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Metropolisation, policentricity and urban size[1]

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Abstract

In this paper we link the neoclassical and regional science perspectives on urban performance. We set up a simple model based on the assumption of spatial equilibrium, and we find predicted optimal city sizes in a sample of 59 EU27 Functional Urban Areas in the period 1989-2010. The model allows us to predict future expected growth patterns for the cities in the sample.

Besides, we go beyond the notion of optimal city size, and test a set of additional explanations for urban overload, including metropolisation, polycentric development, city network effects, and agglomeration. We find strong evidence that cities more embedded in international scientific networks, with a richer endowment with control and power functions and characterized by a denser urban structure are on average larger. Finally, we verify that, ceteris paribus, cities hosting administrative power functions are also on average characterized by a larger size.

Keywords: urban growth, metropolisation, polycentricity.

JEL classification codes: O18, R11, R12.

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"Things have certainly changed around here. I remember when this was all farmland as far the eye could see".

1. Introduction

For centuries the fundamental questions "Why do cities exist?" and "What are the determinants of urban performance?" have been asked. Economists now enjoy a rich set of theories aiming at explaining the strikingly increasing concentration of people in urban areas. Figure 1 shows for instance that the percentage of EU27 citizens living in cities rose to slightly less than three-quarters of the total population; this increase has been equally matched by a simultaneous concentration of European citizens in large urban agglomerations.[2]

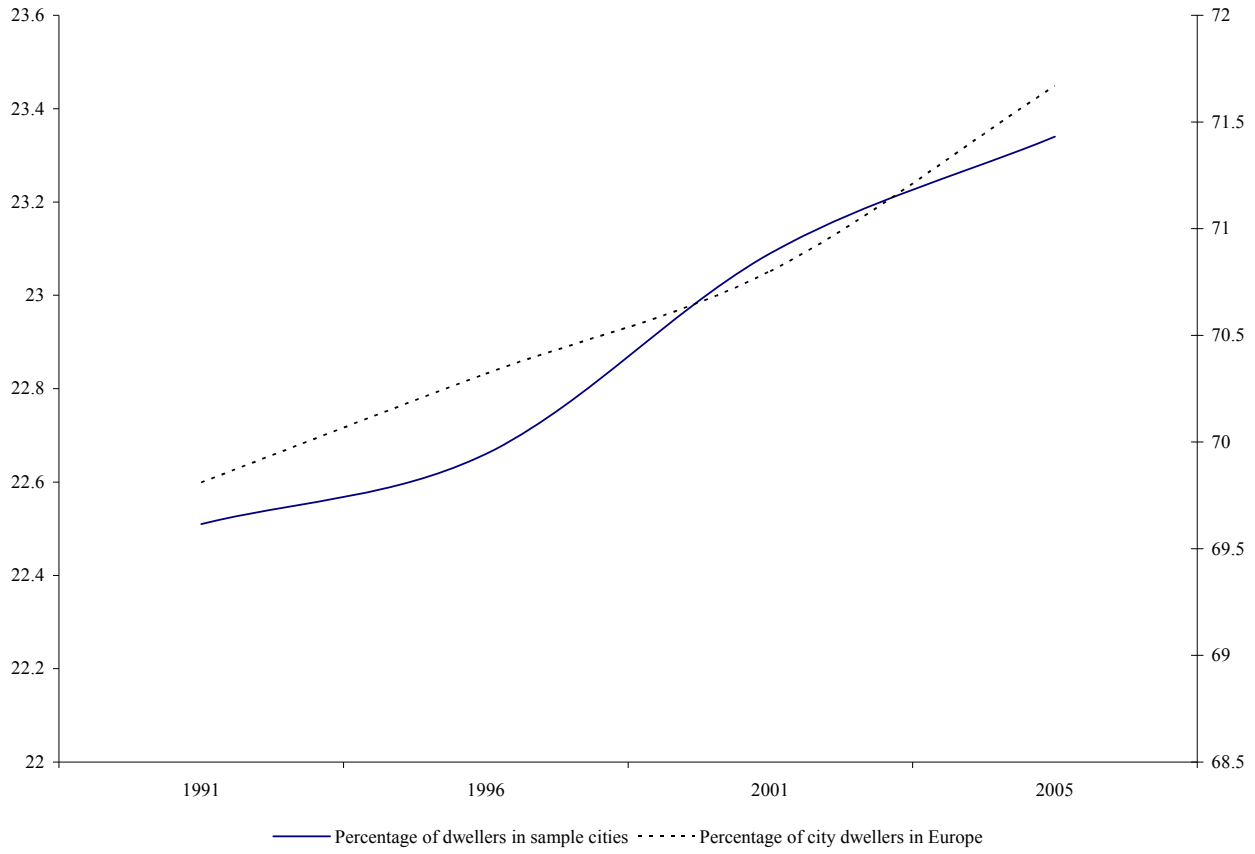


Figure 1. Metropolisation in the EU27.
Source: authors' calculation. Raw data from Urban Audit and UN's World Urbanization Prospect 2009.

This concentration of people and firms in large urban areas changes the form of the environment, and pushes most urban areas towards incorporating significant shares of the green space around them. However, such process of increasing concentration is simultaneously matched by a lasting validity of a hierarchical structure, with large cities cohabiting with smaller centres, much as predicted in classical location theories (Christaller, 1933; Lösch, 1954); stylized facts suggest that the urban system is slowly polarizing with the emergence of larger and larger urban agglomerations of skilled labour, characterized by a wealth of amenities, along with a process of stagnation of medium-small urban centres.

In this paper we address simultaneously the fundamental questions above mentioned, and tackle at the same time the issue of the reasons of existence of cities, as well as the determinants of their sizes. To this aim, we first critically and briefly review some highlights of the rich literature

[T]The continuous line represents the total population living in the 59 cities on which the empirical analysis in this paper is run. For a complete list of such cities, see Appendix 4.

preceding this paper (Section 2); next, we set down a theoretical model capable of predicting different (optimal) city sizes, on the basis of city-specific costs and benefits (Section 3); then, in Section 4 we describe the data set assembled to test our model. Section 5 shows the results of the empirical validation of the model, while finally Section 6 concludes.

2. Literature review

2.1 Traditional views on cities

Cities attracted only relatively recently the interest of economics. Most often, theories and models analyze the way cities work, how the land rent generates and is regulated by market forces, the effects of agglomeration economies on urban performance, and so on. All such theories agree on the primacy of the object "city" in terms of the spatial organization of economic activities.

Cities are also complex to manage; this is probably why no proper "urban agglomeration" ever existed before the invention of agriculture (Bairoch, 1988).[3] In this Section we offer a brief and critical overview of the wealth of theories aiming at explaining why cities exist in the first place, and which factors explain best their performance over time. For a comprehensive review of the rich set of theories being here summarized, the reader may resort on Nijkamp and Mills (1986), and Capello and Nijkamp (2004).

Apparently the main reason for the emergence of cities can be synthesized in the benefits stemming from agglomeration. As forces exist exerting centripetal and centrifugal forces on economic activities, some benefit has to prevail in the former, which has been variously declined over time:[4]

- Localization economies, best known as "Marshallian economies" (Marshall, 1920), which can in turn be synthesized as encompassing:
    - A thick labour market, with easier contacts between employers and potential employees;
    - An industrial atmosphere, providing a fertile soil for the emergence of start-ups, and a better environment for their success;
    - The possibility to share costly common production factors.
- Economies related to the industrial structure of the city, and in particular:
    - Urbanization economies, i.e. reductions of production costs due to the possibility of firms and individuals to share the costs of public intervention, to create a large common market, and to exploit the city as an incubator of production factors (Camagni, 1993);
    - Diversity (Jacobian) economies, stating that agglomerations of people working in technologically different industries would be more creative;
- Learning economies, or more precisely, localized knowledge spillovers, due to the decay process affecting what is traditionally known as "tacit knowledge (Polanyi, 1966; Bathelt et al., 2004)". The crucial relevance of this last set of theories, in particular in a world where pure geography seems to matter less, is advocated Capello (2010).

Moreover, structural views have been developed also on the way cities are organized internally as well as externally. Internally, cities based on market systems are regulated with the rent mechanism

[3] This view has nevertheless been famously contested by Jacobs (1969), where the birth of cities is assumed to precede the invention of agriculture.
[4] In this paragraph we follow the classification first proposed by Rosenthal and Strange (2004).

(whereas activities with a higher willingness to pay for a higher accessibility are assigned locations closer to the Central Business District). Internal traffic flows and external connections of a city have been successfully described with gravitational models (Zipf, 1949), while external relations of cities have been modeled with hierarchical theories (Christaller, 1933; Lösch, 1954).

This theoretical body has been matched by an equally impressive array of empirical estimates, mostly confirming the validity of these assumptions on the rationale for agglomerative behaviour. However, more recently a new stream of studies has focused the attention of academics and policymakers on more subtle, yet insightful, reasons why people decide to agglomerate in the first place, and then which additional, other than pure hierarchical or gravitational, factors rule the urban system we live in. This second wave of studies is summarized in the next Section.

2.2 Beyond traditional views

Recently different views on the structure of urban systems and the reasons for urban performance have emerged. Among the most influential, we review here the effects of policentricity, metropolisation and density.

Policentricity *"occurs when the system is characterized by several cities at different levels rather than just being dominated by one city*" (ESPON 2004, p. 17). Within the POLYCE project, and following previous work carried out in other ESPON projects, policentricity is defined in three, not entirely mutually exclusive, ways, depending on the spatial scale at which polycentric urban structure is looked at, which in turn relates to the type of definition underlying the final measure (Table 1):

Table 1. Definitions of policentricity according to the POLYCE project.

Spatial scale	Micro	Meso	Macro
Definition of policentricity	Presence of multiple job centres within the Metropolitan Region	Ratio of wealth production within the FUA w.r. to lower rank areas outside the FUA	Openness of the metropolitan area to external relations (i.e., urban networks[5])
Type of policentricity	Structural	Morphological	Relational

In this paper, we review the impact on urban efficiency of the second and third definitions of policentricity, as these indicators are believed to provide diversified and equally relevant impacts on urban efficiency. However, future work may include a measure of the first kind of policentricity.

A second interesting and massive process is referred to as "metropolisation". This process, both morphological as well as functional, is in fact a way to describe the spatial organization being increasingly centered around large cities (Elissalde, 2004; Leroy, 2000). In this paper we focus on the second definition of metropolisation, which is strongly connected with the work described in Sassen (2002).

A third element here taken into account related with the positive effects of pure density. In fact, agglomerative forces as summarized above in Section 2.1 imply more indirect effects. A relatively recent wave of quantitative assessments found that pure density may explain up to half the total variance of half of the variance of output per worker (Ciccone and Hall, 1996). These positive effects may be best conceived as the reduced spatial impedance in a dense and agglomerated area, which is expected to raise the levels of competition, thus fostering productivity increases.

Finally, we dig into the notion of sprawl and verify whether, as mostly expected in the urban literature, a compact urban form contributes to a more efficient allocation of economic resources

[5] This argument is made, among others, by Meijers (2005).

within metropolitan areas, thus in turn fostering – once again – productivity increases, and allowing cities to reach on average a larger size (Camagni et al., 2002). Besides, we verify the assumption that, *ceteris paribus*, cities hosting relevant administrative power functions (i.e., being the capital of the country) may on average enjoy a large size.

Both traditional and recent work on urban performance leads us to the fundamental question on this work package:

RQ. What are the determinants of equilibrium city size?

This research question will be answered by setting up a simple urban growth model (Section 3), which will be tested on a sample of 59 European Metropolitan areas. The data set we assembled to estimate our model is described in Section 4, while empirical results are summarized in Section 5.

3. The model

In order to answer the research question previously introduced, we set up a simple urban growth model which provides the framework for our empirical analyses. The model is rooted in the literature summarized in chapter 5 in Fujita (1989), and moves from the work in Capello and Camagni (2000).

We start by assuming the following implicit urban cost and benefit functions:

$$C = f\left(size, rent, sprawl, malaise\right) \tag{1.}$$

and

$$B = f\left(amenities, humancapital, diversity, size\right) \tag{2.}$$

The choice of the arguments for the costs and benefits function is based on the literature summarized in Section 3. In particular, the literature usually finds a non-compact urban form to represent a cost for dwellers (e.g. Jacobs, 1961; with however a notable exception in Glaeser and Kahn, 2004), and equally identifies in a general distress effect the possible consequence from over-concentration of people in large urban areas. This last cost to agglomeration is here labeled as "malaise".

On the benefit side, we include as arguments the quality of urban amenities (Carlino and Saiz, 2008), human capital (in line with the learning economies assumption summarized in Section 2 (see for instance Black and Henderson, 1999), and sectoral diversity (Jacobs, 1969).

Notice that in both equations we assume that urban size represents both a cost as well as a benefit for the city. Size is therefore a dual concept, representing a joint source of positive as well as negative externalities for city dwellers; this assumption is the key to solve the model and obtain an estimable function.

We choose to adopt a standard Cobb-Douglas specification for both function. This specification is more tractable than most others, while also enabling us to avoid the implausible assumptions about the elasticity of the function's arguments (Uzawa, 1962).

Equations (1.) and (2.) therefore, become, respectively:

$$C = size^{\alpha} rent^{\beta} sprawl^{\gamma} malaise^{\delta} \tag{3.}$$

and

$$B = amenities^{\zeta} humancapital^{\eta} diversity^{\vartheta} size^{\kappa} \tag{4.}$$

We also assume, in order to increase the tractability of the model and without losing generality, that all cost and benefit coefficients are bounded in the interval (0,1), but the size parameter in the cost

function, which, à la Alonso, is larger than one in absolute value, reflecting an exponentially increasing cost function.

Notice that both equations are well-behaved with respect to city size. In fact, we assume that urban costs are increasing in city size, more than proportionally; conversely, we assume that urban benefits are increasing with city size, but less than proportionally. Analytically, this implies the following conditions:

$$\frac{\partial C}{\partial size} = \alpha size^{\alpha-1} rent^{\beta} sprawl^{\gamma} malaise^{\delta} > 0,\ \frac{\partial "C}{\partial size"} = \alpha(\alpha-1) size^{\alpha-2} rent^{\beta} sprawl^{\gamma} malaise^{\delta} > 0 \qquad (5.)$$

and

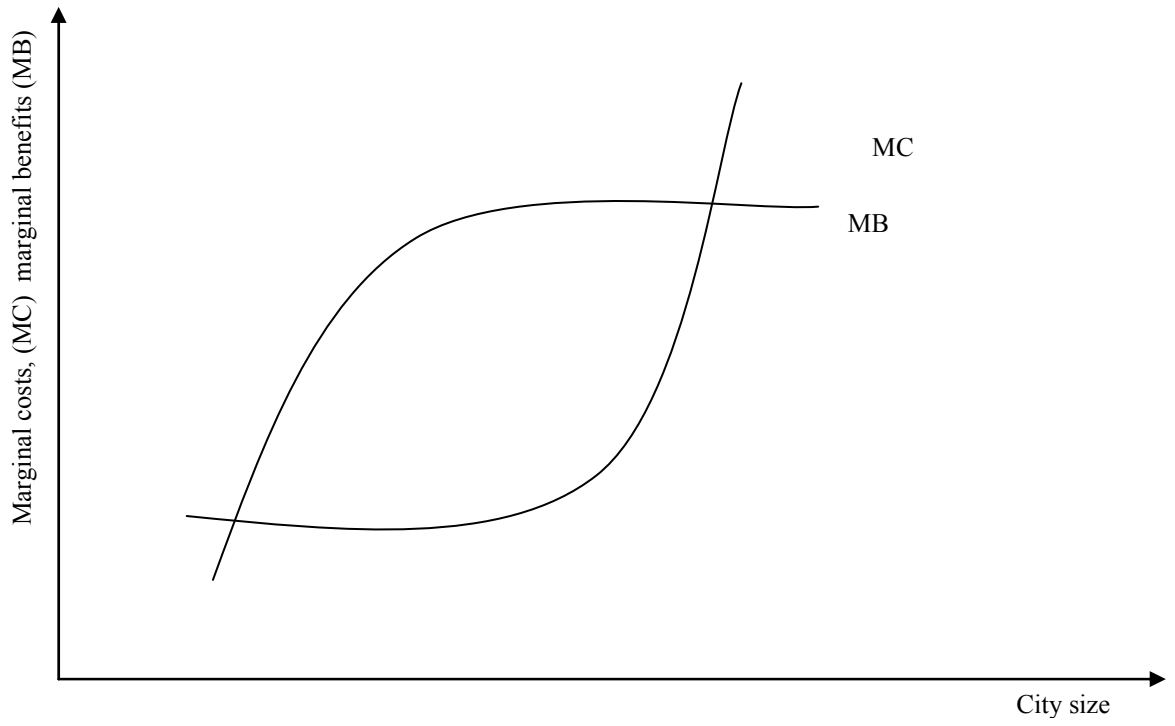
$$\begin{aligned} &\frac{\partial B}{\partial size} = \kappa amenities^{\zeta} humancapital^{\eta} diversity^{\vartheta} size^{\kappa-1} > 0, \\ &\frac{\partial "B}{\partial size"} = \kappa(\kappa-1) amenities^{\zeta} humancapital^{\eta} diversity^{\vartheta} size^{\kappa-2} < 0 \end{aligned} \qquad (6.)$$

For the model to be sustainable, the α and κ parameters must be different, so that the costs and benefit curves cross each other, thereby allowing an equilibrium to exist.

The way we close the model is to assume spatial equilibrium across the analyzed urban system. In other words, as people can freely move across space in order to look for better living conditions (in other words, they can look for cities characterized by higher benefits or lower costs).

Therefore, in order to be in equilibrium, the urban system must satisfy the condition in which marginal costs equal marginal benefits (MC=MB). This condition is represented in Figure 2.[6]

Figure 2. Marginal costs and marginal benefits for city size.



Analytically, this implies the following condition:

[6] As Figure 2 shows, the equilibria may actually be two, with the first being not sustainable, since to its right the marginal benefit curve remains above the marginal cost one.

$$\frac{\partial C}{\partial size} = \alpha size^{\alpha-1} rent^{\beta} sprawl^{\gamma} malaise^{\delta} = \frac{\partial B}{\partial size} = \kappa amenities^{\zeta} humancapital^{\eta} diversity^{\vartheta} size^{\kappa-1} \quad (7.)$$

which in turn implies

$$\frac{size^{\alpha-1}}{size^{\kappa-1}} = \frac{\kappa}{\alpha} \frac{amenities^{\zeta} humancapital^{\eta} diversity^{\vartheta}}{rent^{\beta} sprawl^{\gamma} malaise^{\delta}} \quad (8.)$$

that is

$$size^{\alpha-\kappa} = \frac{\kappa}{\alpha} \frac{amenities^{\zeta} humancapital^{\eta} diversity^{\vartheta}}{rent^{\beta} sprawl^{\gamma} malaise^{\delta}} \quad (9.)$$

Eq. (9.) can be log-linearized in order to obtain an estimable function. This process yields to the following functional form:

$$\begin{aligned}(\alpha-\kappa)\ln(size) = \ln\left(\frac{\kappa}{\alpha}\right) + \zeta \ln(amenities) + \eta \ln(humancapital) + \vartheta \ln(diversity) + \\ -\beta \ln(rent) - \gamma \ln(sprawl) - \delta \ln(malaise)\end{aligned} \quad (10.)$$

and finally

$$\begin{aligned}\ln(size) = \frac{\ln\left(\kappa/\alpha\right)}{(\alpha-\kappa)} + \frac{\zeta}{(\alpha-\kappa)} \ln(amenities) + \frac{\eta}{(\alpha-\kappa)} \ln(humancapital) + \frac{\vartheta}{(\alpha-\kappa)} \ln(diversity) + \\ -\frac{\beta}{(\alpha-\kappa)} \ln(rent) - \frac{\gamma}{(\alpha-\kappa)} \ln(sprawl) - \frac{\delta}{(\alpha-\kappa)} \ln(malaise)\end{aligned} \quad (11.)$$

Eq. (11.) is the basis of our analyses.

The model in eq. (11) can be drawn for simplicity in a linear fashion (Figure 3). Notice that the variables entering the model are those traditionally devised in the literature as the substantial determinants of urban performance.

However, in this work package we bring together traditional and modern theories on urban performance, by letting measures of policentricity, metropolisation, density and sprawl in the model as "vertical shifters" of the benefit function (vertical arrows in Figure 3). This point will be discussed further in Section 5.

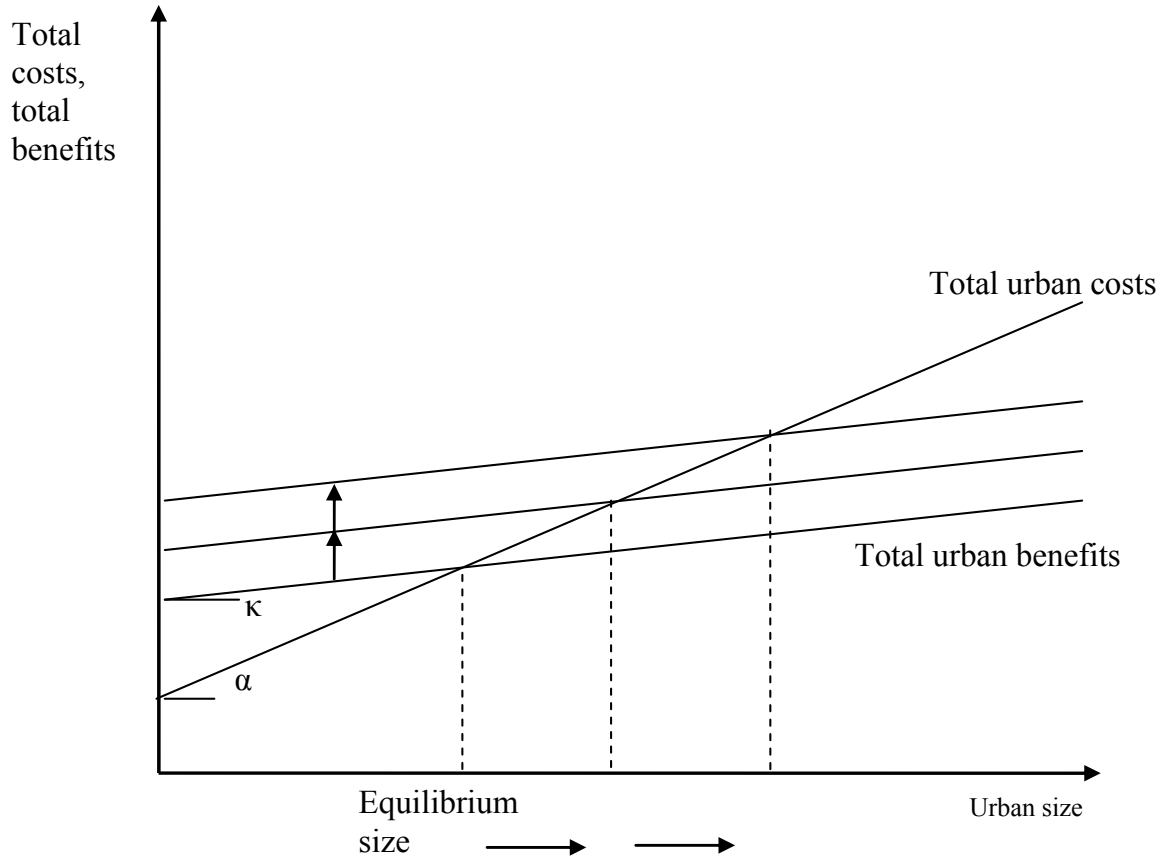


Figure 3. A linearized version of the model in eq. (10).

4. The data set

Our empirical test of the model in eq. (10) is based on a set of 59 Larger Urban Zones, EUROSTAT's definition of the concept of a Functional Urban Area. This choice is mainly motivated by data availability, since the data set merges information from two main sources, viz. EUROSTAT and the ESPON project "Future Orientations for Cities (FOCI).

Appendix 7 shows a map of the city sample employed in this analysis, and presents some revealing figures on the consistent percentage of wealth produced, and population and labour force living, in the metropolitan areas covered.

Table 2 presents instead a summary of the data set built for the empirical analysis.

Table 2. The data set.

Class of variable	Variable	Measure	Source of raw data
Dependent	Size	Log of population levels in 59 LUZ[7]	FOCI/Urban Audit
Urban benefits	Amenities	Log tourist inflows over available years	Urban Audit
	Human capital	Log workforce in ISCO professions 1 and 2 (respectively, legislators, senior officials and managers and professionals).[8]	FOCI
	Diversity	Log sectoral diversity index measured as 1- the share of top 5 NACE 2 digits industries.[9]	FOCI

[7] "The larger urban zone (LUZ) is an approximation of the functional urban zone centred around the city" (from EUROSTAT).

[8] Data for this and the following index are collected at NUTS2 level, and rescaled at the FUa level according to the ratio of FUA population/NUTS2 population.

Urban costs	Land rent	Log cost of average quality apartment per square meter	Various (see table "Land rent sources"in Appendix 4)
	Sprawl	Log percentage of non-urbanized soil	FOCI
	Malaise	Log number of crimes registered per year	Urban Audit
Vertical shifters	Policentricity (structural)	Log disparities in the GDP per capita level between the metropolitan area and its regional hinterland	FOCI
	Policentricity (relational)	Intensity of participations in Framework Programme 5 projects	CORDIS
	Metropolization (functional definition)	Owned subsidiaries without local subsidiaries minus (external subsidiaries/subsidiaries owned by HQ outside FUA + subs owned outside the FUA)	FOCI
	Agglomeration	Log population density	Urban Audit

- **Urban benefits**: the three determinants of urban benefits included in the model and summarized in Section 3, namely urban amenities, proxied by the inflows of tourists in the Metropolitan Area; the wealth of human capital, consistently measured with the workforce employed in ISCO professional groups 1 and 2 share; and the Jacobian source of externality stemming from a diversified labour market, measured with the Glaeser et al. (1992) indicator.
- **Urban costs**: urban costs include the pure cost associated to the land rent (accurately measured with the prices per square meter of average quality apartments in downtown metropolitan areas); sprawl (measured with the percentage of non-urbanized soil) and social malaise/distress, captured by the number of crimes recorded for the metropolitan area.
- **Vertical shifters**: these factors, which are deemed to shift upwards the urban benefit function. These include three forms of policentricity
    - **Structural policentricity**: this form of policentricity is measured as the difference in the development level of the core areas and its surroundings, i.e.

$$StrPol = \left(\frac{pcGDP_{MA}}{pcGDP_{RH}} \right) - 1 \tag{11}$$

      where: MA stands for metropolitan area, while RH indicates its regional hinterland.

    - **Relational policentricity**: following the definition of WP 2.1 within this project, polycentric urban development is also assumed to be fostered by the extent of external relations with other urban centres. This is in this work package measured with the number of Framework Programme 5 projects to which institutions of Metropolitan Areas in this analysis jointly participate.
    - **Metropolisation**: following the functional definition of this concept, it is measured as the total number of subsidiaries of multinational enterprises outside the FUA plus the ratio calculating the degree of internal control of the total number of subsidiaries both owned by companies located within, as well as ouside, the FUA. This indicator (originally labeled as “POWNSUB”) has been calculated within the FOCI project by the Institute of Geography of the University of Lausanne;

[9] See Glaeser et al. (1992) for its inception.

- **Agglomeration**: complementary to the sprawl versus compact urban form debate, a measure of pure agglomeration, i.e. the log population density, including the vertical development of the metropolitan area, and therefore the pure probability of "contagion" of new ideas, is also included in this analysis.

5. Empirical results

Table 3 shows the results of estimating the main model described in Section 3. Results are ordered as follows.

Urban size determinants are ordered vertically with horizontal blocks; first, urban size is regressed against urban cost variables (block 1), then urban benefit variables are included (block 2); finally, the model is completed with urban shifters (block 3). Across all regressions, robust standard errors are employed, in order to correct for likely heteroskedasticity in the data, provided the persistence of country effects.

Results show a remarkable adherence with theoretical ex-ante expectations. If the spatial equilibrium assumption does hold, and people are more or less free to move and look for better life conditions, these estimates provide a reliable first-layer assessment of urban size determinants in the European urban system.

In particular, results show that:

- Land rent, after netting out its relations with other benefit and cost variables, is the single highest cost for urban dwellers, reflected in the highest parameter estimate within our framework;
- Traditional views on the paramount importance of the concentration of human capital as the rationale of urban agglomerations are indeed perfectly right, as the associated parameter is consistently found to be positively associated with a large urban size;
- Modern views on determinants of urban performance are right, too: indeed a relevant share of urban benefits, with the highest parameter estimate being associated to this benefit variable, is also explained by the measure of urban amenities. These alone explain about 12% of the total linear variance;
- Polycentric urban development is indeed associated with a – on average – larger urban size, *both* and *simultaneously* measuring policentricity in morphological as well as in relational terms;
- Metropolised cities, viz. cities with a denser presence of power functions, also reach on average a larger size, although the evidence is here quite weak;
- Finally, the presence of administrative and power functions typical of a capital city also contribute to the equilibrium city size, with capital cities being on average, and ceteris paribus, 3% larger than the rest of the sample.

Table 3. Empirical results for estimating eq. (11.).

	Equilibrium city size (Log city population 2004-2006)												
Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Constant	8.80***	11.97***	16.74***	13.19***	12.86***	5.87*	7.88***	8.42***	8.18***	6.87***	7.81**	7.48***	6.96***
	(1.49)	(1.60)	(1.36)	(1.49)	(1.49)	(3.45)	(2.57)	(2.66)	(2.58)	(2.51)	(3.60)	(2.62)	(2.49)
Land rent (cost of downtown apartments per square meter)	0.70***	0.46**	0.27*	-0.08	-0.12	-0.18	-0.38***	-0.43***	-0.36***	-0.37***	-0.25	-0.42***	-0.46***
	(0.20)	(0.19)	(0.15)	(0.16)	(0.15)	(0.14)	(0.12)	(0.14)	(0.12)	(0.11)	(0.21)	(0.13)	(0.13)
Sprawl (share of discontinuous urbanized area)	-	-0.38***	-0.26***	-0.23***	-0.21***	-0.20***	-0.15**	-0.15**	-0.15***	-0.11*	-0.21*	-0.12*	-0.09
		(0.11)	(0.08)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.11)	(0.06)	(0.06)
Crime (Total number of recorded crimes per 1000 population)	-	-	-0.41***	-0.29***	-0.26***	-0.23***	-0.24***	-0.24***	-0.24***	-0.23***	-0.27***	-0.23***	-0.20***
			(0.07)	(0.08)	(0.08)	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)
Urban amenities (log of tourist overnight accomodations)	-	-	-	0.35***	0.31***	0.31***	0.25***	0.26***	0.25***	0.24***	0.18*	0.25***	0.25***
				(0.08)	(0.08)	(0.07)	(0.06)	(0.06)	(0.06)	(0.07)	(0.09)	(0.07)	(0.07)
Human capital/urban functions (log workforce in ISCO profession groups 1&2)	-	-	-	-	0.15*	0.19**	0.21***	0.20***	0.21**	0.19***	0.22**	0.17***	0.16**
					(0.09)	(0.09)	(0.08)	(0.07)	(0.08)	(0.07)	(0.08)	(0.06)	(0.07)
Urban diversity (1-share of workforce in top 5 NACE 2 digits induestries)	-	-	-	-	-	0.18**	0.15**	0.15**	0.14**	0.15***	0.14*	0.15**	0.16***
						(0.08)	(0.06)	(0.06)	(0.06)	(0.05)	(0.08)	(0.06)	(0.06)
Relational policentricity (log of Framework 5 Programme projects participations)	-	-	-	-	-	-	0.22***	0.23***	0.22***	0.23***	0.16***	0.24***	0.22***
							(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Morphological policentricity (Disparities in the GDP per capita level between the metropolitan area and its regional hinterland)	-	-	-	-	-	-	-	0.12	-	-	-	0.11	0.29*
								(0.14)				(0.13)	(0.17)
Metropolization (*functional* definition) (Log of subsidiaries controlled by LUZ companies /subsidiaries located in LUZ)	-	-	-	-	-	-	-	-	0.06	0.08*	0.01	0.08*	0.07
									(0.04)	(0.04)	(0.05)	(0.04)	(0.05)
Agglomeration economies (Log population density in the FUA)	-	-	-	-	-	-	-	-	-	0.16*	0.25*	0.16*	0.18**
										(0.08)	(0.12)	(0.08)	(0.08)
Dummy capital city	-	-	-	-	-	-	-	-	-	-	-	-	0.25*
													(0.13)
R^2	0.20	0.34	0.61	0.73	0.74	0.76	0.83	0.84	0.84	0.86	0.95	0.86	0.87
Joint F test	12.51***	14.18***	32.01***	41.40***	37.33***	35.07***	50.79***	42.30***	49.79***	35.34***	-	30.37***	26.96***
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	No	No	No	No	No	No	No	No	No	No	Yes	No	No
Number of observations	59	59	59	59	59	59	59	59	59	59	59	59	59

*Note: Standard errors in parentheses. * = significant at the 90% level; ** = significant at the 95% level; *** = significant at the 99% level.*

6. Conclusions

Since the birth of the object city, urban agglomerations have been the loci of innovation, where human capital is attracted as is paid its highest return, and, as one famous saying goes, the place where people are truly free.[10] Recent developments in the urban world, however, prompted the emergence of new trends for urban location. Not only does it pay off to accumulate human capital and locate where the returns associated to education are highest, but also, it becomes increasingly important to enjoy the more open atmosphere which characterizes modern urban agglomerations.

In this paper we review traditional and recent urban trends as sources of urban performance, framing them in a theoretical model which brings together the neoclassical and modern approaches to urban performance. This model is then tested on 59 Functional urban Areas within the EU27.

The evidence suggests that indeed modern paradigms explain much of current disparities in terms of urban performance (and in particular of city size). While rent, net of the urban benefits it reflects, still represents the single highest cost associated to urban size, cities now benefit not only from attracting highly educated professionals, and hosting a rich and diversified labour market, but also from pure amenities, which are found to be associated with a better urban performance.

Besides, results clearly and consistently show that being connected to a network (in this case, of scientific relations), i.e., being relationally polycentric, also fosters urban performance. Less clear, although still positive, is the effect of a metropolised urban system on overall city performance. However, this concept may actually offer a blurred image, being in part overlapping with the professional definition of human capital previously mentioned.

Planning matters, when smartly integrated with a sound urban economic strategy.

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Appendix 1: land rent and city size

Traditional view on the notion of land rent from a macro perspective (i.e., abstracting from classical monocentric models *à la* Von Thunen and Alonso) foresee that rent and city size go hand in hand. This view is in particular true for simple urban growth models based on spatial equilibrium (see Rosen, 1979 and Roback, 1982 as the seminal contributions and, for a comprehensive review, Glaeser, 2008). And indeed, apparently our data confirm this prediction (Figure 3), with a slope equal to 0.70, significant at all conventional levels (model 1 in Table 2).

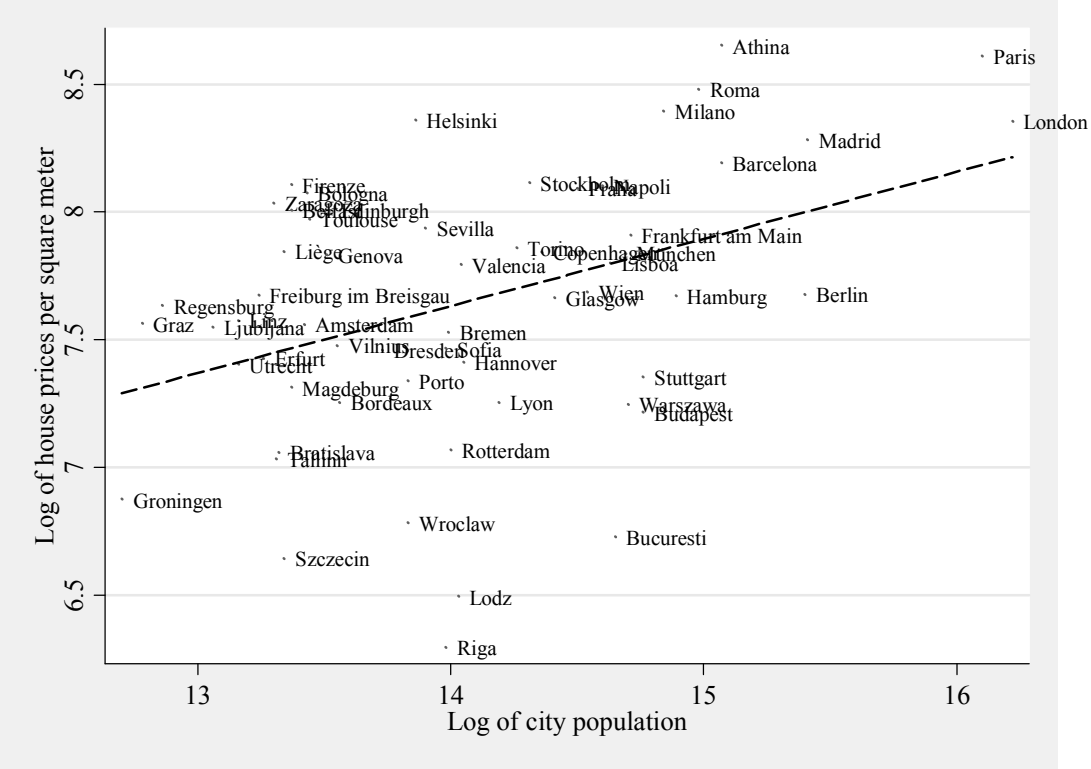
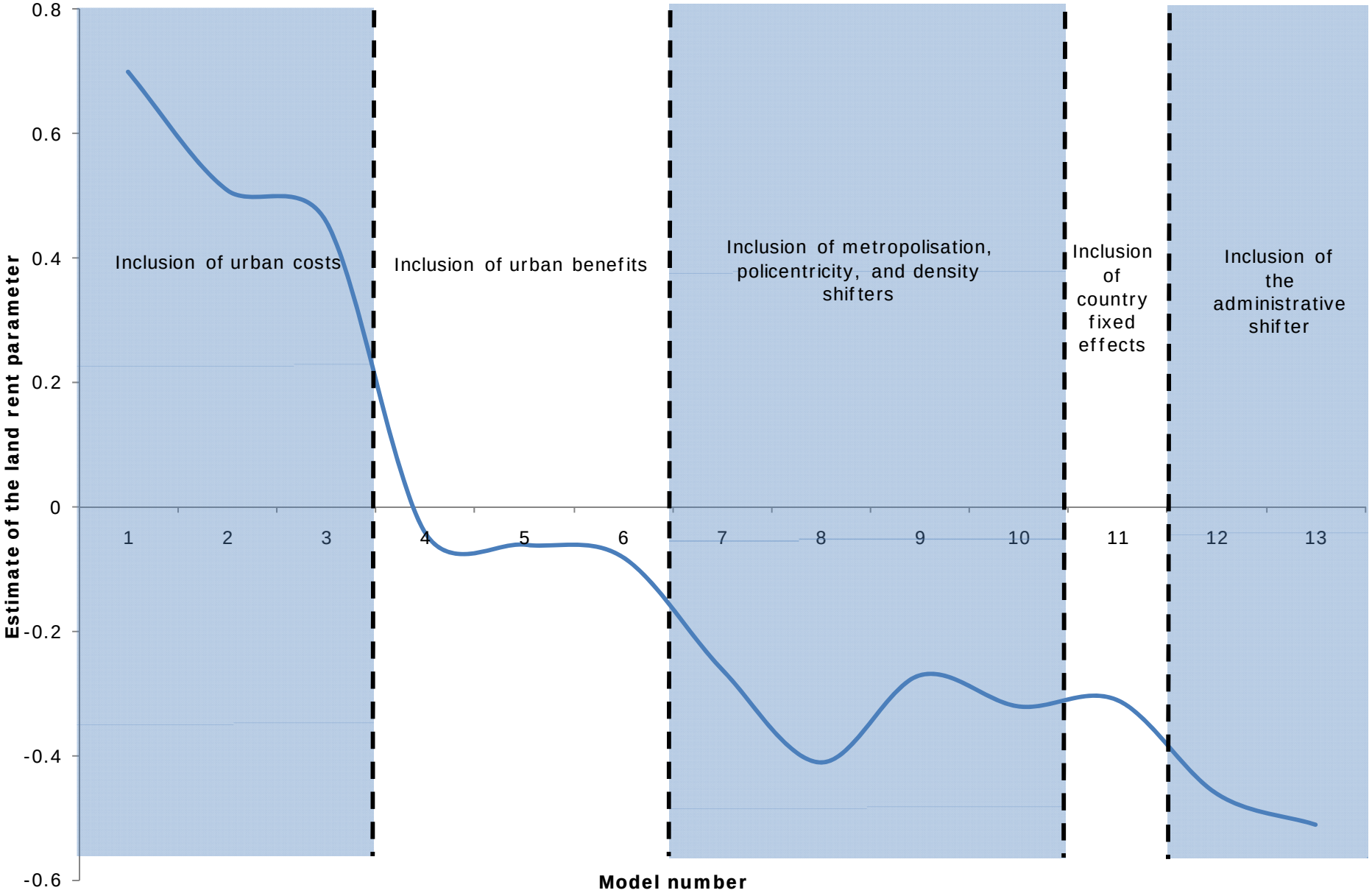


Figure 4. Log city population and log prices of apartments per square meter.

However, this prediction dramatically changes as the model is made more complex as to encompass determinants of urban costs (models 2-3), urban benefits (models 4-6), metropolisation, city network and policentricity controls (models 7-10) and country fixed effects (model 11). The value of the estimated parameter is represented in Figure 4.

Figure 5. Estimated land rent parameter.



Source: authors' calculation. Shaded areas indicate that the land rent parameter is significant at least at the 10% level.

Once variables determining simultaneously the value of land rent and city population are both taken into account, the estimates associated to the land rent parameter become negative and highly significant, highlighting the cost side of the notion of rent. The relationship between city size and land rent, after taking into account rent and size determinants, becomes therefore negative (Figure 5).

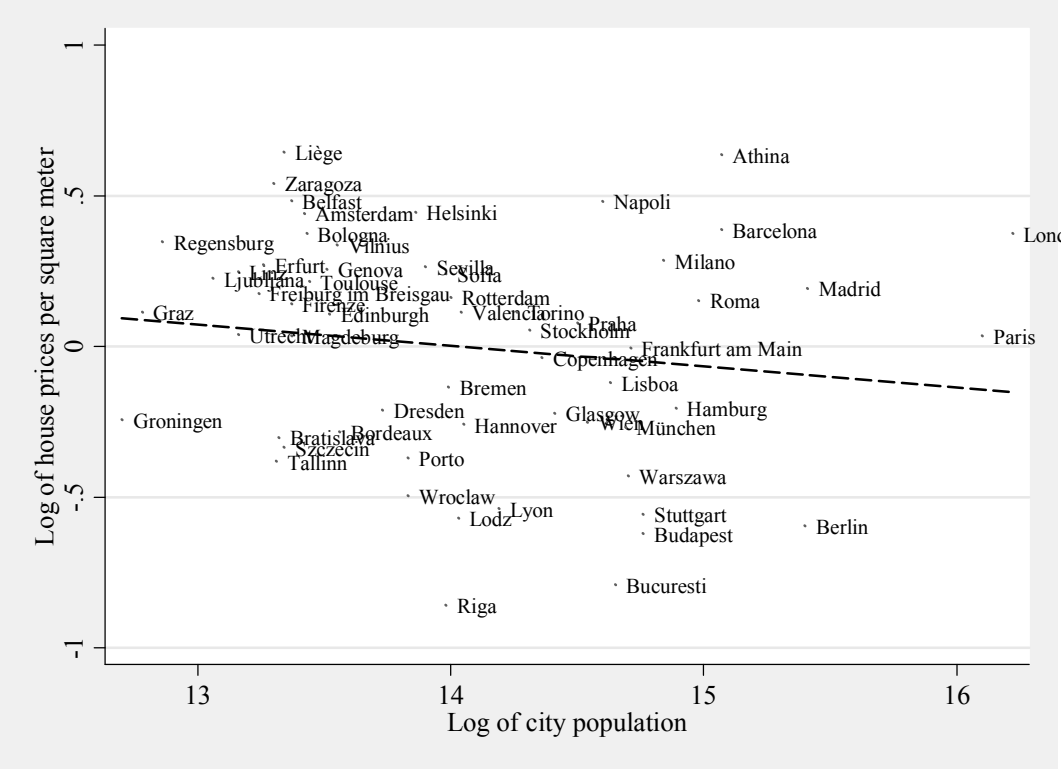


Figure 6. Log city population and log prices of apartments per square meter (predicted value).

Appendix 2: land rent data.

Country	Source of house prices data	Year
Austria	Global Property Guide (www.globalpropertyguide.com)	2006
Belgium	Institut National de Statistique	2006
Bulgaria	National Statistical Institute	2006
Cyprus	Global Property Guide (www.globalpropertyguide.com)	2006
Czech Republic	European Property website (www.europeanproperty.com)	2006
Denmark	Urban Audit 2001-2004 data, inflated by 48% (price increase calculated with GPG data)	2006
Estonia	Urban Audit 2001-2004 data, inflated by 61% (price increase calculated with GPG data)	2006
Finland	Urban Audit 2001 data, inflated by 157% (price increase calculated with GPG data)	2006
France	FNAIM house prices statistics	2006
Germany	Urban Audit 2001-2004 data, inflated by price increase calculated with BulwienGesaAG data)	2006
Greece	Various international real estate agencies (e.g. http://www.mondinion.com/Real_Estate/country/Greece/)	2006

Hungary	Urban Audit 2001-2004 data, inflated by 20'% (price increase calculated with Departement du Logement data)	2006
Ireland	-	2006
Italy	Banca dati delle quotazioni immobiliari - Agenzia del territorio (http://www.agenziaterritorio.it)	2006
Latvia	Central Statistical Bureau of Latvia	2006
Lithuania	Inreal quarterly report	2006
Luxembourg	Urban Audit 2001-2004 data, inflated by 11% (price increase calculated with Departement du Logement data)	2006
Malta	Malta's property price index	2006
Netherlands	Urban Audit 2001 data, inflated by 66% (price increase calculated with GPG data)	2006
Poland	Urban Audit 2001 data, inflated by 66% (price increase calculated with GPG data)	2006
Portugal	http://www.portugalvirtual.pt/real-estate/prices-how-to-finance.php	2006
Romania	Urban Audit 2001-2004 data, inflated by 74% (price increase calculated with GPG data)	2006
Slovakia	Urban Audit 2001-2004 data, inflated by 41% (price increase from the house prices index of Central Bank of Slovakia)	2006
Slovenia	Urban Audit 2001-2004 data, inflated by 57% (price increase from the house prices index of Statistics Slovenia)	2006
Spain	Urban Audit 2001-2004 data, inflated by 35% (price increase calculated with GPG data)	2006
Sweden	Värderings Data SA	2006
United Kingdom	Urban Audit 2001-2004 data, inflated by regional housing price inflators as compiled by Nationwide Ltd.	2006

Appendix 3: city sizes predicted by the model.

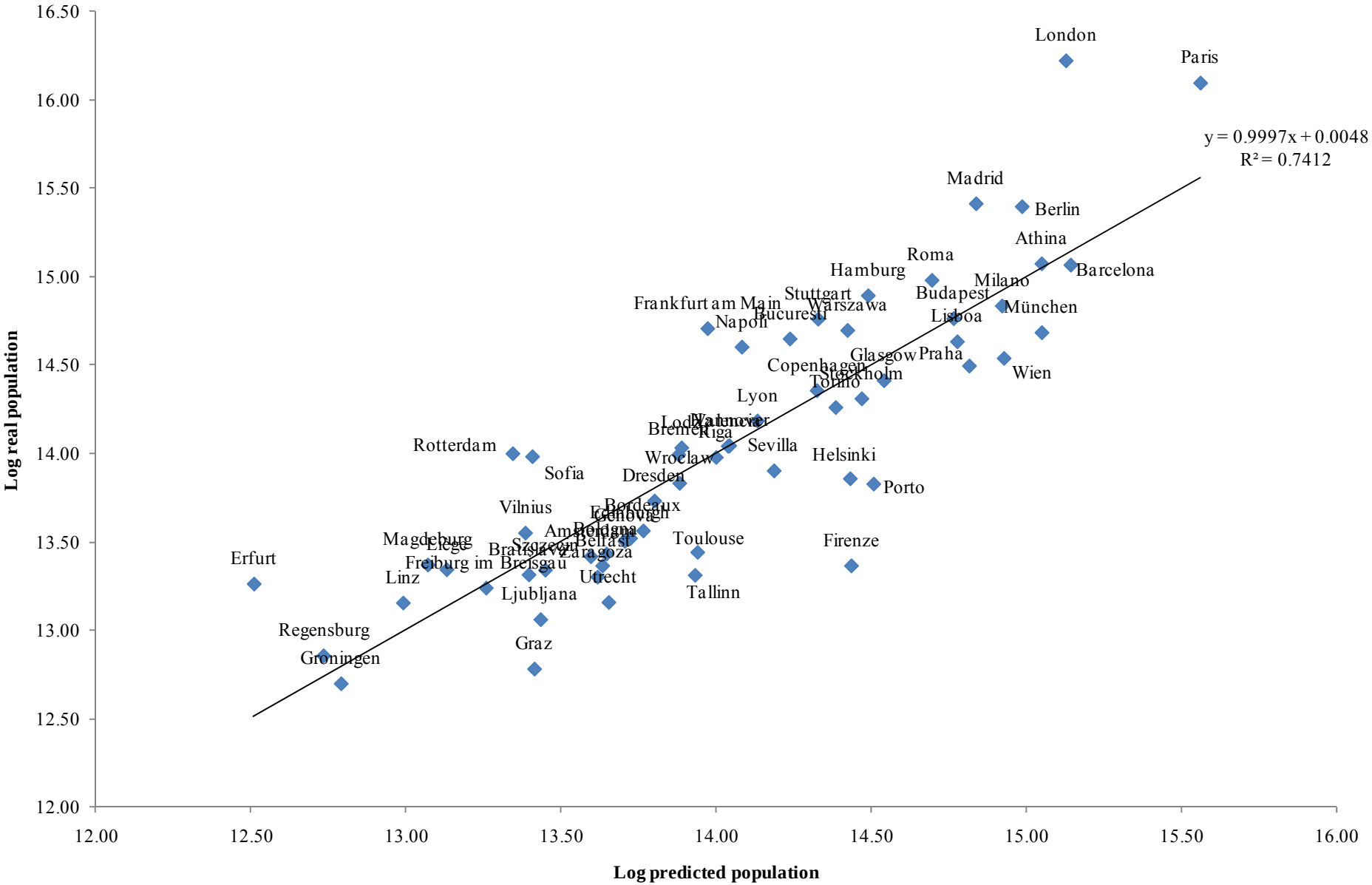


Figure 7. City size as predicted by model 8 vs. real city population.

Appendix 4: city sample.

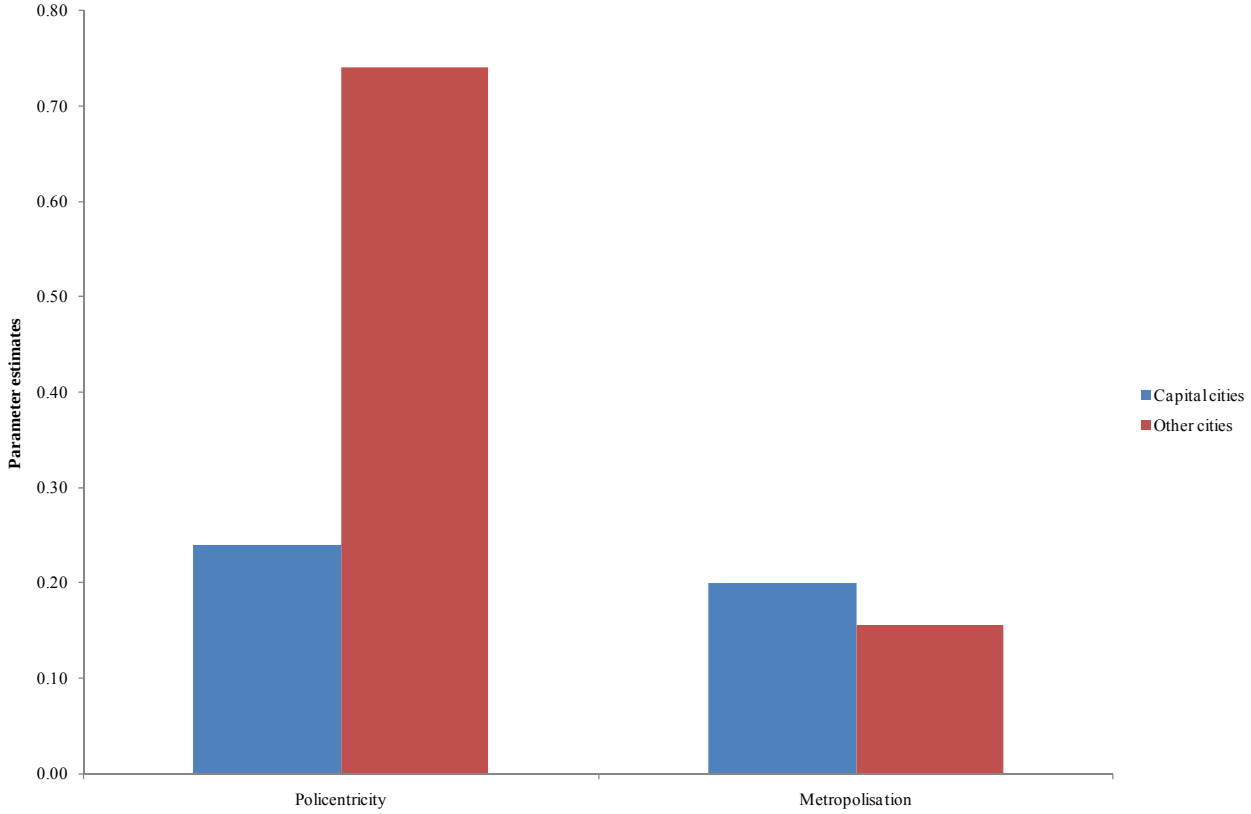
City	Country	City	Country
Wien	Austria	Athina	Greece
Graz	Austria	Budapest	Hungary
Linz	Austria	Roma	Italy
Liège	Belgium	Milano	Italy
Sofia	Bulgaria	Napoli	Italy
Praha	Czech Republic	Torino	Italy
Berlin	Germany	Genova	Italy
Hamburg	Germany	Firenze	Italy
München	Germany	Bologna	Italy
Frankfurt am Main	Germany	Vilnius	Lithuania
Stuttgart	Germany	Riga	Latvia
Dresden	Germany	Amsterdam	Netherlands
Bremen	Germany	Rotterdam	Netherlands
Hannover	Germany	Utrecht	Netherlands
Magdeburg	Germany	Groningen	Netherlands
Freiburg im Breisgau	Germany	Warszawa	Poland
Regensburg	Germany	Lodz	Poland
Erfurt	Germany	Wroclaw	Poland
Copenhagen	Denmark	Szczecin	Poland
Tallinn	Estonia	Lisboa	Portugal
Madrid	Spain	Porto	Portugal
Barcelona	Spain	Bucuresti	Romania
Valencia	Spain	Stockholm	Sweden
Sevilla	Spain	Ljubljana	Slovenia
Zaragoza	Spain	Bratislava	Slovakia
Helsinki	Finland	London	UK
Paris	France	Glasgow	UK
Lyon	France	Edinburgh	UK
Toulouse	France	Belfast	UK
Bordeaux	France		

Appendix 5: descriptive statistics for the main variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Log city population	59	14.11	0.80	12.75	16.29
Log average tourist overnight accomodations	59	14.51	1.11	12.24	17.24
Log percentage of population with tertiary education	59	3.13	0.39	1.99	3.82
Score for a well-developed labour market	59	-0.04	0.96	-3.13	1.65
Log average price of apartments per sq. meter	59	7.64	0.52	6.30	8.65
Log percentage of non urbanized soil (sprawl)	59	-56.21	20.12	-99.00	-7.22
Log number of crimes recorded in city	59	4.22	4.73	4.00	19.00
Log number of FP5 projects in which city organizations took part	59	5.38	1.27	0.69	7.65

Log control/power functions in cities	59	6.47	1.54	3.66	11.23
Log population density	59	6.22	0.82	4.78	8.29

Appendix 6: metropolisation and policentricity in capital cities.



Appendix 7: city sample for Work Package 2.2.

This work package is based on a set of 59 major metropolitan areas in Europe. Figure 7 shows the city sample drafted for this work package, showing a wide coverage of several aspects of economic activity in Europe:

- 22% of cities lie in NMS;
- 37% of total city sample is a capital city;
- Capital cities from the EU27 included are 22, with Brussels, Dublin, Valletta, Nicosia, and Luxembourg excluded because of missing values;
- As of 2010, our sample covers:
    - 26% of total EU27 population;
    - 36% of total EU27 *urban* population;
    - 33% of total GDP produced in the European Union;
    - 29% of total labour force;
    - 32% of total labour force employed in tertiary and advanced industries.

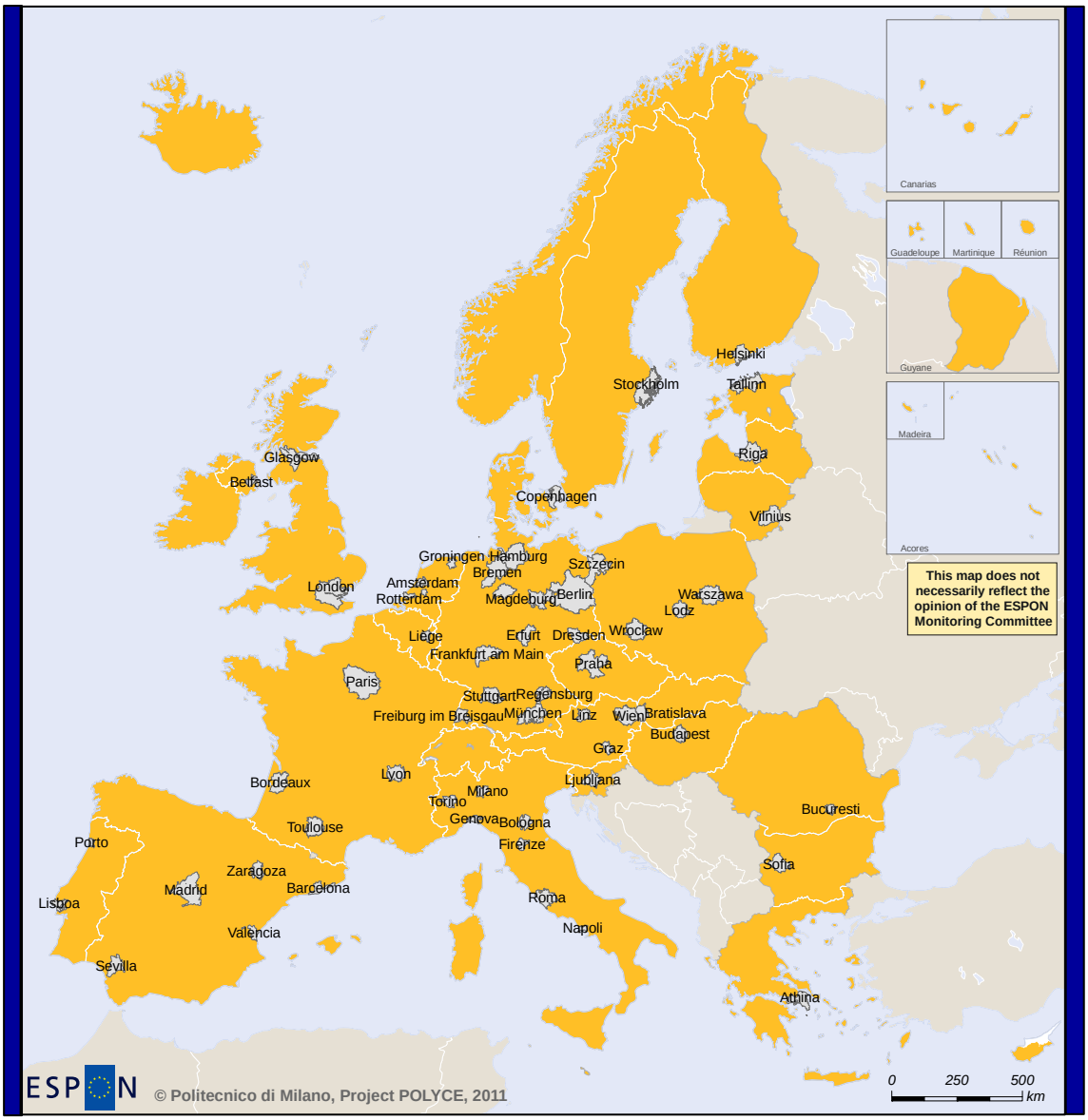


Figure 8. City sample.