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Cities in the EU: economic performance and resilience in the aftermath of the financial crisis

SUPERVISOR

Prof. Giovanna Vallanti

Valentin Vander Borght
Number: 677241

CO-SUPERVISOR

Prof. Salvatore Nitico

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Cities in the EU: economic performance and resilience in the aftermath of the financial crisis

Master Thesis

Valentin Vander Borght

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Abstract

The city is defined as a functional urban area based on Eurostat data at NUTS 3 level. I first regress the economic performance of European cities on economic structure, including human capital, and size-based typology across the period 2003–2013 using fixed effects panel data. At first, I find evidence of convergence between European cities over the studied period. But, the divergence occurs during the crisis. Secondly, I find that metropolitan cities outperform the smallest cities. Thirdly, construction sector and human capital are the engine of economic growth during the studied period. I then regress the economic performance of European cities during the crisis and post-crisis period on initial economic structure, including human capital, and size-based typology using robust OLS model. Given their initial features, manufacturing, administrative, financial and advanced services have a negative impact on the crisis economic growth. Besides, the negative effect of manufacturing and administration persist during the post-crisis. Only human capital has a positive impact on both crisis and post-crisis economic growth.

Contents

List of Tables

List of Figures

Thesis summary

Cities are considered as the major driver for territorial cohesion and economic growth according to European policy. In line with this perspective, my thesis aims at analyzing the impact of the financial crisis on European cities. On the one hand, I regress the economic performance of cities on the economic structure, including human capital, and population size based typology over the period 2003–2013. On the other hand, I try to identify the source of resilience by analyzing the impact of initial economic structure, including human capital, of cities and population size based typology on the crisis and post-crisis economic growth. In summary, the objectives of this study are outlined as follows:

1. Is there a convergence between European cities? In which extent the financial crisis alters this trend?

2. What is the strongest city in terms of economic performance over the period 2003–2013?

3. What are the driving factors of resilience in the aftermath of the financial crisis?

I develop three strands of literature that I deem relevant to answer to these questions: agglomeration economics and network paradigm, convergence theories and the concept of resilience. According to agglomeration economics and network paradigm, it has been argued that metropolitan cities benefit from their position of central nodes in the world economy and the availability of a diversified labor pool. Globalization and the development of ICT accentuate this trend by fostering the concentration of highly value added sector in metropolitan areas. Nevertheless, negative externalities arising from congestion, such as pollution and increasing commuting time, are likely to counterbalance this phenomenon in metropolitan areas. To capture the importance of agglomeration and network effect, I use the classification of city based on population size described in table 1. Secondly, I draw a distinction between two theories concerning convergence. On the one hand, the classical convergence theory explains the catching up process of poor regions as a result of a differential marginal productivity between labor and capital intensive cities. On the other hand, the cumulative causation theory explains why regions does not follow the path recognized by the classics and highlights the importance of long-term structure in order to understand regional divergence. In other words, initial disparities reproduce, or not, spatial inequality due to the cumulative consequences of the regional situation. To assess the extent of a convergence between European cities, I define convergence as a β-convergence, that is, the negative correlation

between the economic growth and the initial level of income. Thirdly, several factors of resilience are emphasized in the economic literature. It can be divided into different strands. At first, the importance of institutions, culture and political, to ensure the resilience. Then, the importance of small and medium sized companies and a creative class in the economy to deal with a negative shock. Finally, some authors point out the impact of specialization in some activities as a shield for the economy. I define resilience as a two-step process, that is, the role of initial features of cities that mitigate the negative shock during the crisis period and foster the adaptation during the post-crisis period.

Table 1: Cities typology

Typology	Criteria
Metropolitan area	FUA population > 500 000 inhabitants
Poly FUAs	2 metropolitan areas with their centers < 60 km apart and labor basins touching each other; 2 large areas with their centers < 30 km apart and labor basins touching each other; 1 metropolitan and 1 large/medium area with their centers < 30 km apart and labor basins touching each other; 2 metropolitan areas with their centers < 60 km apart and labor basins separated only by the labor basin of a smaller FUA touching the both of them.
Large area	FUA population > 250 000 inhabitants
Medium area	FUA population > 100 000 inhabitants
Small area	FUA population > 50 000 inhabitants
Other area	FUA population < 50 000 inhabitants

My database consists on a panel data composing of 1515 units of observation, functional urban areas considered as cities, coming from 26 countries over the period 2003–2013. I construct the functional urban areas based on Eurostat data at NUTS 3 level. By constructing the functional urban areas, I define the concept of city. A city is not only an administratively-delineated area but a place characterized by a labor pool. In other words, a city is composed by the city itself and the share of surrounding agglomeration which economically contributes to the city. The extent of a labor pool associated with a NUTS 3 unit is determined by a coefficient based on commuting statistics. In this analysis, the coefficients are considered as given by my supervisor, Professor G.

Van Hamme. This coefficient represents the percentage giving what part of the NUTS 3 variable, such as gross domestic product, is associated with a single functional urban area. The sum of each adjusted NUTS 3 value corresponding to a functional urban area gives the variable value of this functional urban area. To define the economic structure of a city, I bring together a set of indicator that proxy the importance of the primary sector, manufacturing, construction, financial and advanced services, administrative sectors and human capital. These variables are described in table 2. In addition, it is important to note that I use a restricted sample when I include the variable related to human capital because I have only the data for the most important European cities. For this reason, I do interpret the result of the other variables when I use human capital variable.

Table 2: Description variables data set at NUTS 3 level

Indicator	Explanation	Period	Source
Economic growth	Based on GDP at current market price purchasing power standard in million €. No data of GDP at basic price on Eurostat.	2003-2013	Eurostat
Population	Criteria used for the typology. I assume topology is constant for the studied period.	2014	Eurostat
Agriculture	Gross value added at basic prices in A Eurostat activity in million €. It corresponds to the primary sector.	2003-2013	Eurostat
Manufacturing	Gross value added at basic prices in C Eurostat activity in million €. Exception for Poland where I use B-E Eurostat categories in million €.	2003-2013	Eurostat
Construction	Gross value added at basic prices in F Eurostat activity in million €	2003-2013	Eurostat
Finance and advanced services	Gross value added at basic prices in K-N Eurostat activity in million €. Exception for UK where I use only K Eurostat activity in million €.	2003-2013	Eurostat
Administration	Gross value added at basic prices in O-U Eurostat activity in million €. Exception for UK where I use only O-Q Eurostat activity in million €.	2003-2013	Eurostat
Education	Share of tertiary diploma in the active population. I assume the share is constant through time.	2001	Eurostat; Labour Force Survey

In this thesis, I use two empirical approaches. At first, the specification is designed to emphasize

the economic performance of cities across 2003–2013 using fixed effects panel data. Taking into account the dependent variables, the specification of the model is as follows:

$$GDPgrowth_{it} = \alpha + \beta_1 ln(GDP_{it-1}) + \beta_2 ln(GDP_{it-1}) \times crisis_t + \beta_3 EcoStructure_{j_{it}} + \beta_4 EcoStructure_{j_{it}} \times crisis_t + \beta_5 EcoStructure_{j_{it}} \times typology_i + \beta_6 EcoStructure_{j_{it}} \times typology_i \times crisis_t + \beta_7 education_i + \epsilon_{it} \quad (1)$$

where $\epsilon_{it} = typology_i + \lambda_t + \phi_c + u_{it}$;

$$\text{where} \quad \begin{cases} i = 1, ..., n \quad \text{where} \quad n = 1515 \quad \text{number of cities} \\ j = 1, ..., k \quad \text{where} \quad k = 5 \quad \text{number of economic structure variables} \\ t = 2003, ..., 2013 \quad T = 11 \quad \text{number of years} \\ crisis = 1 \text{ when } t = 2008, 2009, 2010 \quad ; \quad crisis = 0 \text{ otherwise} \end{cases}$$

The methodology I use to estimate this equation is the fixed effects panel data regression. This model allows to control for omitted variables that vary either across time but do not change across country/typology or across country/typology but do not change over time. Therefore, the error term can be decomposed into a country fixed effect, ϕ_c, a typology fixed effect, $typology_i$, a time fixed effect, λ_t, and a residual error term, u_{it}. Given the nature of my data, this model is the most coherent. That is why I put aside the test for random effect model or pooled model. My first specification allows me to draw several interesting results.

From a general point of view, my analysis shows that metropolitan cities performs better than large, medium, small and other cities over the period 2003–2013. All things being equal, the smaller the population size, the lower is the economic growth in the city. This result confirms the importance of the effects of agglomeration and network that characterize metropolitan areas.

Then, I test the extent of β-convergence process between cities and I check the impact of the financial crisis on this convergence process. I find a consistent result through the different specifications. The coefficient associated with the initial level of gross domestic product is negative and significant at level 1 percent. Therefore, this result advocates the hypothesis of convergence between cities because a city with higher level of gross domestic product experience lower economic growth. Further, I test how the crisis has affected the convergence process by adding an interaction variable between the initial level of gross domestic product and the period 2008–2010. This result brings a more nuanced point of view on convergence. During the financial crisis, divergence occurs between European cities. The estimate of convergence during the crisis period can be defined

Table 3: Results of the econometric model using the fixed effects panel data model

Dependent variable: $GDPgrowth_{it}$	Specif. (1)	Specif. (2)	Specif. (3)	Specif. (4)	Specif. (5)
$Constant$	0.074***	0.082***	0.147***	0.146***	0.131***
	(0.006)	(0.006)	(0.008)	(0.009)	(0.022)
$ln(GDP_{it-1})$	-0.001**	-0.002***	-0.003***	-0.003***	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$ln(GDP_{it-1})^{crisis}$		0.004***	0.004***	0.004***	0.003
		(0.001)	(0.001)	(0.001)	(0.002)
$Agriculture_{it}$			-0.072***	-0.103***	-0.168*
			(0.017)	(0.017)	(0.090)
$Manufacturing_{it}$			-0.058***	-0.053***	-0.085***
			(0.007)	(0.007)	(0.023)
$Construction_{it}$			0.191***	0.273***	0.419***
			(0.020)	(0.022)	(0.074)
$Finance_{it}$			-0.140***	-0.146***	-0.177***
			(0.014)	(0.014)	(0.039)
$Administration_{it}$			-0.138***	-0.141***	-0.193***
			(0.009)	(0.010)	(0.031)
$Agriculture_{it}^{crisis}$				0.113**	0.477***
				(0.045)	(0.163)
$Manufacturing_{it}^{crisis}$				-0.022**	0.006
				(0.010)	(0.032)
$Construction_{it}^{crisis}$				-0.311***	-0.390***
				(0.033)	(0.100)
$Finance_{it}^{crisis}$				0.026**	0.049**
				(0.011)	(0.023)
$Administration_{it}^{crisis}$				0.007	0.010
				(0.014)	(0.038)
$Education_i$					0.113***
					(0.023)
$Large$	-0.004***	-0.004***	-0.006***	-0.006***	-0.005**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$Medium$	-0.006***	-0.006***	-0.010***	-0.010***	-0.010***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)
$Small$	-0.008***	-0.008***	-0.013***	-0.013***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
$Other$	-0.009***	-0.009***	-0.013***	-0.014***	
	(0.002)	(0.002)	(0.002)	(0.002)	
Observations	15150	15150	15150	15150	1529
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: These regressions are estimated using fixed effects panel data for 26 countries. Regression (1) through (5) uses data from 2003 to 2013. Table reports estimation associated with the different level of significance (*p<0.1; **p<0.05; ***p<0.01). All models control for country, typology and time fixed effects.

as the sum of the coefficient associated with the initial level of gross domestic product and the interaction variable with the crisis period. As a result, the coefficient is positive implying a positive relationship between economic growth and initial level of income.

Over the period 2003–2013, construction sector and human capital are the engine of economic growth. An additional percentage of share in construction in percentage of gross domestic product increases the economic growth by 0.191 percent. In parallel, an additional percentage of tertiary educated people in percentage of active population increases the economic growth by 0.113 percent. In contrast, manufacturing, administrative, financial and advanced services sectors have a negative impact on economic growth. An additional percentage of share in these sectors decrease the economic growth, respectively, by -0.058,-0.138 and -0.140 percent. It is also important how these sectors behave during the crisis period. While financial and advanced services have a negative impact on economic growth, these sectors have a positive impact on the economic growth. In contrast, construction sector has a negative effect on the economic growth during the crisis period.

Then, the second specification is designed to analyze the resilience of cities in the aftermath of the financial crisis using robust OLS regression controlling for country. In order to emphasize resilience of cities, I show in which extent the average initial condition affect the crisis and post-crisis economic growth. The model specification to test the first part of resilience definition is as follows:

$$GDPgrowth_{i,t}^{average} = \alpha + \beta_1 ln(GDP_{i,t-1}^{average}) + \beta_2 EcoStructure_{j_{i,t-1}}^{average} + \beta_3 typology_i + \beta_4 education_i + \epsilon_i \tag{2}$$

The model specification to test the second part of resilience definition is as follows:

$$GDPgrowth_{i,t+1}^{average} = \alpha + \beta_1 ln(GDP_{i,t-1}^{average}) + \beta_2 EcoStructure_{j_{i,t-1}}^{average} + \beta_3 typology_i + \beta_4 education_i + \epsilon_i \tag{3}$$

where $\epsilon_i = \phi_c + u_i$;

$$\text{where} \quad \begin{cases} i = 1, ..., n \quad \text{where} \quad n = 1515 \quad \text{number of cities} \\ j = 1, ..., k \quad \text{where} \quad k = 5 \quad \text{number of economic structure variables} \\ t-1 \quad = \quad \text{pre-crisis period, 2003–2007} \\ t \quad = \quad \text{crisis period, 2008–2010} \\ t+1 \quad = \quad \text{post-crisis period, 2011–2013} \end{cases}$$

The comparative analysis done using official data showed that, on average, cities with higher economic performance during the pre-crisis period do not experience higher economic growth during the crisis and post-crisis period. Therefore, this result does not advocate the importance of initial economic health to have better economic performance during the crisis and post-crisis period. Taking into account the economic structure of cities, it can be seen that the initial manufacturing, administrative, financial and advanced services activities affect negatively the economic growth during the crisis period. Nevertheless, only initial administrative and manufacturing activities have a persistent negative effect during the post-crisis period. Only human capital has a positive impact on the crisis and post-crisis economic growth.

Table 4: Results of the econometric model using the robust OLS model

Dependent variable	Crisis			Post-crisis		
$GDPgrowth$	(1)	(2)	(3)	(1)	(2)	(3)
$Constant$	-0.007	0.020	0.019	0.024***	0.053***	-0.004
	(0.011)	(0.016)	(0.037)	(0.009)	(0.014)	(0.031)
$ln(GDP_{i,t-1})$	0.001	0.002	0.002	0.001	0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
$Agriculture_{i,t-1}$		-0.043	-0.040		0.038	0.128
		(0.036)	(0.140)		(0.027)	(0.105)
$Manufacturing_{i,t-1}$		-0.064***	-0.084***		-0.021*	0.045
		(0.014)	(0.031)		(0.013)	(0.033)
$Construction_{i,t-1}$		-0.025	0.118		-0.014	0.279**
		(0.049)	(0.105)		(0.032)	(0.115)
$Finance_{i,t-1}$		-0.060**	-0.115**		-0.022	0.034
		(0.026)	(0.046)		(0.022)	(0.045)
$Administrative_{i,t-1}$		-0.027*	-0.075*		-0.062***	-0.040
		(0.017)	(0.041)		(0.016)	(0.039)
$Education_{i,t-1}$			0.087***			0.085***
			(0.029)			(0.027)
Observations	1515	1515	154	1515	1515	154
R-squared	0.59	0.60	0.83	0.57	0.58	0.80
Country control	Yes	Yes	Yes	Yes	Yes	Yes
Typology control	Yes	Yes	Yes	Yes	Yes	Yes

Note: Table reports estimation associated with the different level of significance (*p<0.1; **p<0.05; ***p<0.01). All models control for time fixed effect.

The emerging policy implications can therefore be outlined as follows. According to the EU 2020 objectives, "metropolitan areas play an important role in sustaining the EU's global competitiveness". My results lead us to the traditional trade-off between territorial equality and spatial concentration. On the one hand, metropolitan areas have the highest economic performance

over the period 2003–2013 all things being equal. According to this result, it should lead to a concentration of economic activity in European central place. On the other other hand, human capital seems to be an important factor of economic growth. Increasing the proportion of tertiary educated inhabitant has a positive impact on economic growth and should foster catching up process of European cities on metropolitan areas. Nevertheless, there is a lack of evidence to know how European Union should develop the smallest areas. This results correspond to the willingness towards cohesion of the European Union: "Cities play a crucial role as engines of the economy, as places of connectivity, creativity and innovation, and as centers of services for their surrounding areas. There is a consensus on the key principles of future European urban and territorial development which should: be based on balanced economic growth and territorial organization of activities, with a polycentric urban structure and build on strong metropolitan regions and other urban areas that can provide good accessibility to services of general economic interest".

My thesis has several suggestions because I reach some limits which call for further work to achieve a better comprehension of economic performances of European cities and their resilience. In this paper, I use a typology based on population to assess the importance of agglomeration economies and network effect. This proxy is likely to be misleading. Other variables could be used such as proxy for connectivity, level of internationalization, *et cetera*. Besides, I do not take into account the spatial perspective in this analysis of the economic structure. The economic structure variable that I use in this analysis are broad and heterogeneous. In addition, we need to keep in mind the potential endogeneity issue of my results. This problem may be overcome by using employment data. Moreover, I consider the ability to recover over the period 2011–2013. Nevertheless, this result can be biased by the sovereign debt crisis and not by the financial crisis itself. Then, most of economic geography paper relies on spatial econometrics. It allows to observe the direct and indirect spillover. In this paper, I treat cities as independent. One possible extension would be to use spatial econometrics and observe how the closest cities affect the economic growth of the metropolitan areas. Finally, I look at the impact of the economic structure, including human capital, on economic growth. Nevertheless, other important factors explain the economic growth such as research and development expenditure, level of debt, *et cetera*.

1 Introduction

The city is a major concern for European policy and understanding the changes in economic growth of cities are important for future European regional development. I first regress the economic performance of European cities on the economic structure of cities, including human capital, and a size-based typology across the period 2003–2013 using fixed effects panel data. Using robust OLS estimators, I then consider the resilience of cities by distinguishing the crisis, 2008–2010, and post-crisis, 2011–2013, period. As expected, metropolitan cities experience the best economic performance across the period 2003–2013. Surprisingly, metropolitan cities do not display more resilience than the other city's typologies. Further, I analyze the impact of economic structure, including human capital, in details. In summary, I try to address the following questions:

1. Is there a convergence between European cities? In which extent the financial crisis alters this trend?

2. What is the strongest city in terms of economic performance over the period 2003–2013?

3. What are the driving factors of resilience in the aftermath of the financial crisis?

The financial crisis has a differentiated impact across the European countries [Ball, 2014] and the great recession is anchored in our memory. In other words, many countries experience hysteresis effect [Doran and Fingleton, 2014]. As a result, there is a call for empirical research about the extent of the impact of the financial crisis and the driving factors of resilience at European city level. My thesis differs from the previous works because I quantitatively estimate the economic pattern as well as the crisis and post-crisis resilience at the European city level. Besides, I define cities as functional urban areas based on Eurostat data at NUTS 3 level. Then, based on population size-based typology, proxy of agglomeration economies and network effects, I analyze the impact of economic structure, including human capital, of cities on their economic growth. My results can be summarized as follows. At first, I find evidence of convergence between European cities over the period 2003–2013. Nevertheless, the divergence occurs during the crisis period. Secondly, I find that metropolitan cities outperform the smallest cities. Thirdly, construction sector and human capital are the engine of growth during the studied period. Finally, initial manufacturing, administrative and tertiary sectors have a negative impact on crisis economic growth while manufacturing and administrative sectors have a persistent negative impact on the post-crisis economic growth. Only human capital is a source of resilience during the crisis and

post-crisis period.

The financial crisis raised the importance of cities because, in 2007–2008, the European Union experienced a "very geographical crisis" [French et al., 2009]. At a first sight, the great recession followed the similar pattern of boom-bust scenario. In other words, it started with an irrational exuberance affecting the real estate market in certain regions of the United States. This phenomenon has hidden the underlying factor of a boom-burst crisis: the mispricing of risk. Consequently, when the speculative bubble burst, the housing market corrected the price and had consequences [Demyanyk and VanHemert, 2011]. Not only locally, but also globally. Martin (2011) has pointed out the so-called "glocalisation" concept. Globalization, ICT revolution as well as financial deregulation have increased the inter-connectivity between cities. Making it easier the shift from a "locally originate and locally-hold" model of mortgage credit to a securitization of mortgage credit characterized by "locally originate and globally distribute" model [Martin, 2011]. Therefore, the classic boom-burst American housing market collapse spread like a wildfire around the world through internationalized cities.

The great recession puts back the economic geography at the center of the debates. It has raised the importance to understand the linkage between local and global in order to have a deep understanding of the financial crisis [Aalbers, 2009, O'Brien and Keith, 2009]. Since the globalization era, the world was wrongly seen as "flat rather than curved". However, the combination of an increase in cost of transaction and a decrease in cost of transmission have resulted in a trade-off between localization and globalization [McCann, 2008] shaping the spatial heterogeneity of regional development with the dominance of internationally connected metropolitan areas. As a result, it is deemed necessary to assess the geographical effect of the great recession on European cities. The analysis of the geographical and political consequences of the great recession matter because they are likely to worsen the stability of the European project.

Given the long-lasting consequences of the financial crisis, there are numerous policy implications at the European and national level. This paper contributes to the economic geography literature to avoid that "it misses the next boat" [Engelen and Faulconbridge, 2009, Lee et al., 2009, Sokol, 2013]. From a regulation perspective, the European Union and national authorities have to work hands to hands in order to find a consensus between globally coordinated, locally decentralized regulation focused on the micro economic stability of the financial sector and a centralized intervention mechanism based on macroeconomic prudential perspective [Bieri, 2009, DiGiorgio and DiNoia, 2009]. From a political perspective, the traditional trade-off between terri-

torial equality and spatial concentration has to be rethought in order to be consistent with the EU 2020 Strategy [Martin, 2008].

The following section draws the existing literature on the driving factors of regional growth as well as evidences. Section 3 highlights the database that I use. Then, section 4 presents descriptive statistics summarizing my database. Section 5 describes the two specifications used for my purpose. Finally, section 6 and 7 present respectively the results and the conclusion of this thesis.

2 Literature Review

Now that I highlight the financial crisis from a geographical perspective, this section first aims at summarizing the existing literature about the comparative advantages of cities. Then, I review theories related to convergence. Besides, I portray the definition and the sources of resilience. These topics are directly linked to the purpose of this thesis.

2.1 Triumph of metropolitan cities? A theoretical perspective

Looking at the gross domestic product generated by the different European regions on figure 6, there is a distinction between center and periphery. This dichotomy is the reflect of technological and industrial differences. A second feature is the concentration of advanced tertiary sector such as commandment functions of firms and the financial sector. It ensures a role of central nodes in the globalized economy as it can be seen on figure 7 [Vandermotten et al., 2010]. These characteristics echo two important theories referred as agglomeration economics and network paradigm. In this thesis, I aim at capturing these effects by defining cities as functional urban areas and by using a population size-based typology.

2.1.1 Agglomeration economics

Agglomeration economies can be defined as the benefits arising from the concentration of economic activities and workforce [Polese, 2005, Melo et al., 2009]. This concept is closely linked to the notion of population size and labor pool. In general, it can be observed that the regions with a high level of value added are those with a high population density as it can be seen on figure 8. A reason for this positive correlation is the availability of a diversified workforce and the presence of a wide range of economic activities. As a result, the concentration of supply and demand allows to decrease costs of transaction and information [Glaeser, 1998, Glaeser, 2010, Taylor, 2006].

According to the core-periphery model introduced by Krugman, spatial concentration of economic activities is a self-fulfilling phenomenon giving incentive for the other firms to be located in this area [Krugman, 1991, Baldwin, 1999].

Other elements can be identified as a determinant of agglomeration economies. The concentration of economic activity fosters positive spillover effect due to the increasing interactions [Polese, 2005]. Besides, the concentration of advanced services and financial activities such as "company headquarter, financial institution and governmental organization", mainly located in metropolitan areas, foster agglomeration economies [Zheng, 2001, Turok, 2004].

Nevertheless, this theory that puts weight on metropolitan cities is confronted with several challenges. These regions are characterized by a high population density likely to increase the housing prices and commuting times generating more greenhouse gas emission [Zheng, 2001, Dijkstra et al., 2013]. Consequently, congestion effects create a negative externality which can result in a decentralization process and increase the attractiveness of regions located nearby large cities [Glaeser, 1998, Glaeser, 2010]. However, even cities characterized by a low population density can be confronted with environmental issues due to tourists activity combined with the environmental issues [Vandermotten et al., 2010].

Evidence that "bigger is better", all things being equal, is weak across time when metropolitan cities are characterized by connectivity and location of commandment functions[David et al., 2013]. Despite the mixed evidence about a positive relationship between economic concentration/size and economic growth as well as the methodology issues raised by the endogeneity, this idea is commonly accepted by new economic geographers and policy makers.

2.1.2 Network paradigm

The network paradigm can be defined as a club good, that is, the positive externality is generated by the inclusion of the city into a global network. Topologically, a network consists of nodes and links that display a pattern of connections. According to this definition, cities can be seen as the nodes, the European economy as the "supra nodal network level" and advanced services based industry "forming a critical sub nodal level" [Taylor, 2001, Borgatti and Foster, 2003].

The interaction between each node becomes possible thanks to the emergence of globalization and the development of ICT [Camagni, 1993]. These revolutions highlight the importance of metropolitan cities which are considered as complex nodes and gateways for transmitting essential information [Sassen, 2005]. This paradigm marks the transition of the "space of places" to "the

space of flows" [Castells, 1996, E.Meijers, 2007]. In other words, it is the end of a state-centric approach based on the Christallerian pattern [Beaverstock et al., 2000]. Sassen argues that the globalization implies a dispersion of economic activity around the world. In parallel, there is a need to centralize the different functions to gain efficiency. As a result, given the characteristics of capitals and metropolitan cities, they are the right place to centralize the economic activity [Sassen, 2005, Pflieger and Rozenblat, 2010].

The metropolitan cities are often characterized by the "centers of political power, centers of national and international trade, centers of banking and insurance services, centers of advanced professional activity of all kinds, centers of information, centers of conspicuous consumption, centers of art" [Hall, 1996]. Therefore, they are the central nodes of the world economy. Mainly, this structure is mono-centric giving a large weight on the capital city such as London and Paris. Meanwhile, Germany is poly-centric due to the extent of a federal system that improves the decentralization and the connectivity between cities within the country. Metropolitan cities are also characterized by a large international inter-connectivity due to the variety of access to the city [Dobruszkes and Rérat, 2010]. Besides, the network effect benefits also to cities around the main nodes. The second rank cities are complementary and benefit from synergies with the metropolitan cities [Capello, 2000, Meijers, 2005]. In addition, the surrounding metropolitan areas take an edge of their relative proximity and the low level of population density [Adam, 2006].

In policy terms, the models developed in the new economic geography argue for the existence of a trade-off between national growth and territorial equality [Martin, 2008]. The focus on agglomeration economics and the network paradigm privilege competition rather European cohesion as a key factor of development leading to an increasing disparity between regions and a concentration in the metropolitan area. This philosophy is translated into the EU 2020 strategy by mentioning that "metropolitan areas play an important role in sustaining the EU global competitiveness" [Dijkstra et al., 2013]. In this paper, I try to capture these two effects by including a classification based on population size and a definition of city based on the labor pool. These criteria allow to capture the availability of a diversified workforce and the concentration of economic activity.

2.2 From the bottom to the top: do European cities converge across time?

Another source of economic growth is provided by the convergence theories. The extent of convergence is an important issue in European Union given the integration of developing cities. The economic literature define two types of convergence: σ-convergence and β-convergence. The

former refers to the reduction in inequality of income between economies over time. The latter refers to the a negative correlation between economic growth and its initial level of income over time [Young et al., 2008]. In this thesis, I consider convergence as a β-convergence. In this section, I highlight two main theories: the classical and the cumulative causation approach.

The classical model explains that the process of convergence between developed and lagging cities take place without any external intervention. In a nutshell, poor city specializes in labor intensive activity while the developed city specializes in capital intensive activity. Assuming that production factors are paid according to their marginal productivity, capital intensive workers receive higher wages than labor intensive workers. Due to the perfect mobility of production factors, it leads to a migration towards the most productive place until that the marginal productivity equals between cities [Barro and Salai-Martin, 1992, Dorry, 2014]. According to this perspective, economic growth should be higher in the cities located in lagging countries than in developed countries [Gennaioli et al., 2013].

In reaction to this theory, the model of cumulative causation brings another view by explaining the source of divergence. This theory highlights the importance of long-term structure in order to understand regional disparities. In other words, initial disparities reproduce, or not, spatial inequality due to the cumulative consequences of the regional situation. Endogenous growth, economic and monetary integration, agglomeration economies, concentration of highly skilled workforce, infrastructure development are sources of positive externalities that exert a centripetal force in the city [Martin and Sunley, 1998, Martin, 2001]. These factors lead the region to a virtuous circle that results in higher growth perspective. Meanwhile the migration of highly skilled workforce, the absence of infrastructure, local congestion are factors that provoke a centrifugal effect likely to foster the economic decline [Krugman, 1998, Gardiner et al., 2011]. In order to better understand this phenomenon, Vermotten (1990) describes the evolution of economic inequality between the North Italy and the Mezzogiorno. Before the Italian revolution, they had similar economic activity relying on the primary sector. Then, divergence occurred due to the entrepreneurial and capitalist mindset present in the North, meanwhile the South was aristocratic and did not open to the economy [Vandermotten et al., 2010].

Evidences of regional convergence in the European Union are mixed. Some authors do not find empirical evidence of regional convergence [Boldrin et al., 2001]. Despite the common believe saying that European integration leads to convergence, models testing classical theory as well as non-classical theory draw the conclusion that the convergence may take centuries before it happens

[Fingleton, 1999]. Nevertheless, it is admitted that there is a "before" and "after" the crisis in terms of convergence. Before the financial crisis, evidence of convergence between group of European countries emerges, but the convergence remains low within countries [Puga, 2002, EU, 2007]. In particular, a convergence arises between Eastern European countries and Western European countries [Forgo and Jevcak, 2015, Borsi and Metiu, 2013]. After the crisis, the convergence process stops in terms of gross domestic product and unemployment, especially in the Southern regions [EU, 2013, Z.Darvas and Pisani-Ferry, 2011]. One possible explanation is the presence of national effect [Cuadrado-Roura, 2001]. Evidence points out that regions converge faster than nation, but the convergence remains slow due to national factor such as capital market regulation [Gennaioli et al., 2013]. This thesis differs slightly from these works because I test empirically the convergence between European cities. More importantly, I aim at analysis in which extent the financial crisis has affected this trend.

2.3 Resilience: from definition to evidence

Resilience has several aspects [Davies, 2011]. In this paper, I define resilience as a two-step process: the initial characteristics of cities, 2003–2007, that mitigate a negative shock during the crisis period, 2008–2010, and that foster adaptation during the post-crisis period, 2011–2013. This definition is closed to the concept of ecological resilience pointed out by Martin (2012). It is "the scale of shock or disturbance a system can absorb before it is destabilized and moved to another stable state or configuration. Focus is on far from equilibrium behavior of system" [Martin, 2012].

The institutions, cultural and political, play an important role in order to ensure the resilience and, especially, to foster adaptability. Currently, authors argue that the political power is inefficient to strengthen resilience calling for a growing awareness in terms of regional policy [Eraydin, 2016, Fratesi and Rodriguez-Pose, 2016]. In the same vein, Marques (2015) emphasizes the uneven consequences of an imbalance power in the government for the development of Portuguese economy towards high value added economy [Marques, 2015]. Then, the labor market structure plays an important role to adjust the economy. The extent of pro supply side policy, such as flexible labor market, allows to be more resilient in time of crisis [Andersson et al., 2015, Bell and Eiser, 2016]. This result is not consistent with Wojciky and MacDonald-Korth (2015). In the United Kingdom, he observes a spatial concentration with London as "the sole winner". In contrast, Germany has not experienced a change in spatial distribution reflecting the political structure of the country [Wojciky and MacDonald-Korth, 2015]. In addition, culture, such as interpersonal trust as well as

cultural diversity, allows to foster entrepreneurial resilience by increasing their ability to adapt [Huggins and Thompson, 2015].

Some authors shed light on the importance of small and medium sized companies in order to promote resilience. They are seen as a risk free engine for growth because of their dynamism and the lower pressure exerted by international companies [Clark et al., 2004]. Nevertheless, their development depends on the financial structure of the economy. A decentralization of financial services foster the provision of fund to them [Klagge and Martin, 2005, Hutton and Lee, 2012].

Another important element of resilience is the economic structure. Because some sectors are correlated with the economic fluctuations, they represent a greater risk for the economic stability [Groot et al.,]. In summary, resilient regions are those based on the specialization in "tradable and export-oriented sectors, dynamic and productive industries such as energy, some manufacturing and some advanced market services" [Dokic et al., 2016, Petrakos and Psycharis, 2016, Cuadrado-Roura and Maroto, 2016]. In opposition, the crisis does not hit severely the peripheral regions relying on agriculture and tourism thanks to the healthiness of other countries [Palaskas et al., 2015]. Davies (2010) points out the ability to recover of the manufacturing sector and the persistent negative trend in the sector of construction [Davies, 2011, Caro, 2014]. Secondly, regions benefiting from agglomeration and network effects experience a greater resilience due to the location of the most creative functions [Capello et al., 2015, Gabe et al., 2013]. Nevertheless, investment in advanced technology as well as in research and development to gain a position of world cities may be a waste of money for peripheral regions [Charlot et al., 2015]. Finally, of a major importance for peripheral countries, some macroeconomic factors shape the resilience. "A healthy current account surplus is associated with stronger economic performance during the post-2008 recession. Conversely, high public debt countries are more successful in sheltering their regional economies in the short run" [Crescenzi et al., 2016].

Another strand of literature focuses on a regional perspective. According to the European Commission, most metropolitan regions and capital city metro regions are stronger than small metropolitan regions [EU, 2013]. Brakman et al. (2015) and Fingleton et al. (2015) endorse this point of view. The former finds that regions with high population density and high activity in advanced technology is more prompt to cope the crisis [Brakman et al., 2015]. While the latter argues that the crisis has a significant impact on isolated regions characterized by high sovereign debt and low productivity [Fingleton et al., 2015]. Dijkstra (2015) brings a more nuanced point of view: "The crisis has led to big contractions especially in urban regions and in remote rural regions,

while intermediate and rural regions close to a city displayed more resilience" highlighting the character pro cyclical of capital city [Dijkstra et al., 2015].

In this thesis, I focus especially on the last two strands of literature. I restrict the analysis of resilience to a sector-based approach: agriculture, manufacturing, construction, financial and advanced services, administration as well as human capital. In addition, I point out characteristics of cities associated with their population size, i.e. agglomeration and network effects. Despite the relevance of other sources of economic growth, I do not pay attention to their impact. Nevertheless, there is a scope to analyze the impact of macroeconomic conditions, research and development as well as the total productivity factor at European cities level for instance.

3 Data

My database consists on a panel data composing of 1 515 units of observation, functional urban areas considered as cities, coming from 26 European countries over the period 2003–2013. I construct the functional urban areas based on Eurostat data at NUTS 3 level. The nomenclature of territorial units for statistics, NUTS, is defined as a "geographical nomenclature subdividing the economic territory of the European Union into regions at three different levels according to a set of criteria". For a better understanding, you can keep in mind that the level 0 corresponds to the states. The level 1 takes into account regions such as the federal regions in Belgium and the "länder" in Germany. The level 2 represents most of European regions. But for this analysis, I go one step further and I use one of the most disaggregated data available on Eurostat. The NUTS 3 level includes administrative units with a population threshold between 150 000 and 800 000 inhabitants. In summary, these data include "départements" in France, "arrondissements" in Belgium, "provincie" in Italy and "kreise" in Germany for instance. This requirement restricts the availability of data. Nevertheless, I try to deal with it to take into account every part of the European Union. The table 8 in appendix summarizes the countries that are taken into account in the analysis. Given the lack of data or the unreliability, I do not take into account Croatia, Switzerland, Norway, Portugal and Macedonia. In addition, the France overseas and Spanish islands are also omitted. It is not problematic because these cities have either a low economic weight or are not part of the European Union. The following section describes how I construct the functional urban areas variables.

3.1 Cities as functional urban areas

By constructing the functional urban areas, I define the concept of city. A city is not only an administratively-delineated area, but a place characterized by a labor pool [ESPON, 2007]. In other words, a city is composed by the city itself and the share of surrounding agglomeration which economically contributes to the city. The extent of a labor pool associated with a NUTS 3 unit is determined by a coefficient based on commuting statistics. In this analysis, the coefficients are considered as given by my supervisor, Professor G. Van Hamme. This coefficient represents the percentage giving what part of the NUTS 3 variable, such as gross domestic product, is associated with a single functional urban area. The sum of each adjusted NUTS 3 value corresponding to a functional urban area gives the variable value of this functional urban area.

Table 1: Description variables data set at NUTS 3 level

Indicator	Explanation	Period	Source
Economic growth	Based on GDP at current market price purchasing power standard in million €. No data of GDP at basic price on Eurostat.	2003-2013	Eurostat
Population	Criteria used for the typology. I assume typology is constant for the studied period.	2014	Eurostat
Agriculture	Gross value added at basic prices in A Eurostat activity in million €. It corresponds to the primary sector.	2003-2013	Eurostat
Manufacturing	Gross value added at basic prices in C Eurostat activity in million €. Exception for Poland where I use B-E Eurostat categories in million €.	2003-2013	Eurostat
Construction	Gross value added at basic prices in F Eurostat activity in million €	2003-2013	Eurostat
Finance and advanced services	Gross value added at basic prices in K-N Eurostat activity in million €. Exception for UK where I use only K Eurostat activity in million €.	2003-2013	Eurostat
Administration	Gross value added at basic prices in O-U Eurostat activity in million €. Exception for UK where I use only O-Q Eurostat activity in million €.	2003-2013	Eurostat
Education	Share of tertiary diploma in the active population. I assume the share is constant through time.	2001	Eurostat; Labour Force Survey

The definition of a city is a controversial and a complex exercise. However, the use of functional

urban area presents several advantages. Firstly, it allows a have a better sense of a city and to compare every European cities according to a single definition. Secondly, it allows to partly capture the whole labor pool that can be spread around overcrowded city. Thirdly, functional urban areas correspond to the vision of the Europe 2020 highlighting their importance for regional growth and territorial cohesion. Nevertheless, it is important to keep in mind the drawbacks associated with this definition. By bringing together NUTS 3 units into functional urban areas, I skip the underlying mechanism that characterized each NUTS 3 unit. For instance, manufacturing is assumed to be the same in each city. This method is likely to hide the heterogeneity between cities. In addition, this method increases the gap between metropolitan cities and the others due to the importance of their labor pool.

Now that I fix the definition of functional urban area and city, I am able to construct the different variables based on Eurostat data at NUTS 3 level. The table 1 above summarizes the variables gathered for this purpose. I point out that one indicator misses for Poland and United Kingdom. For the latter, I decide to restrict the indicator Finance to the K Eurostat category and to replace the indicator Administration to O-Q Eurostat category. For the former, I decide to replace the sector manufacturing by the sector industry (except construction) providing by the Eurostat. Even if we have to be cautious with this replacement, I deem that these sectors are acceptable proxies. On the one hand, it is a subcategory of the financial and advanced services sector. On the other hand, it is a category quietly related to manufacturing activities. In addition, it allows to have strongly balanced data over the period 2003–2013.

To transform NUTS 3 unit variables to functional urban areas variables, I use the following methodology which is also described in the ESPON report [ESPON, 2011]:

$$Variable_{FUA_{it}} = \sum_{i=1}^{n} \alpha_i Variable_{NUTS_{it}} \tag{1}$$

Where the variables with subscript FUA_{it} and the variables with subscript $NUTS_{it}$ are respectively the variables associated with the functional urban area i and with the NUTS 3 unit i at time t, α_i is the coefficient associated with the NUTS 3 unit and n =the number of NUTS 3 units belonging to FUA_i.

Now that I have the variable values of functional urban areas, I am able to derive the variables

of interest for the empirical analysis:

$$GDPgrowth_{FUA_{it}} = ln(GDP_{FUA_{it}}) - ln(GDP_{FUA_{it-1}}) \tag{2}$$

$$EconomicStructureShare_{FUA_{it}} = \frac{Sector_{FUA_{it}}}{GDP_{FUA_{it}}} \tag{3}$$

The equation (2) refers to the economic growth of the functional urban area i at time t. The equation (3) refers to the share of sector activities in percentage of gross domestic product of functional urban area i at time t. This latter is computed for the four different economic activities introduced above. These variables are those used the empirical analysis. It can be noted that it would optimal to use employment data rather than gross domestic product for endogeneity issue. Nevertheless, the lack of data restrict my analysis. Summary statistics of these variables are presented in the table 9 in the appendix section.

3.2 Cities typology

Even if the functional urban area definition allows to compare cities in the European Union, I dress a typology of these cities in order to capture the different underlying mechanisms, and consequently, the heterogeneity of the financial crisis. Based on Eurostat population data in 2014 and the typology provided by the ESPON 1.4.3 report, I draw a list of every functional urban area used in this analysis. In the following sections, I use this classification: metropolitan, large, medium, small and other cities. I assume that cities have the same typology over the period 2003–2013. It can be problematic for the cities that are located at the threshold and likely to change or for cities subject to migration. Nevertheless, it should lead to more consistent results. The following table 2 describes these criteria [ESPON, 2007].

This typology makes sense in my analysis because it allows to disentangle the different cities characteristics. The first two typologies are likely to capture the advantage of agglomeration and network effects. Metropolitan regions are the economic engine in the European Union. They have a dominant position in the European economy thanks to the globalization and the development of ICT. They are considered as central nodes where are located commandment functions, services activities and financial sectors. They are the gateways for the world economy. That is why metropolitan area as well as poly functional urban areas, at European level, are considered as the nodes for the insertion in a competitive international economy. I group these categories together, denoted metropolitan, in the empirical analysis. From a political perspective, these categories are the most

relevant because it drives the future of Europe in the Lisbon perspective.

Table 2: Cities typology

Typology	Criteria
Metropolitan area	FUA population > 500 000 inhabitants
Poly FUAs	2 metropolitan areas with their centers < 60 km apart and labor basins touching each other; 2 large areas with their centers < 30 km apart and labor basins touching each other; 1 metropolitan and 1 large/medium area with their centers < 30 km apart and labor basins touching each other; 2 metropolitan areas with their centers < 60 km apart and labor basins separated only by the labor basin of a smaller FUA touching the both of them.
Large area	FUA population > 250 000 inhabitants
Medium area	FUA population > 100 000 inhabitants
Small area	FUA population > 50 000 inhabitants
Other area	FUA population < 50 000 inhabitants

While large, medium, small and other cities are likely to capture the importance of the industrial, administrative and agricultural sectors to mitigate the effect of the crisis. Even if these areas can host important globalized activity, they cannot be considered as central node. It is the case of large and medium cities which have an economic weight at the country level thanks to the connection with metropolitan areas. Besides, large and medium areas are considered as the technological heart of Europe. These regions are globally more industrialized than metropolitan regions. Small and other cities can be seen as economically neutral. However, it is possible to distinguish two types. On the one hand, regions relying on Fordist structure such as Paris area. It consists on exogenous investment that drive the economy. On the other hand, regions relying on Marshallian industrial district composed by small and medium sized companies [Vandermotten et al., 2010].

4 Descriptive statistics

This section aims at emphasizing the main variables that I describe in the previous section. It allows us to provide some preliminary insights to answer to my research questions by focusing

on convergence, resilience, agglomeration and network effects. I pay a particular attention to analyze the functional urban areas data over three relevant periods: pre-crisis (2003–2007), crisis (2008–2010) and post-crisis (2011–2013) period.

4.1 The convergence of cities across 2003–2013

To observe the convergence between European cities, table 3 displays the average economic growth by city groupings and by period. Given the heterogeneity of structure between countries, I draw a distinction between cities of Western Europe, Nordic countries, Southern Europe, Eastern-Central Europe and Baltic countries.

Table 3: Average GDP growth rates by city groupings (in %)

	2003–2007	2008–2010	2011–2013
Eastern-Central Europe	7.56	2.36	3.34
Southern Europe	6.96	-1.60	-1.16
Nordic cities	5.31	0.62	2.18
Baltic cities	10.28	-3.93	7.15
Western Europe	4.49	-0.31	2.11

During the pre-crisis period, Baltic and Eastern-Central European cities have, on average, the best economic performances. Their average pre-crisis economic growths are respectively 10.28 percent and 7.56 percent. Several explanations can be highlighted: catching-up process of metropolitan cities, the increase in investment from Western regions, the European economic integration and European transfers. Metropolitan cities are the main actors of this growth [EU, 2013, EU, 2014, Dijkstra et al., 2015, Vandermotten et al., 2010]. This trend results in a reduction of economic disparities in the European Union, especially between East and West.

Nevertheless, the financial crisis affects this convergence process. Public expenditure has risen sharply since 2008. In addition, most of economic activities declined due to the lower demand. As a result, regional disparities in terms of gross domestic product increase or stop narrowing between European regions [EU, 2014]. Eastern-Central cities are the most resilient with an average crisis economic growth of 2.36 percent. In contrast, Baltic and Southern European cities have the lowest crisis economic growth, on average, with respectively -3.93 and -1.60 percent.

During the post-crisis period, Baltic and Southern European cities display an opposite pattern. On the one hand, Baltic cities recover high growth performance with 7.15 percent. On the other hand, Southern cities face off a persistent negative economic growth. These results can be explained

by the impact of the financial crisis on the real estate market [EU, 2014]. Finally, it can be noted that Nordic and Western European cities are less subject to wide economic variation.

Due to the uneven impact of the crisis, the convergence in terms of gross domestic product between European cities becomes mixed. Table 3 shows that convergence is mainly a story between East and West Europe. In the empirical analysis, I control for this difference in order to obtain accurate estimation of convergence.

4.2 Relationship between typology and economic performance

To observe the relationship between population size and economic performance, table 4 describes the evolution of economic growth by typology across time. According to agglomeration economies and network effects, the largest cities should experience higher economic performance than the smallest cities across time.

Table 4: Average GDP growth rates by typology (in %)

	2003–2007	2008–2010	2011–2013
Metropolitan	5.04	0.01	1.98
Large	4.99	-0.60	2.08
Medium	4.96	-0.73	1.72
Small	4.90	-0.72	1.47
Other	5.51	-0.51	1.27

From a global point of view, metropolitan areas have the highest economic growth over the period 2003–2013. This result can be partly explained by the importance of agglomeration economies and network effects. By decomposing the studied period, the situation is nuanced. During the pre-crisis period, the larger the city, the higher is the economic performance. Notice the exception of the other cities that experience an average growth of 5.51 percent. During the crisis period, metropolitan areas are the only cities that have, on average, a positive economic growth. The other typologies have a relatively similar decline. In addition, large and metropolitan areas experience the highest economic growth during the post-crisis period. This result partially contradicts what we expect: "metropolitan cities are more prone to boom and burst" [EU, 2014].

We need to be cautious in interpreting these results because I do not control for fixed effects. As a result, the typology is likely to hide the heterogeneity among countries as it is shown in tables 10, 11 and 12. The economic growth pattern of typology is rooted in the country framework. Based on these graphs, I can draw several observations.

By looking at the pre-crisis period in table 10, it can be seen that each country experience, on average, an economic growth higher than 2 percent. As we have seen above, Eastern-Central European cities and Baltic cities have higher economic growth than other countries. This observation is consistent through the different typology. Furthermore, the growth is mainly driven by the metropolitan cities in Bulgaria, Estonia, Romania, Lithuania and Latvia that have an economic boom during this period. The differential of economic growth between countries is also visible in the large cities. Nevertheless, it seems that the out-weight of Eastern-Central and Baltic cities is low for medium, small and other typology. It means that metropolitan areas, and especially capitals, have an important weight in these countries and that the growth is probably not inclusive.

During the crisis period, as described in table 11, the economic growth pattern is different according to the typology. We have seen that metropolitan areas are the most resilient cities. Nevertheless, the picture has to be nuanced. It can be seen that it is due to the good performance of Bulgaria, Poland, Slovakia, Hungary and Romania during the crisis. Excepted for Denmark, other metropolitan cities experience a negative economic growth or closed to zero. In these countries, metropolitan areas have an important weight and bring together most of advanced function. As a result, the resilience of metropolitan areas can be at the expense of the smallest cities. In addition, Latvia and Ireland experience severe economic downturn. In Ireland, the smallest cities are the more affected by the crisis than the largest while the opposite holds for Latvia.

During the post-crisis period, as described in table 12, cities in Cyprus, Greece and Spain have the lowest economic performance. While the negative impact of the crisis is similar through typology in Spain and Cyprus, metropolitan areas are more affected than the other typologies in Greece. Among metropolitan areas, it can be observed that cities in Estonia, Lithuania, Romania and Latvia have the highest economic growth. The dominance of Baltic cities is clear in medium, small and other cities. In contrast, it can be seen that the other countries have a low economic growth that oscillates around 1 and 2 percent of economic growth.

These observations shows that economic growth of cities is embedded in the national context. In order to disentangle these effects, I control for country effects in each specification that I use in the empirical section.

4.3 Resilience: a first descriptive assessment

This subsection provides a first assessment of resilience of cities. According to European Commission: "Overall, the highly developed member states were less affected by the crisis [...] The biggest

reduction in gross value added was in construction, manufacturing and agriculture" [EU, 2014]. In this section, I look at the relationship between the average economic structure of cities during the pre-crisis period, 2003–2007, and the average change in gross domestic product during the crisis, 2008–2010, and post-crisis period, 2011–2013. I aim at providing a first assessment of factors that lead to a higher economic growth in these two periods. Nevertheless, it is a bivariate descriptive analysis subject to cautious because I do not control for fixed effects. I treat this issue in the following part of the thesis. In addition, I describe the economic structure of cities by typology in table 13.

At first, I analyze the relationship between the pre-crisis average financial and advanced services sector in percentage of gross domestic product and the average economic growth during the crisis, on the left-hand side, and the average economic growth during the post-crisis, on the right-hand side. The slope is negative in both cases, meaning that an additional share of financial and advanced services in percentage of gross domestic product decreases the crisis and post-crisis economic growth on average. Therefore, it does not provide insight to consider this sector as a source of resilience.

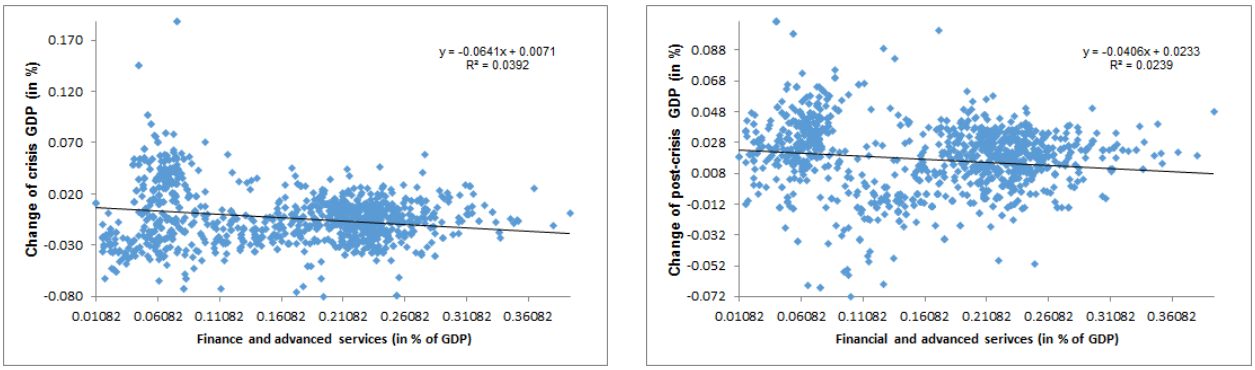


Figure 1: Relationship between the average pre-crisis share of financial and advanced services and the average crisis/post-crisis GDP growth

The table 13 shows the evolution of the average growth in financial and advanced services by typology over time. Relative to small and other cities, it can be seen that the largest areas present the lowest growth in financial and advanced services during the pre-crisis period. During the crisis period, the negative impact is relatively limited because each typology experience, on average, a positive growth. The impact of the crisis is limited due to the strength of Western cities and the underdevelopment of Eastern-Central and Baltic cities in these sectors [EU, 2014]. Due to the presence of main financial and advanced services activities in metropolitan areas, they experience

a growth twice bigger than all the other typologies. Nevertheless, some European capital cities and specialized cities such as Frankfurt in finance suffer from the burden of the financial crisis [EU, 2011b]. During the post-crisis, the average growth is positive in each typology but do not recover the pre-crisis level. Finally, it can be pointed out that metropolitan cities have the largest growth in financial and advanced services activities.

Secondly, I analyze the relationship between the average share of manufacturing sector in percentage of gross domestic product during the pre-crisis and the average economic growth during the crisis, on the left-hand side, and the average economic growth during the post-crisis, on the right-hand side. It can be observed that the relation between the share of manufacturing activities in percentage of gross domestic product and the crisis economic growth is negative. Nevertheless, this sector is positively correlated with the post-crisis economic growth. This behavior means that this sector is pro-cyclical. In other words, the manufacturing sector follows the business cycle. It does not mitigate the negative impact of the crisis but fosters the recovery.

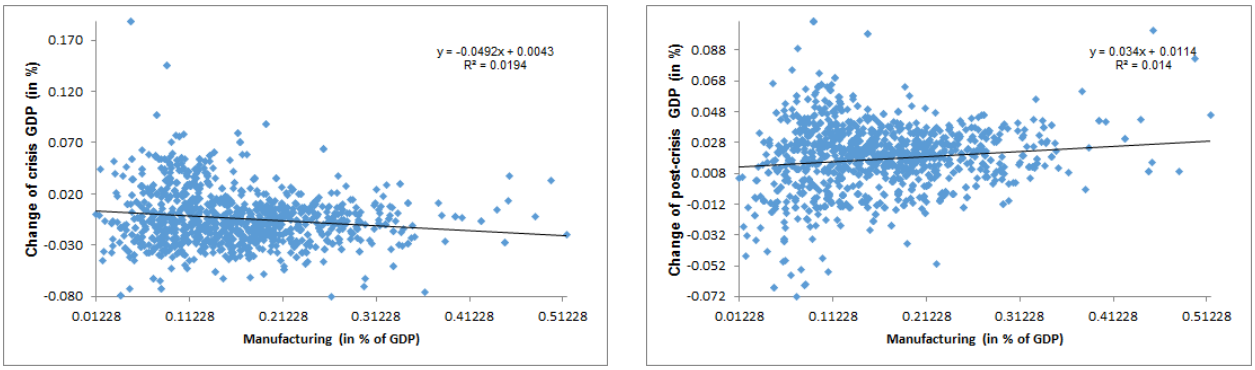


Figure 2: Relationship between the average pre-crisis share of manufacturing and the average crisis/post-crisis GDP growth

Concerning the manufacturing activities, it can be observed on table 13 that the smaller the city, the higher is the growth in the manufacturing sector during the pre-crisis period 2003–2007. However, each typology seems to be hit by the crisis without a clear pattern in terms of population size. Taking into account the national context, it can be said that the growth in Baltic and Eastern-Central cities is high because of "the balance between labor costs, productivity and accessibility created an attractive location for manufacturers" [EU, 2014]. In addition, "the overall potential manufacturing vulnerability is the highest in countries with high impact of financial crisis and low business stimulus: Denmark, Sweden, Slovakia, the UK, the Baltic states and parts of Romania and Hungary" [EU, 2011b]. During the post-crisis period, large cities have the highest average growth

in manufacturing activities. While the smallest cities are far from their initial level of growth.

Thirdly, I analyze the relationship between the average share of construction sector in percentage of gross domestic product during the pre-crisis and the average economic growth during the crisis, on the left-hand side, and the average post-crisis economic growth, on the right-hand side. In both cases, the sector is negatively correlated with crisis and post-crisis economic growth. It can be observed that the slope is steeper in the crisis case than the post-crisis situation. It is in line with the poor performance of this sector during the crisis period.

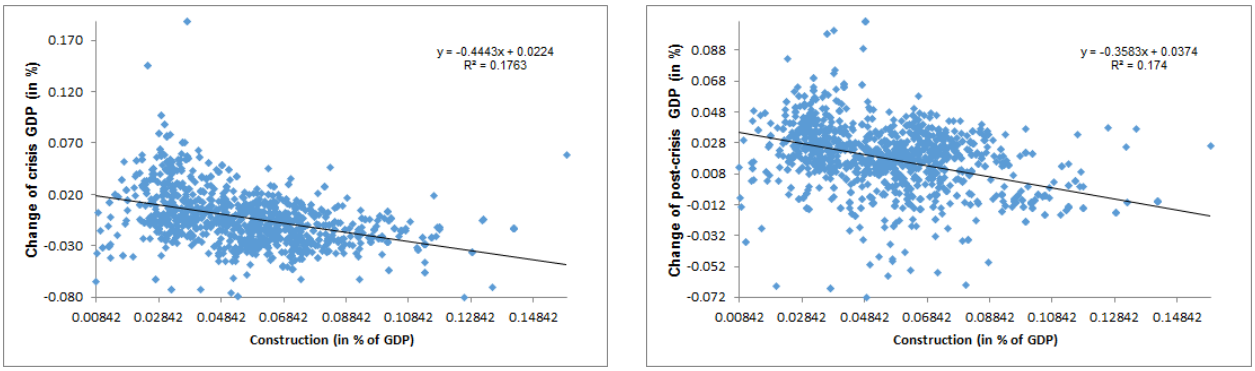


Figure 3: Relationship between the average pre-crisis share of construction and the average crisis/post-crisis GDP growth

The pattern in the construction sector is quietly different of manufacturing as described in table 13. While the manufacturing sector recovers a positive average growth during the post-crisis period, the average growth in construction activities remain negative. It can be observed that smaller the city, higher is the average growth in construction. Nevertheless, this growth is subject to high fluctuation because the smallest cities experience the highest decline during the crisis period. From a country perspective, "the reduction was largest in the three Baltic States, Ireland, Greece and Spain, in all six of which a large real estate bubble burst as the financial crisis hit"[EU, 2014]. Due to the generalized impact of crisis on construction, the most vulnerable cities are those specialized in tourism [EU, 2011b].

Fourthly, I analyze the relationship between the average primary sector in percentage of gross domestic product during the pre-crisis on the average economic growth during the crisis, on the left-hand side, and the average post-crisis economic growth, on the right hand side. It can be observed that the correlation between the average share of the primary activities in percentage of gross domestic product and the average crisis economic growth is negative. Nevertheless, this sector is positively correlated with the average post-crisis economic growth. It should be explained

by the low variation of the primary sector during the crisis relative to the gross domestic variation. Nevertheless, the low importance of primary sector in city leads me to not interpret these results in the empirical sections.

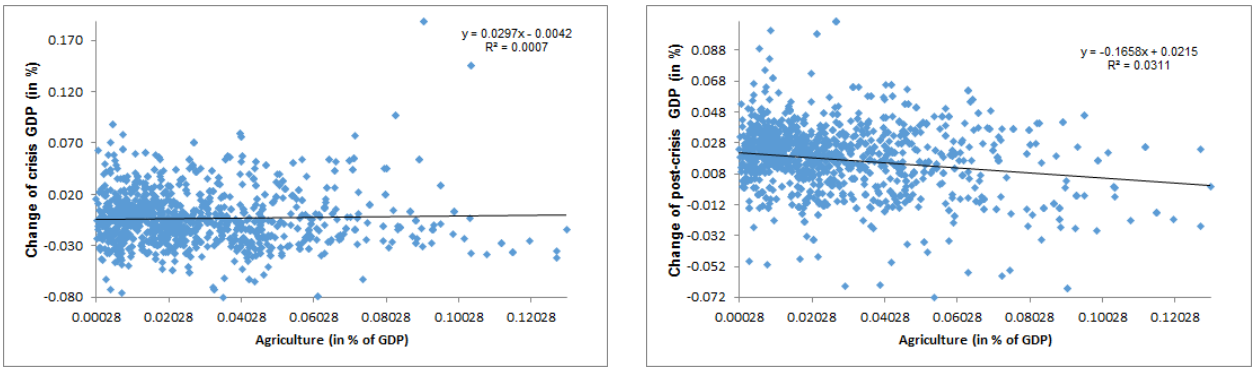


Figure 4: Relationship between the average pre-crisis share of agriculture and the average crisis/post-crisis GDP growth

Looking at table 13, during the pre-crisis period, the small cities experience higher performance in the primary sector than the largest cities. Nevertheless, metropolitan and small areas are the less resilient typology during the crisis. During the post-crisis period, the smaller the city, the higher the growth. The growth is important in Baltic cities and Eastern-Central cities where modernization and restructuring is an ongoing process in these regions [EU, 2014].

Finally, I analyze the relationship between the average share of administration sector in percentage of gross domestic product during the pre-crisis and the average economic growth during the crisis, on the left-hand side, and the average post-crisis economic growth, on the right-hand side. It can be observed that the slope is negative in both cases. I may think that administration is a factor of resilience because it should not vary with crisis.

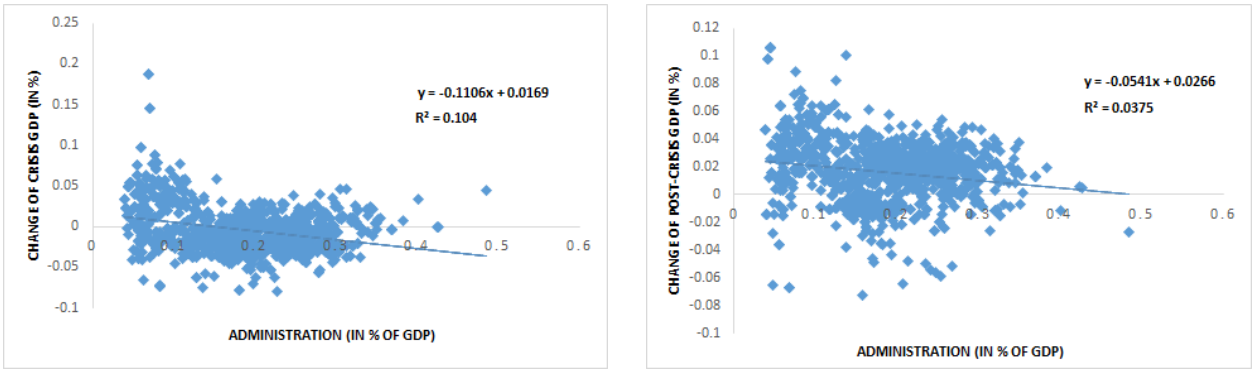


Figure 5: Relationship between the average pre-crisis share of administration and the average crisis/post-crisis GDP growth

Looking at table 13, it can be seen that smaller the city, the higher is the average growth in the administration sector. During the crisis, this sector is not particularly affected. Nevertheless, it can be noted that the average growth during the post-crisis is lower than during the crisis period. It can reflect the implementation of austerity measures.

5 Model specifications

In this section, I describe the specifications used for my research questions. These models are suggested by previous empirical works. Firstly, I point out the specification to analyze the economic performance of European cities over the period 2003–2013 [Petrakos and Psycharis, 2016, Dokic et al., 2016]. Secondly, I focus on capacity of resilience of cities during the crisis and post-crisis period [Davies, 2011, Crescenzi et al., 2016].

5.1 Analysis of economic performance of European cities over the period 2003–2013

To explain the economic performance of European cities, I implement an augmented conditional convergence model. Promoted by Krugman and Solow, this methodology is commonly used in the economic geography but this model differs in several points. At first, I observe economic structure indicators at NUTS 3 level aggregated into functional urban areas for the European Union. Secondly, I take into account the diversity of cities thanks to the typology based on population statistics and the ESPON report. Thirdly, I aim at answering to three issues:

1. Do we observe convergence or divergence between European cities? In which extent the crisis affects this trend?

2. Which characteristics are correlated with higher economic growth?

3. In which extent the crisis affects the economic growth?

For this regression, let's firstly consider the following general model:

$$y_{it} = \alpha + \beta x_{it} + \epsilon_{it} \tag{4}$$

Where y_{it} is the dependent variable: gross domestic product growth rate; α is the intercept; β is a $kx1$ vectors of coefficients on the explanatory variables and ϵ_{it} is the error term; $t = 1,...,T$; $i = 1,...,N$.

This model is relevant because it enables to observe the impact of different variables on economic growth. That is why as explanatory variables, I include the indicators of the economic structure of cities, an indicator of human capital, an indicator of the initial economic strength to emphasize the convergence hypothesis as well as numerous binary variables reflecting the typology of cities and the specific impact of the financial crisis.

Taking into account the dependent variables, the specification of the model is as follows:

$$\Delta y_{it} = \alpha + \beta_1 ln(y_{it-1}) + \beta_2 ln(y_{it-1}) \times crisis_t + \beta_3 x_{j_{it}} + \beta_4 x_{j_{it}} \times crisis_t + \beta_5 x_{j_{it}} \times typology_i + \beta_6 x_{j_{it}} \times typology_i \times crisis_t + \beta_7 education_i + \epsilon_{it} \quad (5)$$

where $\epsilon_{it} = typology_i + \lambda_t + \phi_c + u_{it}$;

$$\text{where} \quad \begin{cases} i = 1, ..., n \quad \text{where} \quad n = 1515 \quad \text{number of cities} \\ j = 1, ..., k \quad \text{where} \quad k = 5 \quad \text{number of economic structure variables} \\ t = 2003, ..., 2013 \quad T = 11 \quad \text{number of years} \end{cases}$$

The methodology I use to estimate this equation is the fixed effects panel data regression. This model allows to control for omitted variables that vary either across time but do not change across country/typology or across country/typology but do not change over time. Therefore, the error term can be decomposed into a country fixed effect, ϕ_c, a typology fixed effect, $typology_i$, a time fixed effect, λ_t, and a residual error term, u_{it}. Given the nature of my data, this model is the most coherent. That is why I put aside the test for random effect model or pooled model.

In this model specification (5), the dependent variable, Δy_{it}, is the percentage change in gross domestic product for the city i at time t while $ln(y_{it-1})$ represents the logarithm of the lagged gross domestic product for the city i at time t. They are respectively denoted $GDPgrowth_{it}$ and $ln(GDP_{it-1})$.

The coefficient associated with the variable $ln(y_{it-1})$ measures the extent of convergence or divergence between cities in the European Union. If this coefficient is negative, it means that cities with a high level of gross domestic product at time $t-1$ will experience a negative economic growth at time t. In this particular case, it leads to a convergence between cities with a high and a low level of gross domestic product. According to the classical theory, I expect a negative coefficient. Otherwise, it contradicts the convergence hypothesis between cities.

However, numerous authors have pointed out the limited regional convergence across time and

the end of economic convergence since the financial crisis. To test the impact of the financial crisis on convergence trend, I include the interaction variable $ln(y_{it-1}) \times crisis$ – denoted $ln(GDP_{it-1})^{crisis}$. The variable *crisis* is a dummy variable equal to 1 for the period 2008–2010 and zero otherwise. It corresponds to the length of the economic recession. In this case, the estimation of convergence can be seen as the sum of β_1 and β_2. Therefore, if β_2 is positive and higher than β_1, it means that the financial crisis increases divergence during this period.

Then, the variable $x_{j_{it}}$ is a matrix $5x16665$ of economic structure indicators. It includes the share of gross value added in the primary sector of city i in percentage of its gross domestic product at time t – $Agriculture_{it}$; the share of gross value added in the manufacturing sector of city i in percentage of its gross domestic product at time t – $Manufacturing_{it}$; the share of gross value added in the construction sector of city i in percentage of its gross domestic product at time t – $Construction_{it}$; the share of gross value added in the financial and advanced services sector of city i in percentage of its gross domestic product at time t – $Finance_{it}$; the share of gross value added in the administrative sector of city i in percentage of its gross domestic product at time t – $Administration_{it}$. These variables highlight in which extent the economic sector contributes to the economic growth of cities. Moreover, I add an interaction variable between the crisis, as defined above, and the economic structure indicators. These variables are denoted with the superscript *crisis* It should emphasize how these sectors affect the economic growth during the crisis period.

Besides, $typology_i$ is a $5x16665$ matrix including binary values to summarize the five cities classifications: metropolitan, large, medium, small and other areas. They are supposed to approximate the importance of agglomeration and network effects on the economic growth. In terms of typology, I expect positive coefficient associated with metropolitan areas even if they are more likely to be exposed to external shock than small areas due to their high level of globalization.

Moreover, I add an interaction variable between the typology and the economic structure. The coefficient associated with the interaction of these two variables describes the impact of different economic sectors conditionally to the size of the city on the economic growth. It is important because the economic structure indicators are broad and heterogeneous. For instance, manufacturing activities can be totally different in German industrial pool and the Eastern cities. I also try to disentangle the crisis effect by interacting the crisis period with the previous variable. Among the sectors composing the economic structure, the great recession affects primary the financial sectors. Thus, I expect a negative relationship between the dependent variable and a high percentage of gross value added in this sector in the metropolitan areas.

Finally, I include a indicator of human capital. In the economic literature, it represents the most important variable. Given the lack of data, I use this indicator with a restricted sample of cities. I expect that the coefficient associated with this indicator is positive.

The results are estimated using a sample of 1515 cities using the fixed effects panel data model over the period 2003–2013. The panel data approach presents several advantages. It allows to increase the efficiency and the accuracy of the estimates and the fixed effect allows to control for every variables that vary across individual but are constant over time. In addition, the error is clustered at the functional urban area level. I estimate this regression using the program Stata and the command *xtreg*.

5.2 Analysis of European cities resilience

To assess quantitatively the resilience of cities in the aftermath of the financial crisis, I adopt another specification based on the resilience definition. This specification differs from previous empirical work because it also takes into account the ability to adapt and recover its initial economic condition during the post-crisis period at the European city level. In addition, I use empirical techniques to take into account the effect on the crisis and post-crisis condition. In summary, I aim at answering to two issues:

1. What initial characteristics of cities mitigate the effect of the financial crisis during the crisis period?

2. What initial characteristics of cities allow to recover their economic growth during the post-crisis period?

In order to emphasize the impact of initial economic structure of cities on the economic growth depending on the period, I divide the sample into three sub-periods: pre-crisis period, 2003–2007, crisis period, 2008–2010, and post-crisis period, 2011–2013. Therefore, the first issue is based on the study of correlation between the economic growth during the crisis and the pre-crisis economic structure. While the second question is based on the study of correlation between the post-crisis economic growth and the pre-crisis economic structure.

This methodology presents several advantages. At first, it facilitates the analysis because I use the average over the relevant period to estimate the regression. Secondly, it allows to deal with the reverse causality issue. It can be assumed that the initial condition has an impact on the future

economic growth. The opposite is not true. Thirdly, it allows to disentangle which characteristics of cities, initially, affect the crisis and post-crisis economic growth.

Based on the general model (2), the specification to test the first part of resilience definition is as follows:

$$\Delta y_{i,t}^{average} = \alpha + \beta_1 ln(y_{i,t-1}^{average}) + \beta_2 x_{j_{i,t-1}}^{average} + \beta_3 typology_i + \beta_4 education_i + \epsilon_i \tag{6}$$

where $\epsilon_i = \phi_c + u_i$;
The model specification to test the second part of resilience definition is as follows:

$$\Delta y_{i,t+1}^{average} = \alpha + \beta_1 ln(y_{i,t-1}^{average}) + \beta_2 x_{j_{i,t-1}}^{average} + \beta_3 typology_i + \beta_4 education_i + \epsilon_i \tag{7}$$

where $\epsilon_i = \phi_c + u_i$;

$$\text{where} \begin{cases} i = 1, ..., n \quad \text{where} \quad n = 1515 \quad \text{number of cities} \\ j = 1, ..., k \quad \text{where} \quad k = 5 \quad \text{number of economic structure variables} \\ t-1 \quad = \quad \text{pre-crisis period, 2003–2007} \\ t \quad = \quad \text{crisis period, 2008–2010} \\ t+1 \quad = \quad \text{post-crisis period, 2011–2013} \end{cases}$$

In these models (6) and (7), $\Delta y_{i,t}^{average}$ and $\Delta y_{i,t+1}^{average}$ are respectively the average of gross domestic product growth in city i during the crisis period, time t, and the average of gross domestic product growth in city i during the post-crisis period, time $t+1$. They are the dependent variables in each specification.

The independent variables have to reflect the initial conditions, time $t-1$, that characterize the cities. That is why I include as explanatory variables for the two specifications, $ln(y_{i,t-1}^{average})$, the logarithm of the average gross domestic product growth in city i during the period 2003–2007. The coefficient associated with this variable does not reflect a convergence process but it highlights whether past good economic performance is correlated positively or negatively with the crisis and post-crisis economic growth. A city that invest in capital intensive activity creating wealth or a city with good economic health should expect to be more resilient to the crisis.

Then, $x_{j_{i,t-1}}^{average}$ is a $5x1515$ matrix of economic structure indicators. I construct these variables by taking the average of the variable $x_{j_{it}}$ over the period 2003–2007. It includes the average

share of gross value added in the primary sector in percentage of its gross domestic product – $Agriculture_{i,t-1}$; the average share of gross value added in the manufacturing in percentage of its gross domestic product – $Manufacturing_{i,t-1}$; the average share of gross value added in percentage of its gross domestic product – $Construction_{i,t-1}$; the average share of gross value added in the financial and advanced services sector in percentage of its gross domestic product – $Finance_{i,t-1}$; the average share of gross value added in the administrative sector in percentage of its gross domestic product – $Administration_{i,t-1}$. Further, I also include the indicator of human capital.

Finally, $Typology_i$ includes the five classifications: metropolitan, large, medium, small and other areas. As described in the previous section, they are supposed to identify whether metropolitan areas are more likely to mitigate the effect of the crisis.

In contrast to the previous model, the data set does not constitute a panel data. By averaging every variable over the different period, it is possible to analyze the correlation between the different period thanks to the robust OLS estimators. In addition, I control for the country fixed effect to take into account omitted variables that vary across country but do not change within the country.

6 Results

This section summarizes the results coming from the specifications described above. Firstly, I focus on the impact of typology and economic structures of European cities on economic growth as well as the extent of a convergence process over the period 2003–2013. Secondly, I assess the resilience of European cities according to their characteristics.

6.1 Economic performance of European cities 2003–2013

Table 5 summarizes the main results related to the regressions of the economic growth on various sets of independent variables. Each column reports a different regression with the same dependent variable: the gross domestic product growth rate. For each row, the table reports the coefficient estimate and the standard error in parenthesis. Moreover, I control for the time and the country fixed effects.

Looking at the variables associated with typology, it can be seen that the coefficients are negative and increasing with population size. Because metropolitan cities are the reference group, metropolitan cities perform better than large, medium, small and other cities over the period 2003–2013. This result is consistent through each specification. All things being equal, the smaller

Table 5: Results of the econometric model using the fixed effects panel data model

Dependent variable: $GDPgrowth_{it}$	Specif. (1)	Specif. (2)	Specif. (3)	Specif. (4)	Specif. (5)
$Constant$	0.074***	0.082***	0.147***	0.146***	0.131***
	(0.006)	(0.006)	(0.008)	(0.009)	(0.022)
$ln(GDP_{it-1})$	-0.001**	-0.002***	-0.003***	-0.003***	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$ln(GDP_{it-1})^{crisis}$		0.004***	0.004***	0.004***	0.003
		(0.001)	(0.001)	(0.001)	(0.002)
$Agriculture_{it}$			-0.072***	-0.103***	-0.168*
			(0.017)	(0.017)	(0.090)
$Manufacturing_{it}$			-0.058***	-0.053***	-0.085***
			(0.007)	(0.007)	(0.023)
$Construction_{it}$			0.191***	0.273***	0.419***
			(0.020)	(0.022)	(0.074)
$Finance_{it}$			-0.140***	-0.146***	-0.177***
			(0.014)	(0.014)	(0.039)
$Administration_{it}$			-0.138***	-0.141***	-0.193***
			(0.009)	(0.010)	(0.031)
$Agriculture_{it}^{crisis}$				0.113**	0.477***
				(0.045)	(0.163)
$Manufacturing_{it}^{crisis}$				-0.022**	0.006
				(0.010)	(0.032)
$Construction_{it}^{crisis}$				-0.311***	-0.390***
				(0.033)	(0.100)
$Finance_{it}^{crisis}$				0.026**	0.049**
				(0.011)	(0.023)
$Administration_{it}^{crisis}$				0.007	0.010
				(0.014)	(0.038)
$Education_i$					0.113***
					(0.023)
$Large$	-0.004***	-0.004***	-0.006***	-0.006***	-0.005**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$Medium$	-0.006***	-0.006***	-0.010***	-0.010***	-0.010***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)
$Small$	-0.008***	-0.008***	-0.013***	-0.013***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
$Other$	-0.009***	-0.009***	-0.013***	-0.014***	
	(0.002)	(0.002)	(0.002)	(0.002)	
Observation	15150	15150	15150	15150	1529
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: These regressions estimate equation (5) using fixed effects panel data for 26 countries. Regression (1) through (5) uses data from 2003 to 2013. Table reports estimation associated with the different level of significance (*p<0.1; **p<0.05; ***p<0.01). All models control for country, typology and time fixed effects.

the population size, the lower is the economic growth in the city. As highlighted in the literature review, this result confirms that, over the studied period, metropolitan areas benefit from their position as central node and the agglomeration economies.

Columns (1) and (2) of table 5 report the regressions that test the extent of convergence between cities and check the impact of the financial crisis on this convergence process. I find that the coefficient associated with the logarithm of gross domestic product at time $t-1$ is negative and significant at level 5 percent. A 10 percent increase in the gross domestic product at time $t-1$ will decrease the economic growth by $0.001 * log(1.1) = 0.001$ percent. This result confirms the hypothesis of convergence between cities because a city with a high (low) level of gross domestic product will experience a lower (higher) economic growth. In addition, column (2) aims at testing how the crisis has affected the convergence process by introducing an interaction variable between the logarithm of gross domestic product at time $t-1$ and the crisis period 2008–2010. This result brings a more nuanced point of view on convergence. It can be seen that the coefficient is positive and significant at level 1 percent. During the crisis period, the convergence can be defined as the sum of these two coefficients: -0.002 and 0.004. As the sum is positive, it means that there is not convergence during the crisis. Further, divergence occurs during the financial crisis. Nevertheless, there is no evidence that the convergence is stopped as suggested by the literature. Given my results, I state that there is a convergence over the period 2003–2013. However, within the studied period, the divergence occurs during the financial crisis.

No changes when control variables for the economic structure of cities are added. As reported in column (3), the coefficients on the logarithm of lagged gross domestic product remain consistent. Moreover, the third regression emphasizes the impact of the economic structure on economic growth. It can be noted that every sector, excepted construction, has a negative effect on the economic growth. Firstly, increasing the share of manufacturing activity in percentage of gross domestic product by 1 percent decreases the economic growth by 0.058 percent. Secondly, increasing the share of financial and advanced services sector in percentage of gross domestic product by 1 percent decreases the economic growth by 0.140 percent. Thirdly, increasing the share of administrative sector in percentage of gross domestic product by 1 percent decreases the economic growth of 0.138 percent. In contrast, construction activities have positive coefficient significant at level 1 percent. In other words, an additional percentage of construction activities in percentage of gross domestic product increases the economic growth by 0.191 percent. Therefore, it can be highlighted that construction sector is the main driver for economic growth.

The fourth regression in table 5 provides additional information. In a first step, column (4) aims at describing the effect of the economic structure on the economic growth. In a second step, I disentangle the impact of the economic structure during the crisis period on the economic growth. The results can be described as follows. At first, financial and advanced services activities have a negative impact on the economic growth. An increase in financial and advanced services sectors by 1 percent leads to a decrease in economic growth by 0.146 percent. However, it can be observed that financial and advanced services have a positive effect during the crisis period on the economic growth. The coefficient associated with the interaction variable is 0.026. Secondly, construction activities have a positive impact on economic growth. An increase by 1 percent of construction sector increases the economic growth by 0.273 percent. Nevertheless, construction activities have a negative impact significant at level 1 percent during the crisis. Thirdly, the manufacturing activities affect negatively the economic growth while these activities does not significantly generate economic growth when they are present during the crisis period. Finally, while the administrative sector has a negative significant impact, it can be observed that the administrative sector has not significant impact on the economic growth during the crisis. In summary, financial and advanced services are the only sector that have a positive impact on economic growth during the financial crisis.

Moreover, I regress the same equation as column (4) but I include interaction effects to take into account the presence of each sector in each typology. Table 6 summarizes the sign of the coefficient associated with the interaction for the studied period (left) and the crisis period (right). The reference typology is the metropolitan areas. In comparison with metropolitan areas, an additional percentage of manufacturing in a large, medium, small and other cities lead to a higher economic growth than in metropolitan areas. Nevertheless, the effect is not significantly different from zero during the crisis. Besides, an additional percentage of construction activities in large, medium and small cities lead to a lower economic growth than metropolitan cities. In contrast, the effect is opposite during the crisis period.

Finally, the last regression introduces an important driver of the economic growth i.e. human capital. It can be observed that the proportion of highly educated inhabitant has a positive impact on economic growth at level 1 percent. Increasing the share of tertiary educated in percentage of active population increases the economic growth by 0.113 percent.

From this section, several results can be highlighted. At first, metropolitan areas have better performance than the other typologies across 2003–2013. Secondly, convergence process occurs

Table 6: Coefficient sign of interaction between economic structure and typology resulting from the equation (5)

	Agriculture	Manufacturing	Construction	Finance	Administration
Large	+/-	+/0	-/+	-/0	+/0
Medium	+/-	+/0	-/+	0/0	0/0
Small	+/0	+/0	-/+	0/0	0/0
other	+/0	+/0	0/+	-/0	0/0

Note: Table reports the sign of each coefficient (statistically significant) associated with interaction of the typology and the economic structure. On the left, it corresponds to the sign associated with the economic structure at time t $\beta_5 x_{j_{it}} \times typology_i$. On the right, it corresponds to the sign associated with the economic structure during the crisis period $\beta_6 x_{j_{it}} \times typology_i \times crisis_t$. When there is a 0, it means that the coefficient is not significant.

during the studied period but divergence occurs during the financial crisis. Thirdly, constructions sectors and human capital are the engine of the economic growth over the period 2003–2013. Fourthly, only financial and advanced services sectors have a positive impact on economic growth during the crisis.

6.2 Cities resilience

Table 7 summarizes the results of regressions of the average economic growth during the crisis, 2008–2010, and post-crisis, 2011–2013, period on various sets of regressors. Each row reports a coefficient estimate and the standard errors in parenthesis. For each regressions, I control for the typology and the country variables.

The left-hand side of the table 7 reports the results for the regression of the impact of the initial average economic structure, 2003–2007, on the average economic growth during the financial crisis. Firstly, the coefficient on the logarithm of average pre-crisis gross domestic product is not statistically different from zero through the different specifications. It means that cities with a high level of economic performance during the pre-crisis period do not experience a high level of economic growth during the crisis. Rather than reflecting the convergence between cities, this estimate reflects the economic health of cities. Therefore, this result does not confirm the initial economic performance mitigates the negative impact of the financial crisis.

Taking into account the economic structure of cities, it can be seen that the initial average share of administration, manufacturing, financial and advanced services in percentage of gross domestic product affect negatively and significantly the average economic growth during the crisis period. While agriculture and construction activities have not impact on the average economic growth, manufacturing, financial and advanced services activities has a similar negative consequence with

Table 7: Results of the econometric model using the robust OLS model

Dependent variable	Crisis			Post-crisis		
$GDPgrowth$	(1)	(2)	(3)	(1)	(2)	(3)
$Constant$	-0.007	0.020	0.019	0.024***	0.053***	-0.004
	(0.011)	(0.016)	(0.037)	(0.009)	(0.014)	(0.031)
$ln(GDP_{i,t-1})$	0.001	0.002	0.002	0.001	0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
$Agriculture_{i,t-1}$		-0.043	-0.040		0.038	0.128
		(0.036)	(0.140)		(0.027)	(0.105)
$Manufacturing_{i,t-1}$		-0.064***	-0.084***		-0.021*	0.045
		(0.014)	(0.031)		(0.013)	(0.033)
$Construction_{i,t-1}$		-0.025	0.118		-0.014	0.279**
		(0.049)	(0.105)		(0.032)	(0.115)
$Finance_{i,t-1}$		-0.060**	-0.115**		-0.022	0.034
		(0.026)	(0.046)		(0.022)	(0.045)
$Administration_{i,t-1}$		-0.027*	-0.075*		-0.062***	-0.040
		(0.017)	(0.041)		(0.016)	(0.039)
$Education_{i,t-1}$			0.087***			0.085***
			(0.029)			(0.027)
Observations	1515	1515	154	1515	1515	154
R-squared	0.59	0.60	0.83	0.57	0.58	0.80
Country control	Yes	Yes	Yes	Yes	Yes	Yes
Typology control	Yes	Yes	Yes	Yes	Yes	Yes

Note: Table reports estimation associated with the different level of significance (*p<0.1; **p<0.05; ***p<0.01). All models control for time fixed effect.

a coefficient respectively equal to -0.064 and -0.060. It means that an additional percentage of manufacturing, financial and advanced services activities in percentage of the gross domestic product decrease the average economic growth respectively by 0.064 and 0.060 percent during the crisis. Therefore, the cities hosting a high share of administration, manufacturing, financial and advanced services activities worsen the average economic growth during the financial crisis. In column (3), I add an additional component of economic growth: human capital. It can be observed that it is the only coefficient positive and significant at level 1 percent. An additional percentage of tertiary educated in percentage of active population increases the economic growth during the crisis period by 0.087 percent. Therefore, it constitutes the only factor of resilience during the crisis based on this regression.

The right-hand side of the table 7 reports the results for the regression on the initial economic structure on the post-crisis economic growth. In column (1), the coefficient associated with the logarithm of the average gross domestic product during the pre-crisis is not statistically different

from zero. Therefore, it can be noticed that better performance during the pre-crisis does not implies an higher post-crisis economic growth. Then column (2) and (3) take into account the impact of economic structure on the average post-crisis economic growth. Looking at column (3), it can be seen that the manufacturing and the administrative activities have a negative impact on post-crisis growth. An additional percentage of manufacturing and administrative activities in percentage of the gross domestic product decreases the post-crisis average economic growth respectively by 0.021 and 0.062 percent. Looking at column (3), human capital have a positive and significant impact on the post-crisis economic growth. An additional percentage of tertiary educated in percentage of active population increases the post-crisis average economic growth respectively by 0.085 percent. Therefore, the pre-crisis construction activities and human capital are the only factors that foster the recovery after crisis.

From this section, several results can be highlighted. At first, better initial economic condition does not imply better average crisis and post-crisis economic growth. Secondly, the administrative, manufacturing, financial and advanced services sectors are the sectors that have a negative impact on the crisis economic growth. Thirdly, manufacturing and administrative sectors still have a persistent negative impact on the post-crisis growth. Fourthly, human capital is the only factor that improves the economic growth during the crisis and post-crisis period.

7 Conclusion

In this paper, I review the literature on agglomeration economics and the network paradigm, assuming a positive impact of population size on economic growth of cities. According to these theories, metropolitan areas benefit from the insertion in the national and world economy as well as positive externalities generated by the concentration of labor pool and economic activity. As a result, they are considered as the engine of growth. In addition, I point out the resilience of European cities based on their characteristics.

In this paper, I systematically test the impact of population size and economic structure on economic performance of cities in the European Union across the period 2003–2013. This paper draws several results. Firstly, metropolitan areas outperform the smallest cities over the period 2003–2013. It confirms the importance of metropolitan areas as engine of growth. Secondly, there is a convergence in terms of economic growth between cities over the period 2003–2013. However, within this period, divergence occurs during the financial crisis. Thirdly, the construction sector

and human capital are the engine of growth during the period 2003–2013. Fourthly, administrative, manufacturing and financial and advanced services activities affect negatively the economic growth over the studied period. Nevertheless, financial and advanced services are the only sector that has a positive impact during the crisis. Then, I test the resilience of European cities according to their characteristics. Manufacturing, administrative, financial and advanced services have a negative impact on the pre-crisis economic growth while manufacturing, financial and advanced services still have a persistent negative impact on the post-crisis economic growth. Human capital is the only factor of resilience during the crisis and post-crisis period.

Finally, I reach some limits which call for further work to achieve a better comprehension of economic performances of European cities and their resilience. In this paper, I use a typology based on population to assess the importance of agglomeration economies and network effect. This proxy is likely to be misleading. Other variables could be used such as proxy for connectivity, level of internationalization, *et cetera*. Besides, I do not take into account the spatial perspective in this analysis of the economic structure. The economic structure variable that I use in this analysis are broad and heterogeneous. In addition, we need to keep in mind the potential endogeneity issue of my results. This problem may be overcome by using employment data. Finally, I consider the ability to recover over the period 2011–2013. Nevertheless, this result can be biased by the sovereign debt crisis and not by the financial crisis itself. Then, most of economic geography paper relies on spatial econometrics. It allows to observe the direct and indirect spillover. In this paper, I treat cities as independent. One possible extension would be to use spatial econometrics and observe how the closest cities affect the economic growth of the metropolitan areas. Finally, I look at the impact of the economic structure, including human capital, on economic growth. Nevertheless, other important factors explain the economic growth such as research and development expenditure, level of debt, *et cetera*.

My results have several implications in terms of European policy. According to the EU 2020 objectives, "metropolitan areas play an important role in sustaining the EU's global competitiveness". My results lead us to the traditional trade-off between territorial equality and spatial concentration. On the one hand, metropolitan areas have the highest economic performance over the period 2003–2013 all things being equal. According to this result, it should lead to a concentration of economic activity in European central place. On the other other hand, human capital seems to be an important factor of economic growth. Increasing the proportion of tertiary educated inhabitant has a positive impact on economic growth and should foster catching up process of

European cities on metropolitan areas. Nevertheless, there is a lack of evidence to know how European Union should develop the smallest areas. This results correspond to willingness towards cohesion of the European Union: "Cities play a crucial role as engines of the economy, as places of connectivity, creativity and innovation, and as centers of services for their surrounding areas. There is a consensus on the key principles of future European urban and territorial development which should: be based on balanced economic growth and territorial organization of activities, with a polycentric urban structure and build on strong metropolitan regions and other urban areas that can provide good accessibility to services of general economic interest" [EU, 2011a].

Appendix

Appendix A

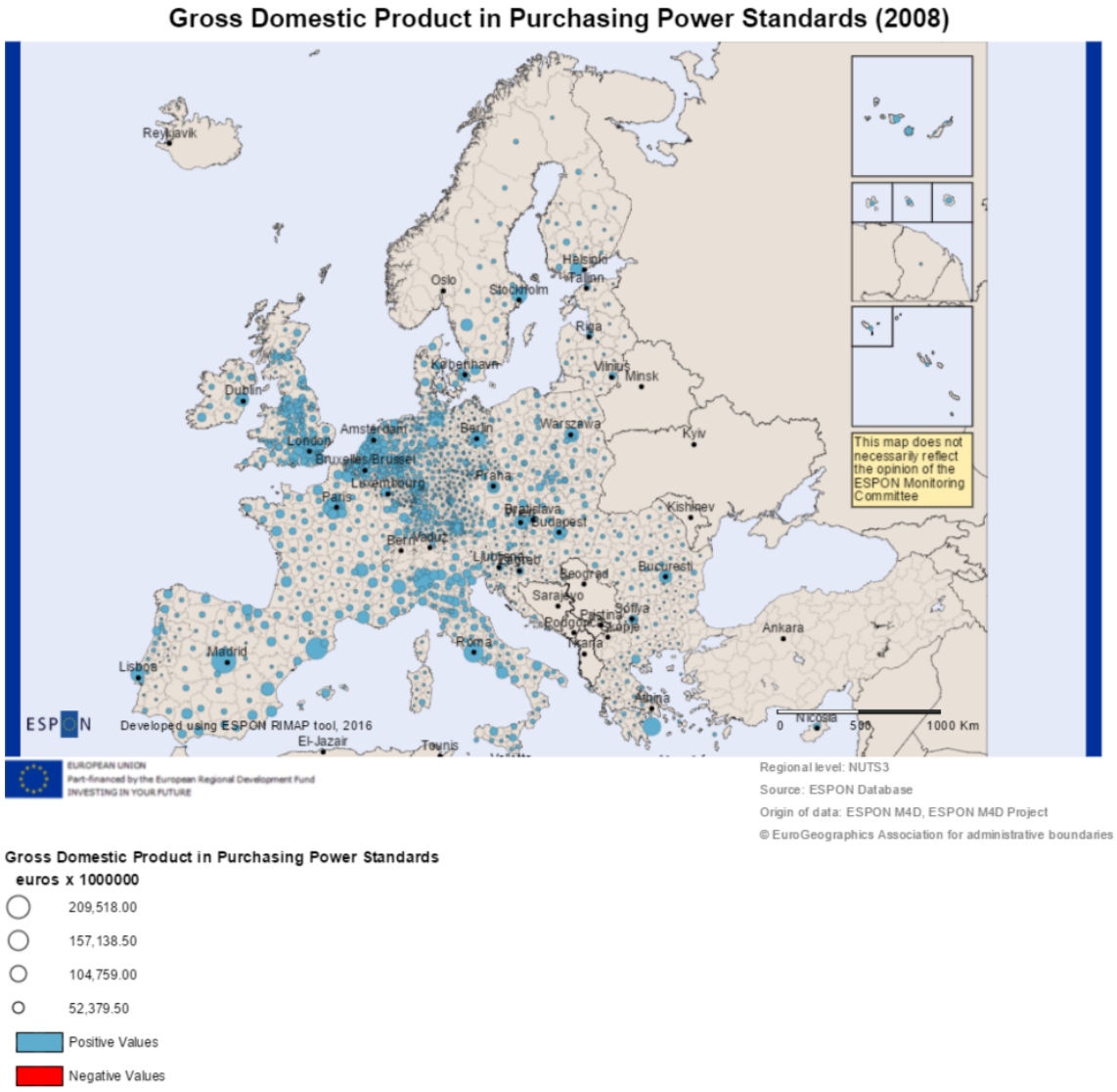


Figure 6: EU-28 GDP in purchasing power standards per inhabitant at NUTS 3 level – 2008.
Source: Graph generated by ESPON mapping tool

Appendix B

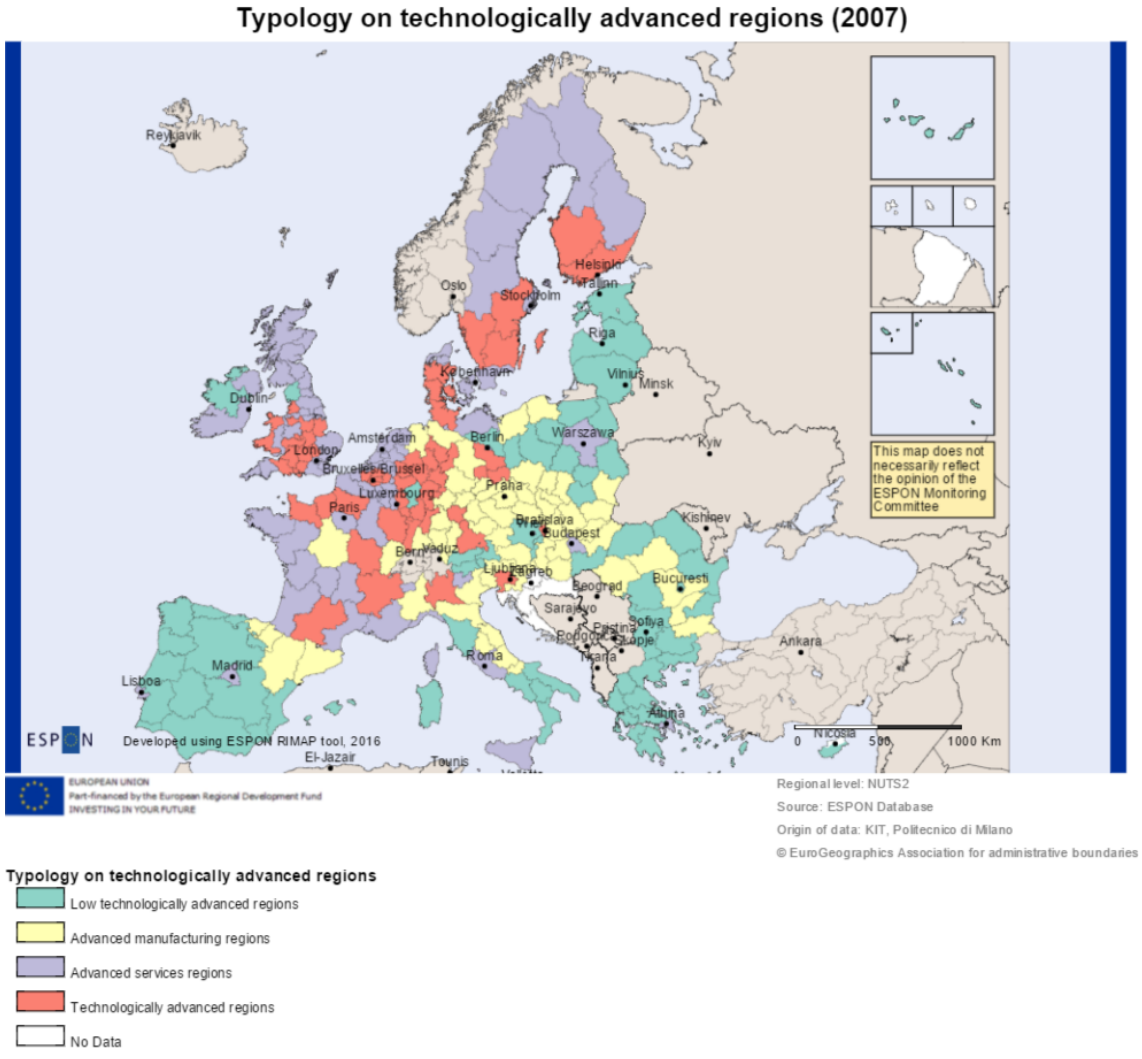


Figure 7: EU typology on technologically advanced regions at NUTS 2 level – 2007.
Source: Graph generated by ESPON mapping tool

Appendix C

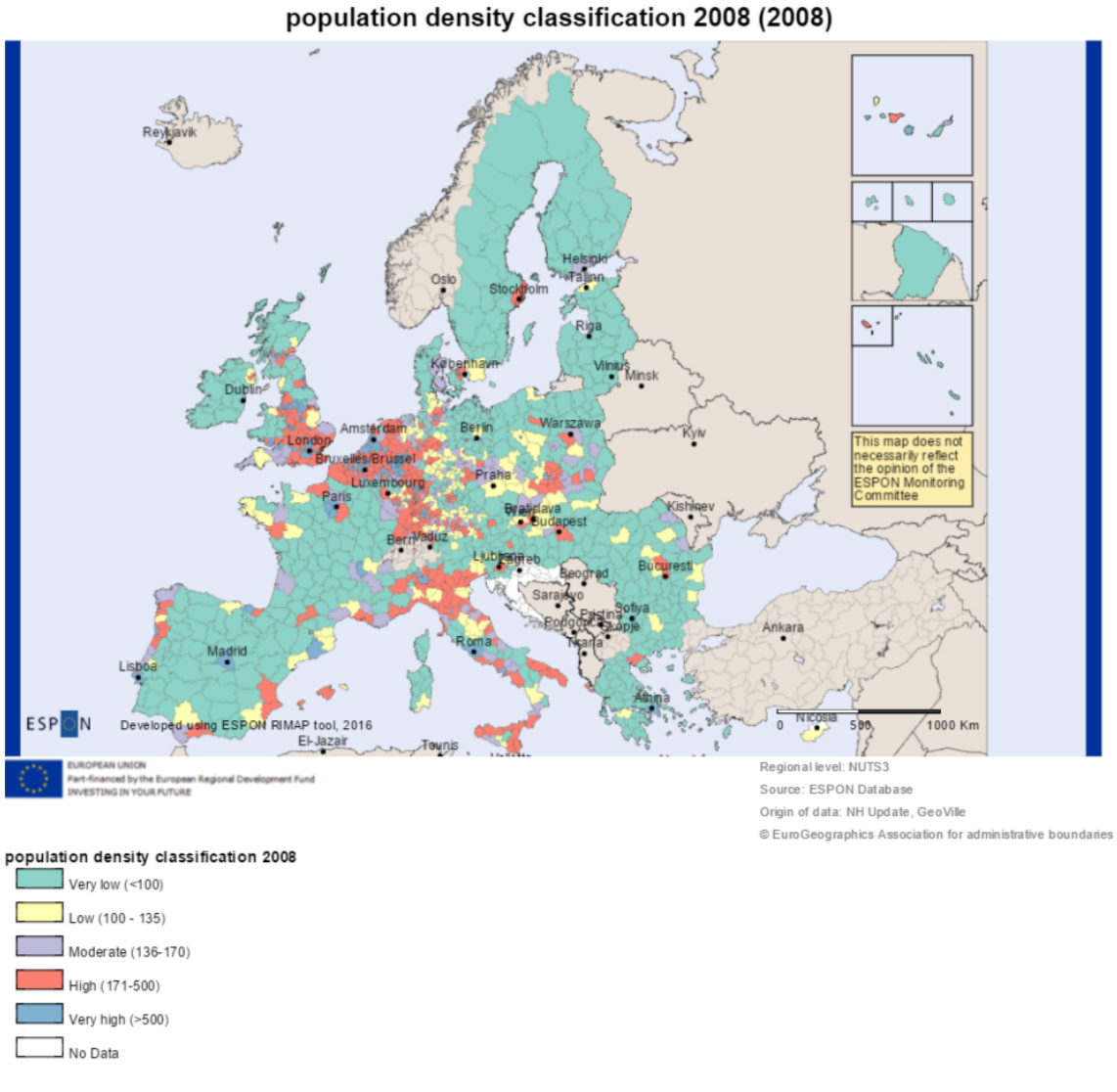


Figure 8: EU population density classification at NUTS 3 level – 2007.
Source: Graph generated by ESPON mapping tool

Appendix D

Table 8: Main functional urban areas (number of FUA per country)

Western Europe	Belgium (26)	Brussels, Antwerpen
	France (176)	Paris, Nantes, Marseille
	Luxembourg (1)	Luxembourg
	United Kingdom (109)	London, Birmingham, Manchester, Leeds-Bradford
	The Netherlands (64)	Noord-Brabant, Randstad Holland, Amsterdam
	Germany (187)	Berlin, Stuttgart, Rhein-Main, Ruhr, München-Augsburg
	Ireland (7)	Dublin, Cork
	Italy (265)	Roma, Milano, Napoli, Torino
	Austria (20)	Wien, Salzburg, Linz-Wels-Steir
Southern Europe	Cyprus (4)	Lefkosia, Lemassoss, Larnaka
	Malta(1)	Valletta
	Spain (169)	Madrid, Barcelona, Sevilla, Valencia
	Greece (26)	Athinai, Thessaloniki
Baltic countries	Lithuania (6)	Vilnius, Kaunas
	Latvia (6)	Riga
	Estonia (7)	Talinn
Nordic countries	Sweden (30)	Stockholm, Göteborg, Malmö
	Denmark (25)	Kobenhavn
	Finland (22)	Helsinki, Tampere, Turku,
Central Eastern Europe	Poland (88)	Warszawa, Katowice
	Bulgaria (33)	Sofia
	Romania (104)	Bucaresti
	Hungary(49)	Budapest
	Slovenia (7)	Ljubljana
	Slovakia (34)	Bratislava, Maribor
	Czech Repulic (49)	Praha

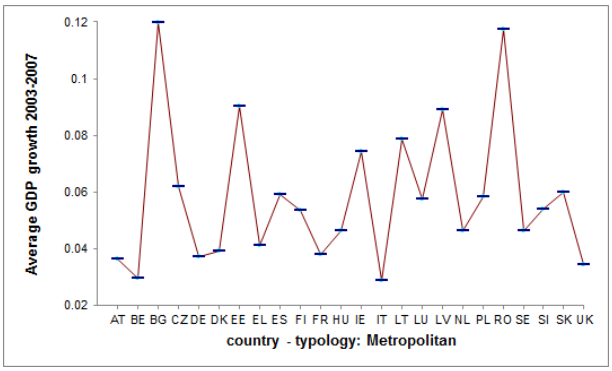
Appendix E

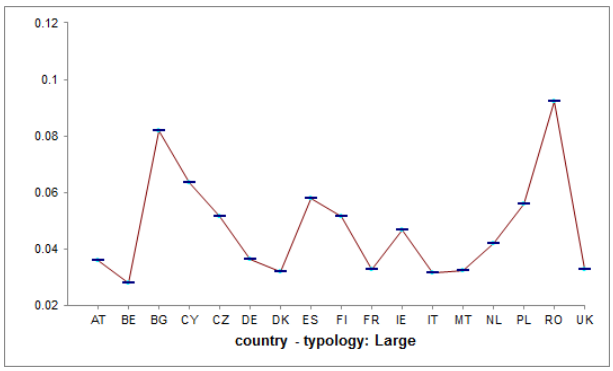
Table 9: Summary statistics variables

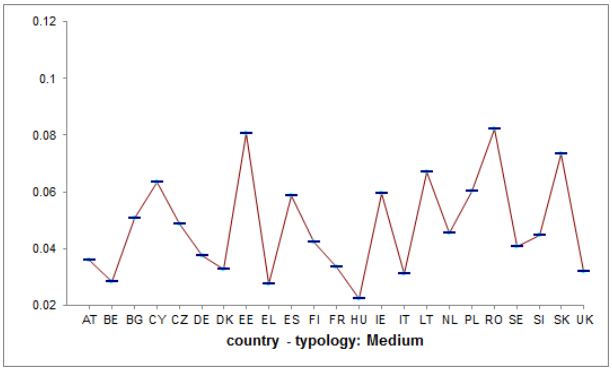
Variables	Mean	Standard deviation	Minimum	Maximum
GDP growth	0.023	0.05	-0.36	0.31
Agriculture (percentage of GDP)	0.028	0.022	-0.054	0.16
Manufacturing (percentage of GDP)	0.15	0.073	0.009	0.56
Construction (percentage of GDP)	0.06	0.023	0.003	0.18
Finance and advanced services (percentage of GDP)	0.17	0.082	0.008	0.45
Administration (percentage of GDP)	0.19	0.079	0.033	0.51
Education	0.22	0.086	0.052	0.41

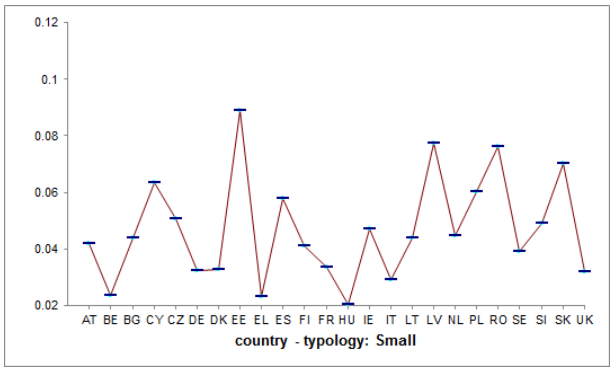
Appendix F

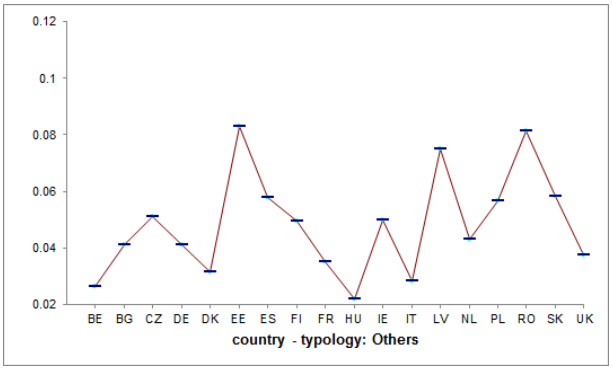
Table 10: Relationship between average GDP growth 2003–2007 and typology





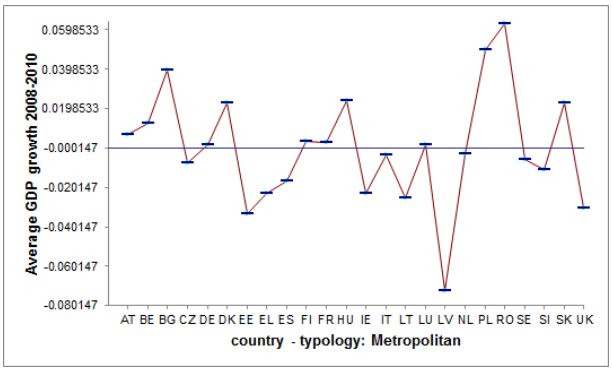


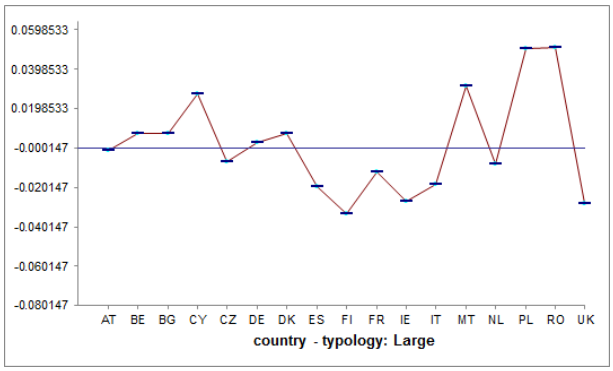


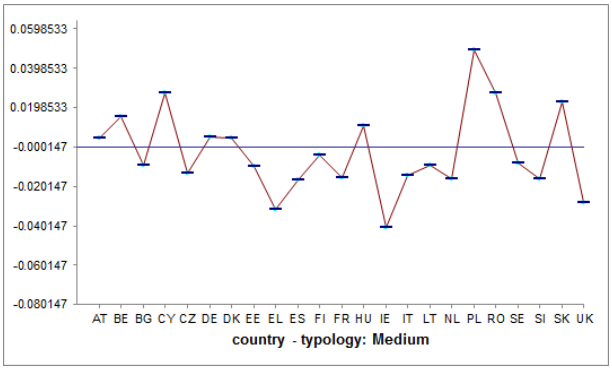


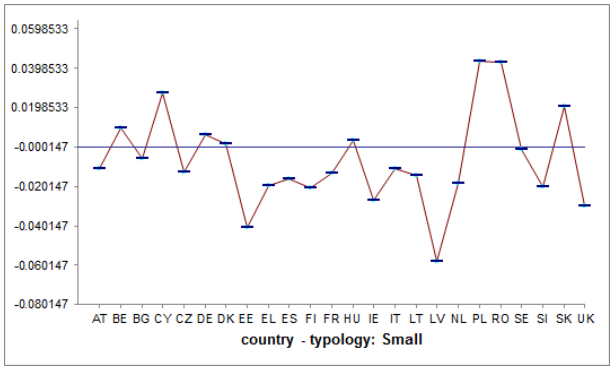
Appendix G

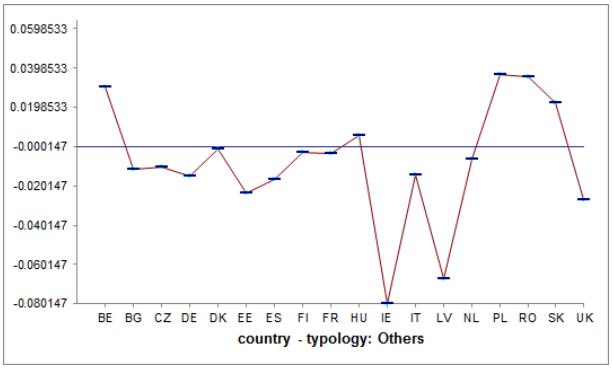
Table 11: Relationship between average GDP growth 2008–2010 and typology





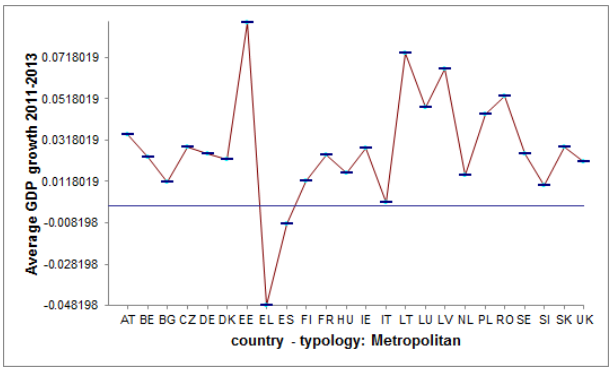


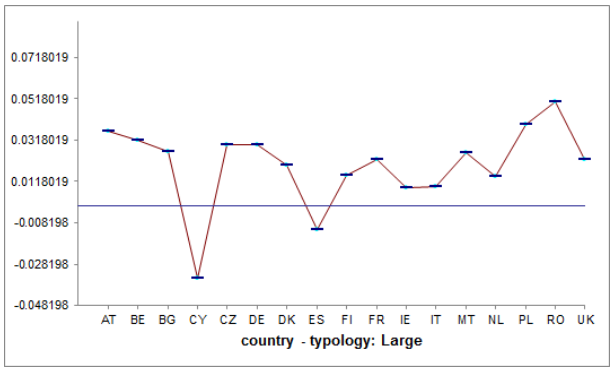


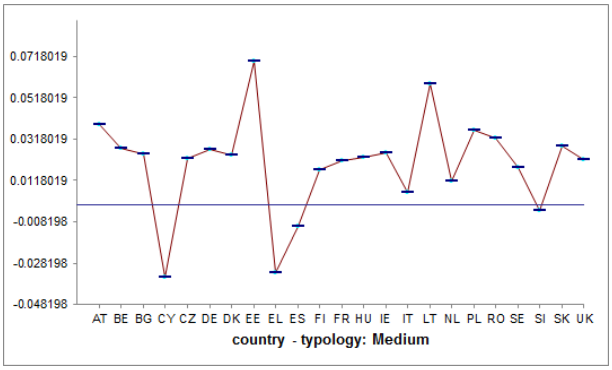


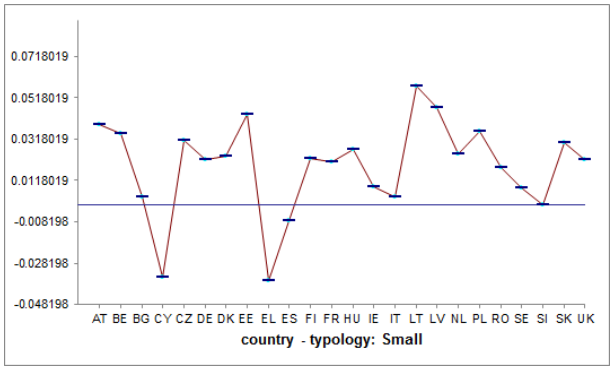
Appendix H

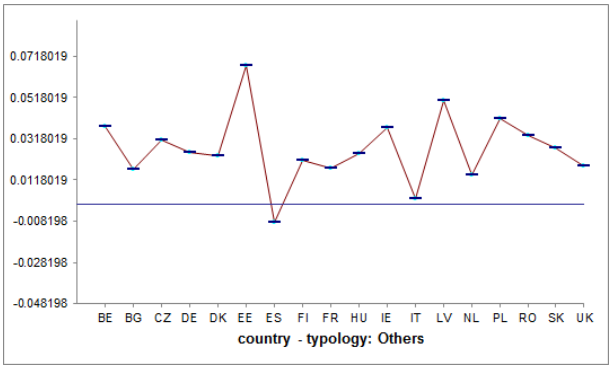
Table 12: Relationship between average GDP growth 2011–2013 and typology











Appendix I

Table 13: Average gross value added per sector growth rates by period (in %): financial and advanced services (1), manufacturing (2), construction (3), administration (4), agriculture (5)

(1)	2003-2007	2008-2010	2011-2013
Metropolitan	5.98	1.09	2.05
Large	5.72	0.49	1.83
Medium	5.94	0.25	2.02
Small	6.26	0.56	1.82
Other	7.09	0.40	1.19

(2)	2003-2007	2008-2010	2011-2013	(3)	2003-2007	2008-2010	2011-2013
Metropolitan	3.82	-2.81	1.77		5.97	-2.14	-0.39
Large	4.01	-2.74	2.17		6.42	-2.70	-1.16
Medium	4.42	-2.41	1.71		6.85	-2.73	-1.22
Small	4.73	-2.64	1.48		7.60	-3.28	-2.30
Other	5.96	-2.81	1.05		8.43	-4.24	-5.52
(4)	2003-2007	2008-2010	2011-2013	(5)	2003-2007	2008-2010	2011-2013
Metropolitan	4.00	2.92	1.87		0.53	-1.41	2.84
Large	4.09	2.70	2.11		0.46	-0.76	2.23
Medium	4.01	2.77	1.72		0.17	-0.91	3.43
Small	4.45	2.68	1.29		0.60	-1.38	3.36
Other	5.28	2.98	0.15		-0.08	-0.32	4.33

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