpful in this respect. It shows the way in which marginal location benefits change by increasing the high-value functions. For second-rank outperforming cities the

Table 5. Estimates of borrowed size

Model	(1)	(2)	(3)
Constant term	−46.51	−59.32*	−49.95
	(29.62)	(31.48)	(31.03)
Metro area population	7.84*	9.48**	8.27*
	(4.36)	(4.54)	(4.49)
Metro area population^2	−0.28*	−0.34**	−0.30*
	(0.16)	(0.17)	(0.16)
Dummy rank 2 city outperfomed the country	55.78*	62.10*	44.09*
	(33.05)	(33.09)	(30.13)
Dummy rank 2 city outperfomed the country × metro area population	−8.47*	−9.40*	−7.24*
	(4.86)	84.87)	(4.50)
Dummy rank 2 city outperfomed the country × metro area population^2	0.32*	0.36**	0.28*
	(0.18)	(0.18)	(0.16)
Borrowed size	–	0.12	0.04
		(0.11)	(0.10)
Rank 2 city outperfomed the country × borrowed size	–		0.25*
			(0.15)
Number of obs.	158	158	158
Wald χ^2 test	4.16***	30.15***	36.19***
Breusch–Pagan test (OLS vs. RE)	16.78***	16.90***	18.01***
	(0.00)	(0.00)	(0.00)
R-squared	0.07	0.07	0.07
Within	*0.13*	*0.15*	*0.18*
Between	*0.06*	*0.06*	*0.06*
Robust standard errors	Yes	Yes	Yes
Estimation technique	RE	RE	RE

Notes: All variables are in log. Dependent variable: average urban benefits (Log urban rent). Standard errors are in parentheses.

Abbreviation: RE—random effects estimates.

*Significance at 1%.

**Significance at 5%.

***Significance at 10%.

role of functions in marginal urban benefits is high, but the intensity of the effect (the slope of the line) remains constant as the intensity of functions increases.

5.3. *Exploitation of Agglomeration Economies: Does Borrowed Size Play a Role?*

In this section, the empirical analyses presented above are complemented with a specific analysis of the role of the cities' capability of borrowing size from nearby large metro areas in fostering agglomeration economies. Table 5 shows the estimates of the baseline model, which, for convenience, is repeated in column 1, and of the model in eq. (3), which encompasses borrowed size (column 2) and the interaction term between borrowed size and the dummy for outperforming second-rank cities (column 3).

As anticipated in Section 4, Table 5 presents results where high-level urban functions and city networks are substituted by borrowed size. The results suggest that, after controlling for the other main determinants of location benefits, while borrowed size does not suffice to allow higher benefits (column 2), it acts as a catalyst for second-rank cities that outperformed with respect to the country mean (column 3). Thus, the hypothesis is that such cities can actually borrow functions and networks located in large urban areas, but without incurring the costs typically associated with locations in large urban areas.

This finding can be further evidenced graphically. This is done in Figure 6, where ALBs are plotted against the measure of borrowed size, along with confidence intervals calculated for the quintiles of borrowed size distribution.

Figure 6 suggests that indeed as second-rank cities can increasingly get access to the functions and networks hosted by large metro areas, their ALB increase even if those func-

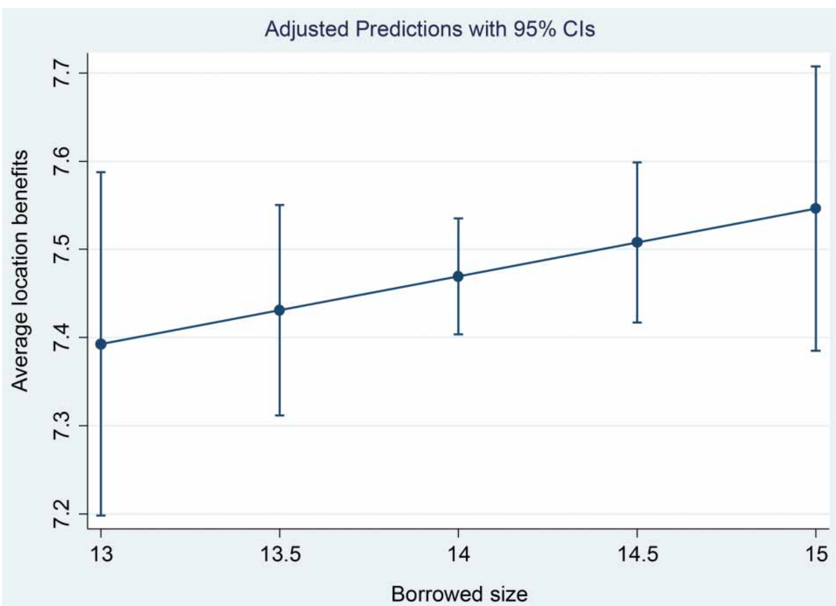

Figure 6. Marginal location benefits as borrowed size increases.
Source: authors' calculations.

tions and networks are not located within the city itself. This interesting finding paves the way for possible future research aiming at explaining the conditions for such polycentric urban structure to emerge and succeed. In fact, it could be argued that other characteristics of urban systems influence the capacity of a second-rank urban areas to profitably benefit from being close to large metro areas.

6. Conclusions

By entering the debate on the reasons for the recent relatively better performance of second-rank cities with respect to first-rank ones on the national dynamics, the present work has been able to demonstrate that some general common beliefs on the determinants of urban growth are too simplistic.

The success of cities is generally attributed to the existence of agglomeration economies and, by the same token, the urban decline is explained by the loss of increasing returns when a city achieves an excessive size. Starting from existing theoretical approaches, this paper proves that the existence of agglomeration economies is undeniable, as well as the risk of agglomeration diseconomies. However, as theoretically suggested, this paper empirically shows that cities are able to overcome diseconomies of scale either through innovating in the functions that they perform, or in the organization of activities with other cities, through city networking. Besides, such a finding is complemented by the empirical verification that cities can "borrow size" from neighbouring large metro areas, thus getting access to the functions and networks there hosted, without incurring high location disadvantages.

In fact, our empirical study has shown that outperforming cities are the ones that are characterized by economies of scale, and that these economies of scale are related to the level of functions and networks that cities have or, in other words, their capacity to borrow size from large metro areas.

These results have important urban policy implications. Concerning the recent question raised whether in a period of crisis like the present one, policy-makers should concentrate their limited resources in their large cities in order to exploit agglomeration economies, or spread their investment in a larger set of cities, the reply comes very easily after the results of this exercise. Investment should be devoted to cities in order to make any of them, irrespective of their size, be able to turn their risk of decreasing returns into agglomeration economies, by investing in renovating their functions and their way of cooperation.

Notes

1. An alternative way to explain the efficiency of second-rank cities goes through the role of size borrowing from nearby large metro areas, hosting high-level functions and being connected in transnational networks, as suggested in Alonso (1973). See Camagni *et al*. (2013).
2. More details on the empirical approach to the definition of urban rank and the relative performance of second-rank cities with respect to larger metro areas in the last 15 years are provided in Section 3.
3. Richardson (1972) suggests replacing the concept of optimal city size with an efficient interval of urban size in which urban marginal benefits are greater than marginal location costs.
4. The two cities will differ, though, in dynamic terms: the one belonging to the lower rank 1 will not grow further, having reached the maximum size of its interval, while the one having developed the higher functions (linked to rank 2) will grow, due to the presence of new and wide net urban benefits (profits).

5. Camagni (1993) theorised the concept applying it to urban systems. The same concept was already utilised in other fields, such as the behaviour of the firm and microeconomic organisational behaviour. For a review of the concept, see Capello and Rietveld (1998).
6. In another paper, the same authors show that these features are common to cities of different size, demonstrating that cities grow according to the same structural laws, but with some specificities (Camagni *et al*., 2013).
7. For this reason, in the empirical analysis (Section 5), rank 2 cities will only be analysed in EU15 countries. The trends above discussed allow the identification of four periods within the 1995–2009 time span observed in this paper.
8. Urban rent is usually interpreted as the rent paid to the house owner. However, house prices represent the capitalized rent over time, and for this reason may be chosen as a proxy for urban rent.
9. In dynamic terms, the reasoning requires another important hypothesis. Since the analysis is developed in relative and not absolute terms, between different cities or between core and ring areas, it is assumed that for each relative dimension (large vs. small cities, ring vs. core), the supply curve of houses has the same slope. If this were not the case, a shift upwards of the demand curve, generated by a higher appreciation of location advantages, would give rise to a different increase in prices. This hypothesis does not limit too much the comparison between large and small cities, but could give a heavy bias in a comparison between core and ring areas because of the different potential for the expansion of residential supply in the two areas.
10. Interestingly enough, when a measure for borrowed size is inserted in our estimated model, multicollinearity exists among borrowed size from one side, and functions and networks on the other.
11. A full list of cities surveyed in this paper is available in the appendix.
12. Clearly, this indicator represents only a subset of all possible ways of transnational networking for the surveyed urban areas, and in particular refers to a scientific type of connectivity (thus reflecting an innovation-oriented type of knowledge being exchanged via these connections). However, this is perfectly in line with the scope of this analysis, and fits much better the aims of the empirical work here presented, rather than the use of more classical (and geographically based) networks of physical accessibility.
13. The bar notation indicates a vector.
14. The non-interacted variables "networks" and "functions" have not entered this equation; lacking degrees of freedom, we preferred to keep the specification that is conceptually the most interesting for us.
15. Networks turned out to be insignificant, and for this reason they are not treated in this part. Their role will be highlighted when a diachronic analysis is developed. See Section 5.3.

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Appendix. Details on the database

The database for the empirical analyses in this paper comprises the following 100 metro areas:

Århus, Aalborg, Aberdeen, Antwerpen, Arnhem, Augsburg, Bari, Belfast, Bilbao, Bologna, Bordeaux, Bremen, Bristol, Brno, Bydgoszcz, Caen, Cagliari, Cardiff, Charleroi, Clermont-Ferrand, Cluj-Napoca, Craiova, Czestochowa, Dijon, Dresden, Edinburgh, Eindhoven, Enschede, Erfurt, Exeter, Firenze, Freiburg im Breisgau, Gdansk, Genova, Gent, Graz, Groningen, Göteborg, Göttingen, Halle an der Saale, Hannover, Karlsruhe, Kiel, Kielce, Kingston-upon-Hull, Koblenz, Kosice, Kraków, Palmas/Sta. Cruz de Tenerife, Lefkosia, Leicester, Lille, Linz, Liverpool, Liège, Luxembourg, Lódz, Malmö, Maribor, Montpellier, Murcia, Nancy/Metz, Nantes, Napoli, Newcastle upon Tyne, Nottingham, Nürnberg, Ostrava, Oviedo, Palermo, Palma de Mallorca, Pamplona/Iruña, Plovdiv, Plzen, Porto, Portsmouth, Poznan, Regensburg, Rennes, Riga, Rostock, Santander, Sevilla, Sheffield, Stoke-on-Trent, Strasbourg, Szczecin, Tallinn, Tampere, Thessaloniki, Timisoara, Toulouse, Turku, Valencia, Valletta, Varna, Venezia, Vilnius, Wroclaw, Zaragoza.

Data encompass two observations per city, with the time coverage described in Section 4.