Discussion Papers

Collana di E-papers del Dipartimento di Economia e Management – University of Pisa

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The Determinants of Resilience in European Regions During the Great Recession: a Bayesian Model Averaging Approach

Discussion Paper n. 235

2018

Discussion Paper n. 235, presentato: Luglio **2018**

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Please cite as it follows
Lisa Gianmoena and Vicente Rios (2018), "*The Determinants of Resilience in European Regions During the Great Recession: a Bayesian Model Averaging Approach*", Discussion Papers del Dipartimento di Economia e Management – University of Pisa, n. 235 (https://www.ec.unipi.it/ricerca/discussion-paper).

Discussion Paper
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The determinants of resilience during the great recession in European Regions: a bayesian model averaging approach.*

Abstract

This study analyzes the determinants of resilience outcomes of European regions during the 2008-2013 crisis. Bayesian Model Averaging techniques are used in order to examine the empirical relevance of a large number of institutional, innovation, socio-demographic and labor market factors that could affect resilience patterns. The findings of this study suggest that regional disparities in resilience patterns are mainly determined by factors such as regional quality of government, the level of innovation, the functional specialization and by national level labor market institutions. The findings are robust to (i) the definition of the dependent variable and the (ii) employment of different g-priors and priors on model size.

Classificazione JEL: O11, C23, C11
Keywords:

*This research has benefited from the financial support of the Spanish Ministry of Economy and Competitiveness (Project ECO2016-76681-R).

Contents

I. Introduction

The Great Recession has affected Europe more severely than any other crisis since the end of the Second World War with sizeable effects on output growth and unemployment rates (Capello and Caragliu, 2016; Fratesi and Rodríguez-Pose, 2016). Nevertheless, the impact of the crisis has been highly uneven across Europe, both between countries as well as between regions within countries (e.g. Capello *et al.*, 2015; Christopherson *et al.*, 2015). Therefore, it is especially important to examine what factors drive this geographical variation. To address this issue, one should investigate the factors behind regional economic resilience. Triggered by the context of the Great Recession, the concept of resilience has begun to be extended in regional economic analysis to try to understand the dynamics that occur in different spatial environments (countries, regions, cities, etc.) in relation to how they are affected by shocks and how they respond to them (Dubé and Polśe, 2016; Martin *et al.*, 2016).

To date, most of the studies on resilience have focused on the role played by the composition of the productive structure and the degree of specialization (i.e, Martin *et al.*, 2016; Cuadrado-Roura and Maroto, 2016), thus over-looking the possible effect of other factors that may impact the behavior of regions in the context of the Great Recession. The reason of this research trend is explained by the fact that in biological and ecological research, diversity has been argued to play a key role in influencing developmental robustness (Ulanowicz *et al.*, 2009; Goerner *et al.*, 2009).[1] Hence, following the natural science analogy, the focus in many regional economic resilience studies has been to test if the diversification or specialization of the industry mix increases economic robustness. Nevertheless, regional resilience does not depend exclusively on these factors. Factors characterizing the institutional setting (i.e, quality of government, regional autonomy), the innovation system (i.e, innovation, patent activity, R&D spending, etc), labor market institutions (union density, unemployment benefits, employment protection legislation, etc) might be of major relevance to explain regional labor market disparities during turbulent times. Therefore, studies focusing solely on the issue of the diversification of the sectoral composition might suffer from a severe omitted variable bias which in turn, could affect the validity of the conclusions derived therefrom.

Therefore, to increase our understanding of regional economic resilience and its determinants, the present study contributes to the existing literature in three key aspects:

First, regional economic resilience is analyzed in a larger sample of regions

[1]For instance, a number of studies involving social insects such as those of Jones *et al.* (2004) focusing on the effect of genetic diversity on optimal thermoregulation in bee hives, or Matilla and Seeley (2007), who study their food storage productivity, have shown that diverse populations outperform homogeneous ones in their adaptation to changes in environmental conditions.

than previous studies by means of an indicator of resistance based on employment rates following Martin *et al.* (2016). In particular, resilience is measured by means of a resistance index for a sample of 238 European regions belonging to 21 European countries for the period 2008-2013. This contrasts with most of existing literature where resilience is usually measured at the country level or at the regional level within a specific country. [2] While these approaches provide useful information about the role played by different factors shaping resilience patterns in specific countries, the approach adopted here delivers generalizable findings that can be extrapolated to formulate efficient policies and reforms to the whole set of European regions.

Second, a key differential feature of this paper is its methodological approach, given that unlike previous studies analyzing resilience, where inference is based on shift-share analysis or in a single econometric model containing a reduced set of regressors, this research considers model uncertainty by means of Bayesian Model Averaging (BMA) techniques in a set of twenty-five possible explanatory variables measured at both the regional and the national level. This type of analysis is intended to generate a probabilistic ranking of the determinants of resilience together with a conservative estimate of the existing relationship between the various factors considered and our indicator of resilience which facilitates the assessment of the relative importance of the various determinants considered (Fernádez *et al.*, 2001; Moral-Benito, 2015). The set of potential determinants analyzed at the regional level includes: (i) regional institutional factors, (ii) regional knowledge and innovation intensity factors, (iii) socio-demographic factors and (iv) labor market factors. In addition, to control for cross-country specific characteristics we also analyze the role played by (v)labor-market institutions.

The paper is organized as follows. In Section 2, we provide the conceptualization of resilience and the methodology employed to operationalize this concept. In Section 3, we provide a theoretical discussion on the potential effects associated to the determinants considered in the empirical analysis. In Section 4, we explain the BMA modeling methodology employed to derive our probabilistic ranking of our explanatory factors and the analysis of their effects on resilience outcomes. In Section 5, the results are presented and discussed whereas in Section 6 we offer the main conclusions from this work.

[2]Examples of national-level or specific country regional analyzes are Briguglio *et al.* (2009) and Briguglio (2014) who calculate a resilience indicator for a sample of countries. On the other hand, resilience has been analyzed for the Italian regions (Cellini and Torrisi, 2014, Lagravinese, 2015), Greek (Psycharis *et al.* 2013), Dutch (Diodato and Weterings, 2015), Spanish (Cuadrado-Roura and Maroto, 2016; Rios *et al.* 2017) and the United Kingdom (Fingleton *et al.*, 2012, Gardiner *et al.*, 2013).

II. Measuring regional resilience

Martin (2012) and Martin and Sunley (2015) suggest the existence of different interpretations of the concept of resilience stemming from different disciplines of knowledge. The first comes from *engineering* and focuses on the resistance of an economic system to the disturbances and the speed of recovery, such that resilience will be greater the less it is affected by the disturbance and the sooner it returns to its steady state or equilibrium, which is often assumed to be unique. The *ecological interpretation*, builds upon the notion of an ecosystem in which external shocks and disturbances can move the system from one equilibrium to another. Hence, in contrast with the engineering view, it assumes that there are multiple stability domains. The magnitude of the shock that a system can absorb without generating changes in its structure is an important factor in this regard (Fingleton *et al.*, 2012). According to this view, a resilient economic system is one that adapts successfully by either resuming or improving its long-run equilibrium growth path (Simmie and Martin, 2010). In addition, the adaptive resilience view, with its roots in the theory of *complex adaptive systems*, understands resilience as the ability of a system to carry out anticipatory reorganizations (Simmie and Martin, 2010) or, as the capacity to develop new long-term growth paths (Boschma, 2014). The adaptive view conception of resilience, focuses on the self-organizational aspects of governance structures and institutions. According to this view, resilience is an evolutionary process of continual adjustments.

These different approaches to resilience, allow us to identify common central elements and the key concepts that together create what can be conceptualized as *economic resilience*: (i) disturbances and exogenous *shocks*, (ii) *context*, (iii) *responses* to the shocks (resist, withstand, adjust, renew) and (iv) outcomes (pre-shock state, new growth paths). The first element is the negative *shock* or external disturbance, which is assumed to weaken the functioning of the economy. The second element is the *context*, which shapes the economic structure and which largely depends on institutions, socio-economic and socio-demographic conditions. The third element, which is context bounded, is the *response* or the adaptive capacity to the shock. The response is related to the ability of the system to deal with the shock by innovating or re-arranging the institutional structure. Furthermore, the response to the shock is highly influenced by the economic policy. Finally, the *outcome* refers to whether the economy has bounced back and recovered achieving its pre-shock state (or even improved it). Taken together, these elements allow us to define resilience as *"the capacity of the system to resist, withstand or quickly recover from negative exogenous shocks and disturbances and to renew, adjust or re-orientate from these shocks"* (Bigos *et al.*, 2013).

As refers to the measurement of economic resilience, the literature has employed different approaches (Martin and Sunley, 2015, Modica and Reggiani, 2015). Whereas some authors propose the use of univariate indicators based on GDP per capita or employment rates (Cellini and Torrisi, 2014; Di Caro, 2015;

Fingleton *et al.*, 2012; Fingleton and Palombi, 2013; Lagravinese, 2015; Martin, 2012), a different approach to measure the concept of resilience in the literature has been the elaboration of composite indexes based on a diverse number of variables that could affect negatively the degree of economic vulnerability (Briguglio *et al.* 2009; Briguglio, 2014; Modica and Reggiani, 2015).

To operationalize the concept of economic resilience at the regional level we employ as our baseline metric of resilience, a univariate indicator based on employment rates given that (i) the majority of the impact of recessive shocks is directly translated into labor market variables, causing layoffs, inequality and social tension and because of (ii) the GDP provides a less accurate view of the state of the regional economy due to recent the jobless growth recovery phenomenon. We consider that this approach is more informative in this context than focusing on output changes, as variations in employment better reflect the social impact of the Great Recession (Giannakis and Bruggeman, 2017). Against this background, and taking into account the nature of our study, we resort to a widely used measure of regional resistance to recessionary shocks (Lagravinese, 2015; Martin *et al.*, 2016; Giannakis and Bruggeman, 2017):

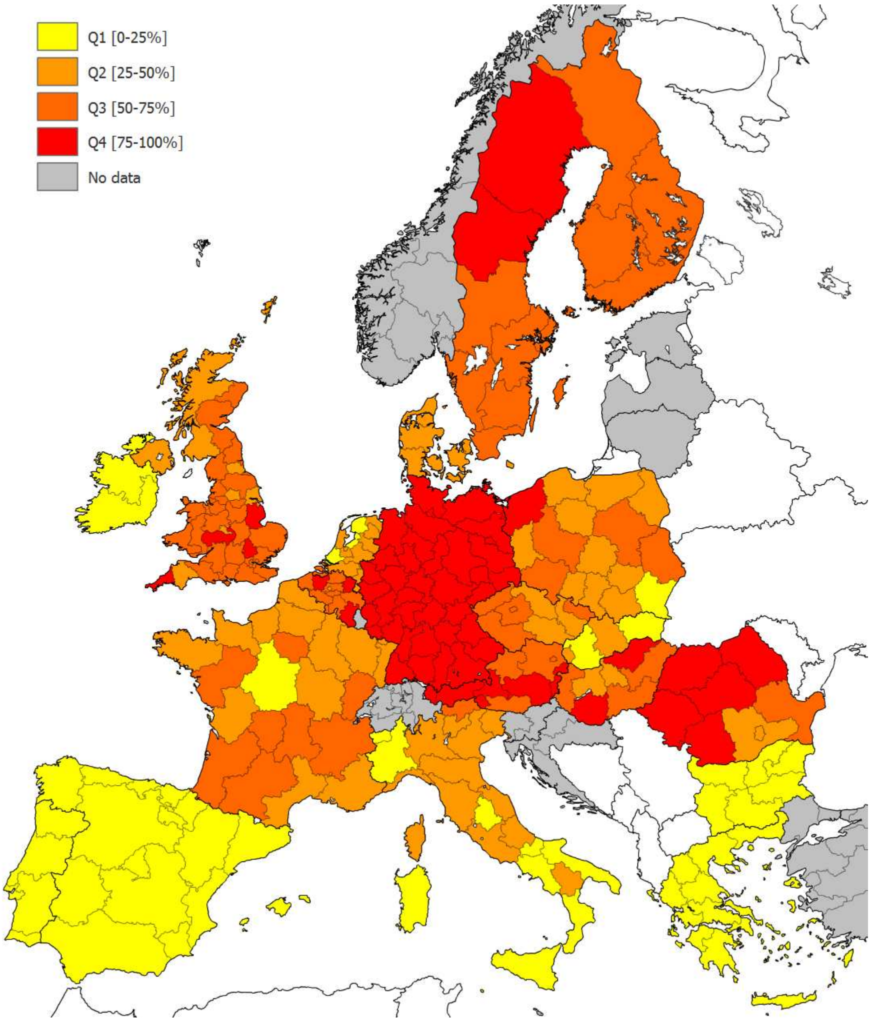
$$RES_i = \frac{\Delta E_i - \Delta E_{EU}}{|\Delta E_{EU}|} \tag{1}$$

where ΔE_i is the change in the employment rate in region i between the turning points into recession and into recovery. In turn, ΔE_{EU} stands for the average variation in the employment rate in the EU regions. A positive value of this index means that region i exhibits greater resistance to a recessionary shock than the EU average, while a negative value implies that region i is less resistant than the EU average. RES equals to zero when there is no difference in the variation of the employment rate in region i and the EU average. As is usual in the literature, this measure of regional resilience concentrates on the capacity of regional labor markets to adapt to adverse shocks.

We calculate the index of regional resilience just described for 238 NUTS2 regions of 21 European countries, using data drawn from Eurostat for the crisis period 2008-2013.[3] The results are displayed in Figure 1. As can be observed, the impact of the Great Recession has been far from homogeneous across the EU, and there are important geographical differences. The countries in the Southern periphery of Europe (i.e. Portugal, Spain, Italy and Greece) have been particularly hard hit (Fingleton *et al.*, 2014; Fratesi and Rodríguez-Pose, 2016). Likewise, the labor markets of Ireland have shown relatively low levels of resistance to the economic downturn. On the contrary, Germany, where employment continued

[3]NUTS2 regions are used instead of other possible alternative for two reasons. First, NUTS2 is the territorial unit most commonly used in the literature on regional resilience in the EU (e.g. Brakman *et al.*, 2015; Giannakis and Bruggeman, 2017; Rizzi *et al.*, 2018), which facilitates the comparison of our findings with those obtained in earlier studies. Second, NUTS2 regions are the basic unit for the application of cohesion policies in the EU.

Figure 1: Measuring Regional Resilience 2008-2013



to grow during the crisis, exhibits the best performance. Austria, Belgium, Finland and Sweden also show relatively high values of the resilience index. The observed differences between countries, however, not hide the existence of important within-country disparities (Capello *et al.*, 2015; Giannakis and Bruggeman, 2017). This is the case, for example, of France, Italy, the Netherlands or the United Kingdom.

III. The Determinants of Regional Resilience

This section focuses on the determinants of resilience included in our empirical analysis and summarizes the main findings of previous empirical studies.

III.A. Institutional Factors

Nowadays, there is the widespread view that institutions modulate and shape economic growth paths in the long run defining and bounding the context in which the agents of the economic system operate, mainly through the definition of incentives to behave in a certain way (Acemoglu *et al.*, 2005; La Porta *et al.*, 2008). Among the most central elements of the institutional setting of a country or a region we find (i) the *quality of government* and the (ii) level of *economic self-rule*.

To measure *Regional Quality of Governance* (RQOG) we use the index developed by Charron *et al.* (2015). The indicator is built upon three different pillars that refer to impartiality, corruption and quality, which are weighted to form the regional index. Quality of government will be higher the less corrupt is the government, the higher its degree of impartiality and the higher the quality of the public services provided (Rothstein and Teorell, 2008). There are different reasons to believe that the quality of governance may have positive direct and indirect effects on resilience.

First, the quality of government may exert a moderating effect on the type, frequency and intensity of the shocks as shown by Sondermann (2017). Financial shocks such as the one in the origin of the 2008-2013 crisis, have been occurring cyclically since the development of money and financial markets (Bigos *et al.*, 2013). In this regard, the quality of government can play a crucial rule minimizing the vulnerability to adverse financial shocks hitting labor markets given that well-regulated capital markets are likely to experience a lower frequency and less intense crisis (OECD, 2017). The level of corruption, which is a central element of the quality of government can undermine financial stability given that practices such as related lending are more likely to happen, which reduces the quality of the bank loan portfolio and increase concentration risk (La Porta *et al.*, 2003). Additionally, the quality of government can help reducing the likelihood of sudden stops of capital inflows (Honing, 2008).

Second, the quality of governance may increase regional resilience by improving policy responses, in particular, in what refers to the efficiency of public investment. At the European regional level there is evidence that shows that good institutions have affected the returns of European cohesion policies (Rodríguez-Pose and Garcilazo, 2015) and the decisions on the type of public good investment (Crescenzi *et al.*, 2016).

Third, quality of government can increase resilience by strengthening contract enforcement and the overall efficiency of the judicial system. As far as the quality of government is linked to high quality in the provision the public services, such as the case of justice, it can contribute to resilience by improving bankruptcy procedures/insolvency regimes. Efficient bankruptcy regulations are crucial to allow for low-cost exit of less productive and insolvent firms and therefore, improving resource allocation (OECD, 2017). Promoting impartial legislations and regulations that permit and foster private sector development, quality of government can strengthen antitrust enforcement, minimize barriers of entry and decrease privileges of stablished firms (OECD, 2010). Taken together, the existing empirical evidence supports the view of the quality of government as a driver of private sector dynamism at the regional level as it has been shown that it (i) shapes its competitiveness (Anoni and Dijkstra, 2013) and that (ii) corrupt and/or inefficient governments undermine regional potential for innovation (Rodríguez-Pose and Di Cataldo, 2015) and entrepreneurship (Nistotskaya *et al.*, 2015).

On the other hand, the expected effect of *economic self-rule* is ambiguous, as decentralization can affect resilience via several different channels that work in opposite direction. According to Oates (1972), greater efficiency adapting to citizen's preferences can be achieved by means of a decentralized service. When diseconomies of scale exist, decentralization can also promote production efficiency; that is, delivering a particular bundle of public services at a minimum cost, which ultimately may translate into an increased quality and quantity of the services (Martínez-Vázquez *et al.*, 2017). The proposition that fiscal decentralization enhances economic efficiency (Oates, 1972), may have a corresponding effect on economic performance and in the response of the economy to negative shocks. On the other side of the coin, sub-national governments may lack the adequate expertise and human resources to apply viable policies and, if large economies of scale and scope exist, regional governments may lack the necessary size to deliver public goods efficiently. Other authors argue that decentralized frameworks may be more sensitive to the problem of soft budget constraints than centralized ones and that borrowing rules may not always be effective enough, which in turn, could increase economic vulnerability to shocks (Martínez-Vázquez and Vulovic, 2016). Nevertheless, it has also been argued that increased tax autonomy could lead to improved fiscal discipline and responsibility (Neyapti, 2010), thus increasing regional stability in the context of a recession. The indicator of economic self-rule is based on the recent contribution to fiscal federalism literature of Sorens (2011).[4]

III.B. Knowledge and Innovation System Factors

The second group of variables used to analyze resilience patterns in Europe are those capturing the intensity of invention and innovation and draws from previous studies of knowledge and development such as Capello and Lenzi (2013, 2014), Paci and Marrocu (2013) and Rios *et al.* (2016). This group of factors consists on (i) the *number of patents* per million of people, (ii) the *share of R&D spending in*

[4]Sorens (2011) argues that previous measures employed by the literature to approximate the degree of decentralization are not informative given that (i) they assume that a higher level of sub-central autonomous tax revenues as a percentage of total government revenues (or spending) reflect a higher level of decentralization whereas (ii) even if in some European countries (i.e, Denmark, Sweden or Finland) sub-central governments raise a great deal of the revenue, this does not necessarily imply they have political autonomy to implement their desired policies as far as the sub-central collection of revenues is to fund centrally mandated programmes.

the GDP, (iii) an *innovation index*, (iv) *infrastructure density* and (v) the *human capital*.

Overall, factors favoring knowledge creation such as (education, patent activity and R&D efforts) and innovation are expected to have positive effects on resilience given that in periods of recession where *creative destruction* is likely to be at work, product and process innovations might have a potentially beneficial effect on the development of new growth paths if old technologies are replaced by newer ones. As pointed by Crescenzi *et al.* (2016) the relevance of an innovation-prone regional environment can contribute to alleviating the negative consequences of the crisis not only by developing new products and/or new technologies, but also by organizational innovation and the reduction of production costs to maintain regional competitiveness.

Nevertheless, as shown by Capello and Lenzi (2013), knowledge factors do not overlap with innovation and regional knowledge does not automatically nor necessarily turn into innovation. Moreover, patents and/or R&D expenditures are not always translated into market innovations and confusing these controls may neglect innovative efforts that can be developed either in the form of process, organizational configuration or product. Thus, the distinction between formal/basic knowledge captured by patent activity, R&D and education with respect the innovation, is relevant in this context. [5]

In the context of recessive phases, there are additional reasons other than the *productivity* explanation to believe that knowledge factors may be relevant explain resilience. For instance, human capital is expected to affect labor market resilience figures as it is related to lower probability of lay off (Nickell and Bell, 1996). Furthermore, people with higher educational attainment are likely to conduct more efficient searches and are less prone to layoffs in an economy with continued technological advancements.

Infrastructure density may enhance knowledge creation through different mechanisms associated with its influence on the spatial organization of economic activities (Capello and Lenzi, 2013; 2014). However, the a priori effect of higher infrastructure density on resilience is not clear. On one hand, if infrastructure density allows to reduce barriers to trade and increases regional connectivity, it might increase exposure to external shocks, which in the cases of small open economies (as it is the case of regions) could substantially increase vulnerability. On the other hand, improved infrastructures raising regional connectivity allow faster diffusion of knowledge and provide incentives for the firms to increase competition. Therefore, if infrastructure density increases links across interacting economies, it could also have a positive effect on developmental robustness decreasing regional vulnerability to shocks.

[5] Following Capello and Lenzi (2014) and Rios *et al.* (2016) to approximate the degree of innovation an index measuring the share of small and medium firms introducing a new product and/or a new process in the market is employed.

III.C. Socio-Demographic Factors

Apart from institutional and innovation factors, socio-demographic characteristics might also have effects on resilience.

Regional and urban economics literature has considered that one of the key factors for economic development is the size of the population (agglomeration) and the level of urban development (Duranton and Puga, 2014). Cicone (2002) argues that agglomeration economies arise when people and firms locate near one another together in cities and industrial clusters, which generally implies higher population or employment density. Agglomerations ultimately imply transport costs savings, lowering the difficulties in exchanging goods, people, and ideas. However, the impact of agglomeration in regional resilience is not clear beforehand. On the one hand, highly urbanized and dense areas may increase the probability of matching job seekers and firms, which should improve the overall functioning of labor markets. However, negative effects and (dis) agglomeration economies may arise if the time spent by workers to collect information about the vacancies on the job market rises or if problems of crowding and congestion increase excessively (Rios, 2017). In fact, the evidence provided by Brakman *et al.* (2015) show the relationship between the patterns of spatial allocation of a region's population and resilience during the Great Recession is complex. To control for the potential effect of agglomeration we include in our specification an indicator of (i) *population density*.

The demographic composition is directly related to the availability of adequate labor supply for the different labor markets and to the degree of social vulnerability (Greenwold, 1997; Bigos *et al.*, 2013). The expected effects of the demographic structure on resilience are theoretically ambiguous. On one hand, regions with elder populations are at higher technological risk than younger ones due to the skill obsolescence effect and the skills miss-match implied by the rapid technological progress (Dixon, 2003). Moreover, older populations are less flexible and mobile than younger ones, which should amplify the skills miss-match between labor demand and supply along the geographical dimension, thus increasing regional labor market vulnerability. In addition, the empirical evidence shows that elder populations are less prone to innovation (Askoy *et al.*, 2015) which should have a negative effect on the ability to develop new growth paths once a region has been hit by a shock. These arguments suggest older populations might have lower levels of resilience than younger ones. Nevertheless, there are also arguments that suggest the opposite might also be true as it has been argued that a mature labor force might be more productive (Aiyar *et al.*, 2016) due to higher average levels of work experience (Disney, 1996; Burtless, 2013). To control for the role of age structure we include the (ii) *share of population aged between 15-24 years old* (i.e. young population) and (iii) the *share of population aged between 55 and 64 years old* (i.e. old population).

Migration dynamics may also affect resilience patterns across European regions as it is a key factor in labor market performance. Migration increases labor supply directly and labor demand indirectly. If labor demand effects such as skill complementariety, additional expenses and investments dominate labor supply, then migration may benefit resilience. Thus, we control for the potential effect of migration patterns by means of (iv) the *net migration rate*.

The social capital of a region can also be a relevant determinant of resilience. Populations with high levels of social capital tend to have higher levels of interpersonal trust and spend less to protect themselves from being exploited in economic transactions, which minimizes the costs of control, monitoring and the enforcement of contracts. Hence, social capital results in lower levels of litigation and within firms, reduces the time and resources spent to control partners, employees, suppliers, etc, thus allowing for more free time to introduce innovations (Knack and Keefer, 1997). In addition, in contexts of crisis, where financial transactions fall, informal credit markets dependent on interpersonal trust can facilitate investment. Additionally, social capital might exert indirect effects through the improvement of institutional quality and sectoral diversification (Cortinovis *et al.* 2018). Thus the expected effect of (v) *social capital* on resilience is positive.

III.D. Labor Market Factors

The fourth group of factors considers regional labor market variables. To control for differences in labor market characteristics the following variables are considered: (i) *wages*, (ii) *the share of employment in agriculture*, in (iii) *manufactures*, in (iv) *non-market services* in (v) *financial services*, in (vi) *high-tech sectors* and (vii) the *sectoral specialization*.

Given that wages are supposed to exert a negative influence on labor demand and a positive effect on labor supply, a negative relationship with resilience is expected (Rios *et al.* (2017)).

Although the European economy has experienced a process of convergence in regional productive structures during the last decades, considerable differences persist in the patterns of regional specialization across Europe (Ezcurra *et al.*, 2006). Some economic activities are more vulnerable to changes in the business cycle than others and, as such, suffer the most from recessionary shocks (Fiaschi *et al.*, 2017). This is the case of manufacturing and construction, which traditionally are the most affected sectors during an economic crisis. Conversely, other activities are more impervious to fluctuations in the business cycle. For example, regions with higher levels of public employment are more protected from downturns in the cycle, since they experience less job destruction during economic crisis. Likewise, the degree of protection and regulation of agricultural markets in the EU implies that regions with relatively large agricultural sectors tend to be less exposed to changes in the business cycle (Rodríguez-Pose and Fratesi, 2007). Sectoral diversification in a region may also affect employment rates and resilience outcomes (Longhi *et al.*, 2005). However, the expected effect is not clear beforehand. The more specialized a regional economy is, the less able to adjust employment reductions in any given sector when it receives a negative shock (Simon, 1988). The intuition is that a different economic structure should allow a regional economy to "spread risk", thus reducing the intensity of cyclical fluctuations and increasing regional resilience (Ezcurra, 2011). At the same time, a region with an excessive reliance on a small number of activities is potentially more vulnerable and unstable in case of a downturn, as it has much less scope to provide some measure of buffering against the perturbation (Trendle, 2006). However, it should be noted that firms located in more specialized regions might gain from agglomeration effects such as knowledge spillovers and be more productive than similar firms in less specialized regions.

III.E. Labor Market Institutions

Figure 1 shows that regional resilience in the EU is clearly affected by national patterns (Crescenzi *et al.*, 2016; Giannakis and Bruggeman, 2017). In view of this, our analysis also incorporates labor market institutional characteristics at country level. In order to approximate the role of labor market institutions a number of indicators are considered: (i) an *employment protection legislation index* (EPL), (ii) the generosity of *unemployment benefits*, (iii) the *tax wedge*, (iv) a *bargaining coverage index* and (v) *coordination-centralization index* and its square.

The expected effect of the EPL is ambiguous as employment protection has been designed to protect jobs and increase job stability by reducing job destruction (Rios, 2017) which may help to increase resistance to shocks. However, according to Boeri and Van Ours (2008) a stronger EPL reduces job creation, because employers are more reluctant to open a vacancy. Unemployment benefits might also affect resilience affecting the incentives to work and the degree of labor market dynamism since they might reduce search intensity. However, they increase the expected profit of participating in the labor market with respect the one associated to inactivity which may be beneficial to resilience. Most of the literature at this respect finds a negative relationship between unemployment benefits and labor market performance (Blanchard and Wolfers, 2000; Belot and Van Ours, 2004). Thus, a negative effect on labor market resilience is expected. Additionally, we consider the gap between the cost of labor to the firm and the net wage of the worker, the so called tax wedge. The extent to which the tax wedge affects resilience depends on whether the taxes are passed on workers in the form of lower wages, which ultimately depends on the elasticity of labor supply and demand. Although most of the studies find a negative link between the tax wedge and labor market performance, others show that for a given level of taxation, better performance is achieved by progressive taxation (Lehman *et al.*, 2014).

The characteristics of different collective bargaining systems may affect regional resilience patterns. In centralized systems, negotiations take place at the country level between national unions and employer's associations whereas in decentralized ones, negotiations take place at individual enterprise level. Another relevant feature of the institutional framework is the degree of coordination between the bargaining partners in order to reach consensus. However, there are only minor differences in the degrees of centralization and coordination. In view of this, we follow Rios (2017) and these two variables are aggregated in a centralization-coordination index. In relations to this, empirical analysis shown that both centralized (at national or multi-industry level) and decentralized (at the level of firms) bargaining systems perform better than intermediate ones (at industries level) (see for instance: Calmfors and Driffill, 1988; Calmfors, 1993).This finding can be attributed to both, (i) the cooperative behavior of the former that creates incentives to moderate wage claims and, (ii) to the greater aggregate real wage flexibility and market forces restraining wages when bargaining occurs at the plant level; thus offering stronger relative wage flexibility. Bargaining institutions force the wage distribution and raise the relative wage for specific socio-economic groups (e.g. youth or less educated workers). Higher union density and coverage can have a positive effect on resilience since it can limit layoffs and minimize unemployment hikes. However, the existence of a negative relationship can also be conceivable because the impossibility of firms to adjusting wages and costs could lead to bankruptcy. A bargaining coverage index is calculated as the average of the union density and the collective bargaining coverage indicators.[6]

IV. Econometric Strategy: Bayesian Model Averaging

In this section we describe the functioning of the BMA methodology applied in this study to analyze the determinants of regional resilience. We begin by considering the following conventional regression model:

$$y = \alpha \iota_n + X\beta + \epsilon \tag{2}$$

where y denotes a $N \times 1$ dimensional vector consisting of observations for the average resilience index during 2008-2013, for each region $i = 1, \ldots, N$. X is an $N \times K$ matrix of explanatory variables with associated response parameters β contained in a $K \times 1$ vector. α reflects the constant term, ι_n is a $N \times 1$ vector of ones. Finally, $\epsilon = (\epsilon_1, \ldots, \epsilon_N)'$ is a vector of i.i.d disturbances whose elements have zero mean and finite variance σ^2.

Note that there are many sub-models M_k of the model in Equation (2) given by the subsets of coefficients $\eta^k = \left(\alpha, \beta^k,\right)$ and combinations of regressors $k \in$

[6] The reason for this choice is due to the relationship between union density and bargaining coverage. When the outcome of collective bargaining is extended to all workers, the incentive for workers to join unions is clearly lower than in those cases when the conditions collectively bargained are binding only for union members (Longhi *et al.*, 2005). Hence, the higher the collective bargaining coverage, the lower the union density and viceversa.

Table 1: Data: Descriptive Statistics

Variables	Code	Mean	StandardDev	Min	Max	Definitions	Sources
1. Institutional Factors							
Quality of government	QOG	62.595	15.810	8.536	95.609	Regional quality of government index based on the indicators of corruption regulatory quality and impartiality	QOGI
Economic self-rule (*a*)	ESR	13.714	14.279	0.000	48.000	Economic self-rule index based on the indicators of policy scope, fiscal autonomy, political representation and institutional depth	Sorens (2011)
2. Knowledge-Innovation Factors							
Patents	PAT	105.967	125.518	0.735	772.877	Number of patent applications to the EPO by priority year per million of inhabitans	Eurostat
Innovation	INNOV	50.900	18.516	7.397	83.775	Innovation index measuring the share of small and medium firms introducing a new product and/or a new process in the market.	RIS. CIS
R& D spending	RD	1.514	1.234	0.108	7.260	Research and development spending to GDP (%)	Eurostat
Infrastructure density	IDEN	1076.900	771.37	0.00	4259.8	Number of kilometres of motorways and railways network on usable land (in levels)	Eurostat
Human capital (*b*)	EDUC	37.291	8.028	12.441	56.033	Combined index of secondary and tertiary education attainment	Eurostat
3. Social-Demographic Factors							
Population density	PDENS	0.344	0.867	0.003	9.108	Thousand inhabitants per squared kilometer	CE
Old population	OLD	10.907	3.030	5.188	20.008	Population share between 55-65 years old (%)	Eurostat
Young population	YOUNG	12.157	2.695	4.546	18.708	Population share between 15-24 years old (%)	Eurostat
Social capital (*c*)	SCAP	0.297	0.089	0.099	0.563	Index of social capital (scale 0-1)	ESVS
Net migration (*d*)	NM	0.392	0.586	-1.163	2.827	Net migration rate (%)	Eurostat
4. Labour Market Factors							
Wages	WAGE	26836.018	10682.03	5197.0	53571.0	Compensation per employee (euros)	CE
Agriculture	AGRI	6.464	6.732	0.077	37.646	Employment share in agriculture (%)	CE
Manufactures	MANU	18.499	6.670	5.215	36.879	Employment share in manufacturing (%)	CE
Financial services	FS	12.722	5.557	4.161	32.045	Employment share in financial market services (%)	CE
Non-market services	NMS	29.214	5.577	17.217	46.458	Employment share in non market services (%)	CE
High-tech employment	HTECH	4.077	1.818	0.983	11.503	Employment share in high-tech sector (%)	CE
Sectoral specialization(*e*)	HF	0.229	0.020	0.189	0.291	Herfhindal index calculated over the employment shares in 6 different sectors	CE
5. Labour Market Institutions							
Employment Prot. Legisl.	EPL	2.373	0.647	1.198	4.491	Employment protection legislation index	OECD
Unemployment benefits	UBEN	52.378	12.599	22.025	77.612	Aggregate index of unemployment insurance and unemployment assistance	OECD
Union density & coverage	UDC	47.834	15.779	15.964	84.495	Average of union density and collective coverage	ICTWSS
Tax wedge	TWED	40.007	6.481	22.778	49.956	Ratio of labor taxes to total labor costs	OECD
Coordination-centralization	CC	2.523	1.028	0.667	4.778	Average of coordination and centralization indexes	ICTWSS

Notes: QOGI denotes the Quality of Government Institute, CE denotes the Cambridge Econometrics Database, RIS refers to the Regional Innovation Scoreborad and CIS to Innovation Community Survey, ESVS denotes the European Social Value Survey and ICTWSS refers to Database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts. (a) Economic sel-rule index is calculated following Sorens (2011) as $ESR_i = [PS_i \times FA_i \times PR_i] \; \forall \; ID_i = 3$ and $ESR_i = \frac{[PS_i \times FA_i \times PR_i]}{2} \rightarrow ID_i \neq 3$ where: PS denotes policy scope, FA fiscal autonomy, PR political representation and ID stands for institutional depth. (b) Human capital is calculated as $H_{it} = \frac{1}{3}(1 - S_{it}) + \frac{2}{3}T_{it}$ where S and T are pop shares with lower secondary and tertiary education. (c) Social capital is calculated as the unweighted average of (d) The net migration rate for each year of the period 2000-2008 is calculated as $nm_{it} = \frac{M_{it}}{n_{it}} = \frac{(n_{it+1} - n_{it}) - (b_{it} - d_{it})}{n_{it}}$ where M is net migration, b and d are total births and deaths, whereas n_{it} denotes the population. (e) The sectors $s = 1, \ldots, S$ considered to obtain the Herfindahl Index are agriculture, manufactures, construction, distribution, non-market services and financial services.

$\left[0, 2^K\right]$.[7] A problem arises when there are many potential explanatory variables in a matrix X. Which variables $X_k \in X$ should be then included in the model? And how important are they? In order to analyze the relevance and the effect of a specific regressor X_h on y, a researcher can either (i) perform a traditional analysis selecting a single model and make inference using that model at the cost of ignoring completely the uncertainty surrounding the model selection process or (ii) estimate all the candidate models implied by the combinations of regressors in X and then compute an average of all the estimates of the corresponding parameter of X_h. The direct approach to do inference on a single linear model that includes all variables is inefficient or even infeasible with a limited number of observations. In the second case, the researcher does not only consider the uncertainty associated to the parameter estimate conditional on a given model, but also the uncertainty of the parameter estimate across different models. To carry out inference on the parameters of the variables included in X, BMA methodology takes into account model uncertainty by using all information available and derives the effect of each of the regressors by relying on probabilistic weighted averages of parameter estimates of individual models. The key metrics in BMA analysis are the Posterior Mean (PM) of the distribution of η:

$$E\left(\eta|y, X\right) = \sum_{k=1}^{2^K} E\left(\eta_k|M_k, y, X\right) p\left(M_k|y, X\right) \tag{3}$$

and the Posterior Standard Deviation (PSD):

$$PSD = \sqrt{Var\left(\eta|y, X\right)} \tag{4}$$

where the $Var\left(\eta|y, X\right)$ is given by:

$$\begin{aligned} Var\left(\eta|y, X\right) = \quad & \textstyle\sum_{k=1}^{2^K} Var\left(\eta_k|M_k, y, X\right) p\left(M_k|y, X\right) + \\ & \textstyle\sum_{k=1}^{2K} \left(E\left(\eta_k|M_k, y, X\right) - E\left(\eta|y, X\right)\right)^2 p\left(M_k|y, X\right) \end{aligned} \tag{5}$$

With the aim of generating a probabilistic ranking we compute the Posterior Inclusion Probability (PIP) for a variable h:

$$p\left(\eta_h \neq 0|y, X\right) = \sum_{k=1}^{2K} p\left(\eta_{k,h}|M_k, y, X\right) p\left(M_k|\eta_h \neq 0, y, X\right) \tag{6}$$

and the Conditional Posterior Positivity of h:

$$p\left(\eta_h \geq 0|y, X\right) = \sum_{k=1}^{2^K} p\left(\eta_{k,h}|M_k, y, X\right) p\left(M_k|y, X\right) \tag{7}$$

[7]Note that for a total number of possible explanatory variables K, the total number of possible models is 2^K.

where values of conditional positivity close to 1 indicate that the parameter is positive in the vast majority of considered models. Conversely, values near 0 indicate a predominantly negative sign.

To derive these metrics, it is necessary to calculate the Posterior Model Probability $p(M_k|y,X)$ of each of the sub-models M_k. These can be obtained as:

$$p(M_k|y,X) = \frac{p(y,X|M_k)\,p(M_k)}{\sum_{k=1}^{2^K} p(y,X|M_k)\,p(M_k)} \tag{8}$$

where $p(y,X|M_k)$ is the marginal likelihood and $p(M_k)$ is the prior model probability. The marginal likelihood of a model k is calculated as:

$$p(y,X|M_k) = \int_0^{\infty}\int_{-\infty}^{\infty} p\left(y,X|\eta_k,\sigma^2,M_k\right) p\left(\eta_k,\sigma^2|g\right) d\eta d\sigma \tag{9}$$

where $p(y,X|\eta,\sigma,M_k)$ is the likelihood of model k and $p(\eta_k,\sigma^2|g)$ is the prior distribution of the parameters in model M_k conditional to g, the Zellgner's g-prior. The employment of the g-prior scales the variance of the coefficients in η_k such that a higher value of g reflects a stronger belief on the prior.[8] On the other hand, to elicit the prior model probability we employ a Binomial prior on the model space $p(M_k) \propto \left(\frac{\phi}{K}\right)^k \left(1-\frac{\phi}{K}\right)^{K-k}$, where ϕ is set to $K/2$ to assign an equal prior probability $p(M_k) = 2^{-K}$ to all the models under consideration.

A relevant issue in this context is that we employ Monte Carlo Markov Chain Model Composition (MC^3) methodology initially developed Madigan and York (1995) to evaluate a relevant sample of models from the the full model space. The key feature of this econometric procedure is that it eliminates the need to consider all possible models by constructing a sampler that explores relevant parts of the large model space. The algorithm operates in the model space as follows. If we let M denote the current state of the chain, models are proposed using a neighborhood , $nbd(M)$ which consists on the model itself and models containing either one variable more (*birth step*) or one variable less (*death step*) than M. A transition matrix q, is defined by setting $q(M \to M') = 0$ for all $M' \notin nbd(M)$ and $q(M \to M')$ constant for all $M' \in nbd(M)$. The proposed model M', is compared with the current model state M using the acceptance probability P:

$$P = min\left[1, \frac{p(M'|y)}{p(M|y)}\right] \tag{10}$$

The vector of log-marginal values for the current model M and the proposed alternative models M' are scaled and integrated to produce Equation (8). In

[8]The g-prior shapes the distribution of the parameters in each model M_k such that:
$p(\eta_k) \sim N\left[0, \sigma^2\left(\frac{1}{g_k}X_k'X_k\right)^{-1}\right]$
Following the convention in BMA analysis the g-prior takes the value of $g_k = max\left\{n, K^2\right\}$, Fernández *et al.* (2001).

addition to the birth and death steps, the sample employed here includes a third strategy to create models labeled as *move step* consisting on replacing randomly variables in X with variables not included currently in the model which leaves the model proposal M' with the same dimension as M.

V. Results

V.A. Main Results

Table (2) reports the results obtained when implementing the MC^3 algorithm for the 1,000 top models out of the 132,688 generated by the sample [9] However, before continuing with the discussion of the results in Table (2), it is worth mentioning the problems that the methodology applied here is able to solve and those problems that may persist, affecting the quality of the estimates. The strong point of the BMA methodology employed here is that it accounts for the uncertainty of the parameter estimates across different models while controlling for omitted variable bias (Moral-Benito, 2015). However, it does not correct for the potential negative effect of endogeneity generated by reverse causal relationships or measurement errors. In fact, how to tackle the issue of endogeneity in a model averaging framework is an important line of open research.[10] To minimize the potential problems caused by reverse causality the explanatory variables taken as the average value between 2000-2007.[11]

As usual in BMA exercises, the concentration of the posterior density in this context is very high. In particular, the top 1% models concentrate the 55.69% of mass, while the top 5% concentrate the 77.56%. We scale the PIPs of the different variables in quartiles to classify evidence of robustness of resilience drivers into three categories so that regressors with PIP $\in [0 - 25\%]$ are considered as weak determinants, variables with PIP $\in [25 - 75\%]$ as moderate determinants and with PIP $\in [75 - 100\%]$ as important.

As observed, the group of important determinants consists on the quality of government (100%), the share of employment in the high-tech sector (100%), the net migration rate (100%), a variety of labor market institutional factors (tax wedge, 100 %, the centralization-coordination and its square (100%)) and the innovation index (89%). In the group of determinants of medium importance we find the share of young population (70%) and the level of bargaining coverage (57%). Finally, weak resilience drivers include institutional factors (economic self-rule), other labor market (e.g. wages, the share of employment in agriculture, manufactures, financial services, non-market services, specialization), socio-demographic factors (social capital, population density, the share of old), knowl-

[9]The number of draws to carry out the sampling exercise on the model space was 1 million.

[10]This is because in the context of endogenous regressors the model posterior probabilities are based on pseudo-likelihoods that are not fully comparable across models.

[11]The only exception is the quality of government for which data exists only for 2010, 2013 and 2017. We use the 2010 value.

edge (education, patents, R&D expenditure, infrastructure density) and labor market institutional factors (employment protection legislation, unemployment benefits). Overall, our findings suggest that, on the one hand, institutional factors and labor market institutions are the key factors shaping regional resilience patterns even though some innovation and socio-demographic factors also play a non-negligible role. It is also worth mentioning that our findings suggest that diversification and the productive specialization might not be as relevant as previously thought given that only the share of employment in high-tech sectors enters into the group of important drivers of resilience.

Table 2: Main Results

	PIP (1)	*Post Mean* (2)	*Post SD* (3)	*Cond.Pos.Sign* (4)	*T-stat* (5)
Quality of government	1.00	0.43	0.09	1.00	1.00
Coordination&centralization	1.00	-34.89	4.20	0.00	1.00
(Coordination&centralization)^2	1.00	5.04	0.66	1.00	1.00
Emp. High technology	1.00	2.24	0.45	1.00	1.00
Tax wedge	1.00	1.94	0.22	1.00	1.00
Net migration	1.00	-5.76	1.35	0.00	1.00
Innovation index	0.89	0.17	0.08	1.00	1.00
Young population	0.70	0.73	0.57	1.00	0.98
Union density & coverage	0.57	-0.11	0.11	0.00	0.83
Emp. Financial services	0.24	0.09	0.18	1.00	0.42
Emp. Manufacturing	0.16	0.04	0.10	1.00	0.08
Emp. Agriculture	0.16	-0.04	0.10	0.00	0.15
Economic self-rule	0.13	0.01	0.04	1.00	0.38
Social capital	0.13	2.67	8.74	0.98	0.43
Infrastructure density	0.11	0.00	0.00	1.00	0.00
Wages	0.08	0.00	0.00	0.00	0.22
Human capital	0.08	0.01	0.05	0.98	0.44
Employment Prot. Legisl.	0.07	0.14	0.74	1.00	0.10
Unemployment benefits	0.06	-0.01	0.04	0.07	0.37
Emp. Non-market services	0.05	0.00	0.05	0.58	0.04
Old population	0.05	0.00	0.07	0.19	0.03
Sectoral Specialization	0.05	-0.86	9.97	0.16	0.01
Patents	0.04	0.00	0.00	0.88	0.04
Population density	0.04	0.00	0.19	0.72	0.00
R&D	0.04	-0.01	0.15	0.23	0.00

Notes: The dependent variable in all regressions is the resilience index calculated over the period 2008-2013. All the results reported here correspond to the estimation of the top 10,000 models from the 34 million possible regressions including any combination of the variables. Prior mean model size is 12.5. Variables are ranked by Column (1), the posterior inclusion probability. Columns (2) and (3) reflect the posterior mean and standard deviations for the linear marginal effect of the variable conditional on inclusion in the model, respectively. Column (4) denotes the sign certainty probability, a measure of our posterior confidence in the sign of the coefficient. Finally, Column (5) is the fraction of regressions in which the coefficient has a classical t-test greater than 1.96, with all regressions having equal sampling probability.

Columns (2) and (3) show the mean and the standard deviation of the posterior parameters distributions conditional on the variable being included in the model.[12] To complement these statistics, Column (5) reports the fraction of models where the t-stat of the corresponding variables is higher than 1.96 (which implies statistical significance at the 5% level), while Column (4) presents the results of the posterior sign certainty, which measures the posterior probability of a positive coefficient expected value, conditional on inclusion. The results obtained for the weak determinants do not allow to draw clear conclusions on the effect exerted on resilience. The reasons are twofold. First, in many cases the posterior sign certainty of these regressors is different from 0 or 1, suggesting that both positive and negative effects can be observed depending on the concrete regression. Consequently, the causal relationships for this group of variables are not robust. Second, the fraction of regressions where these variables exhibit t-stats above the 5% significance level is always below the 43% and even virtually 0% in the majority of cases. On the contrary, the groups of medium and important determinants of resilience display robust sign effects (either positive or negative) and are significant at the 5% level in most of the models. Therefore, for the reminder of the paper we will only discuss the results for the regressors with a PIP above 25%.

First, we consider the impact of institutional factors. As expected, the quality of government is the primary driver of resilience exerting a positive effect whereas economic self-rule does not appear to be relevant. This suggest that regional governments aiming to improve resilience should focus on improving the quality of the administration rather than increasing their level of competences.

Second, labor market institutions such as the level of bargaining coverage and the degree of centralization are statistically significant and have the expected sign. The negative effect of the linear and the negative effect of quadratic term of the coordination-centralization index supports previous findings that suggest a U pattern between labor market performance and centralization.[13] Thus, highly centralized and highly decentralized systems outperform medium centralized systems. Additionally, the negative estimated parameter of the union density and the coverage, suggests that wage rigidity in the labor market affect foster labor market adjustments through the reduction of the quantity of labor employed, lowering regional resilience. On the other hand, the results of the positive link between the tax wedge and resilience deserve some comments. Although this

[12]The key difference with respect to unconditional posterior estimates of Equations (3) and (4) is that conditional posterior estimates for a particular variable are obtained as the weighted average over the models where the variable is included. On the contrary, the unconditional posterior estimate is the averaged coefficient over all models, including those in which the variable does not appear, hence having a zero coefficient. Thus, the unconditional posterior mean can be computed by multiplying the conditional mean in Column (2) times the PIP in Column (1)

[13]To read correctly the high estimated value of the linear term of -34.89, notes that a 1 unit increase in this index implies increasing a 25% the level of coordination and centralization.

finding might be counter-intuitive from a theoretical point of view, it could be due to the fact that the parameter is picking up a *country effect* since regions that belong to Germany, Sweden or Austria are the among the most resilient ones and in these countries, the tax-wedge is very high relative to the sample regions (in Germany it is about the 45%). Nevertheless, this result can also be explained by the fact that social security contributions financed by labor-market taxation provide income support to various non-working groups including the unemployed, the sick and disabled, and the early retired. Thus, we conjecture that labor market taxation and the redistribution of revenues across the population in recessive periods could act as a buffer helping to keep consumption levels and firms' activity over a threshold thereby limiting the contraction of labor demand.

As regards the demographic factors we find that the net migration rate exerts a negative effect on resilience whereas the share of young population has a positive impact. The negative relationship between net migration can be explained by the excess of labor supply implied in destination region and by the fact that the skill set of in-migrants and residents of regions are not complementary or because of their expected levels of consumption and investments are not high, thus deteriorating labor demand prospects. The positive effect of the share of young is in line with the theoretical expectations as younger populations had a higher level of adaptability to the Great Recession due to higher geographical mobility and a set of skills better suited for rapid technological change and changing labor-market conditions.

The effect of innovation in resilience is positive and appears among the top factors explaining regional disparities. Thus, we find evidence supporting the hypothesis that product and process innovations had a potentially beneficial effect on the development of new growth paths and through reduction of production costs to maintain regional competitiveness. Finally, we find a positive effect of functional specialization in high-technology sectors as a knowledge and innovation are more likely to be developed through high-level than low-level functions. This finding suggests the need to develop productive structures and strength the incentives to develop industries that are better integrated into global value chains that require increasingly complex and sophisticated tasks.

V.B. Robustness Checks

The analysis performed so far reveals the existence of robust set of regional determinants of regional resilience such as the quality of government, innovation, the share of young, migration and some national-level labor market institutional determinants. In this section we investigate the robustness of these findings with respect the (i) measurement of resilience and (ii) the role of priors.

V.B.i. Measurements of resilience

We no check whether our results are sensitive to the definition of resilience. To that end, we construct a composite index of resilience based on both, employment growth rates and GDP per cpita growth rates. Our index takes the form of:

$$RES_i^{(a)} = \left[\left(\frac{\Delta E_i - \Delta E_{EU}}{|\Delta E_{EU}|} \right) \left(\frac{gY_i - gY_{EU}}{|gY_{EU}|} \right) \right]^{1/2} \tag{11}$$

where RES_i^a is the alternative resilience index, E denotes employment and gY denotes GDP per cpita growth rates. Thus, this index considers the effect the Great Recession on both, labor market and the goods market. As observed in Table (3) the set of top determinants is quite similar (i.e, quality of government, tax wedge, coordination and centralization, the share of employment in high-tech sectors and the net migration rate). The main differences observed between the results of Table (3) refer to the higher PIPs observed for the indicators of economic self-rule, employment protection legislation and education. These variables appeared to be weak determinants whereas in this context, they all display PIPS above the 75%. It is also worth-mentioning that the union density and coverage index does not enter in the group of medium relevance determinants whereas and instead the share of employment in manufactures enters in this group with PIPs of the 36% and a positive effect on resilience. Thus, although the measurement of resilience with this composite index suggests that other variables might also be relevant, the core group of variables driving resilience outcomes remains the same.

V.B.ii. The Role of Priors

An implication of Bayesian econometrics is that inferences drawn on the relevance of different regressors depend on prior distributions assigned to the model parameters and to the models. Often, Bayesian analysis tries to avoid situations where the conclusions depend heavily on subjective prior information. For this reason, in this subsection we present robustness checks of our findings regarding elicitation of the g-prior and the prior over the model space using the global sample of countries.

The g-prior specification

We begin by considering fixed g-priors following Fernández *et al.* (2001) as it is the case of our baseline g-prior, the BRIC which sets $g = max\,(N; K^2)$. In this group of priors we also consider the (i) Unit information prior (UIP) which sets $g = N$; the (ii) Risk information criteria prior (RIC) where $g = K^2$ and (iii) the Hannan-Quinn (HQ) g-prior setting $g = log(N)^3$. However, we also consider the (iv) Empirical Bayes prior (EBL) of Liang *et al.* (2008) which is a model k specific g-prior estimated via maximum likelihood. In this case $g = max\,(0, F_k)$ where $F_k = \frac{R_k^2(N-1-k)}{\left(1-R_k^2\right)}$. Finally, we consider the Hyper-g prior of Liang *et al.* (2008) who

Table 3: Robustness Check (I): Dependent variable

	PIP (1)	*Post Mean* (2)	*Post SD* (3)	*Cond.Pos.Sign* (4)	*T-stat* (5)
Quality of government	1.00	0.49	0.07	1.00	1.00
Tax wedge	1.00	1.59	0.21	1.00	1.00
Coordination&centralization	1.00	-43.46	4.79	0.00	1.00
$(\text{Coordination\&centralization})^2$	1.00	6.39	0.80	1.00	1.00
Emp. High technology	1.00	2.15	0.42	1.00	1.00
Economic self-rule	1.00	0.28	0.06	1.00	0.99
Net migration	0.99	-4.98	1.29	0.00	1.00
Employment Prot. Legisl.	0.99	7.53	2.00	1.00	0.96
Young population	0.98	1.31	0.37	1.00	1.00
Human capital	0.84	0.30	0.17	1.00	1.00
Emp. Manufacturing	0.36	0.11	0.18	1.00	0.30
Emp. Non market services	0.22	0.08	0.19	1.00	0.52
Infrastructure density	0.15	0.00	0.00	1.00	0.83
Emp. Financial services	0.12	0.04	0.13	0.99	0.15
Social capital	0.09	1.31	5.61	1.00	0.22
Emp. Agriculture	0.07	0.00	0.05	0.21	0.09
Patents	0.06	0.00	0.00	1.00	0.05
Innovation index	0.06	0.00	0.02	1.00	0.71
Unemployment benefit	0.06	0.00	0.03	0.11	0.50
Sectoral specialization	0.06	-1.95	12.37	0.04	0.01
Union density & coverage	0.05	0.00	0.02	0.81	0.04
Wages	0.04	0.00	0.00	0.23	0.26
Population density	0.04	0.00	0.17	0.37	0.00
R&D	0.04	0.01	0.14	0.89	0.00
Old population	0.04	0.00	0.06	0.32	0.08

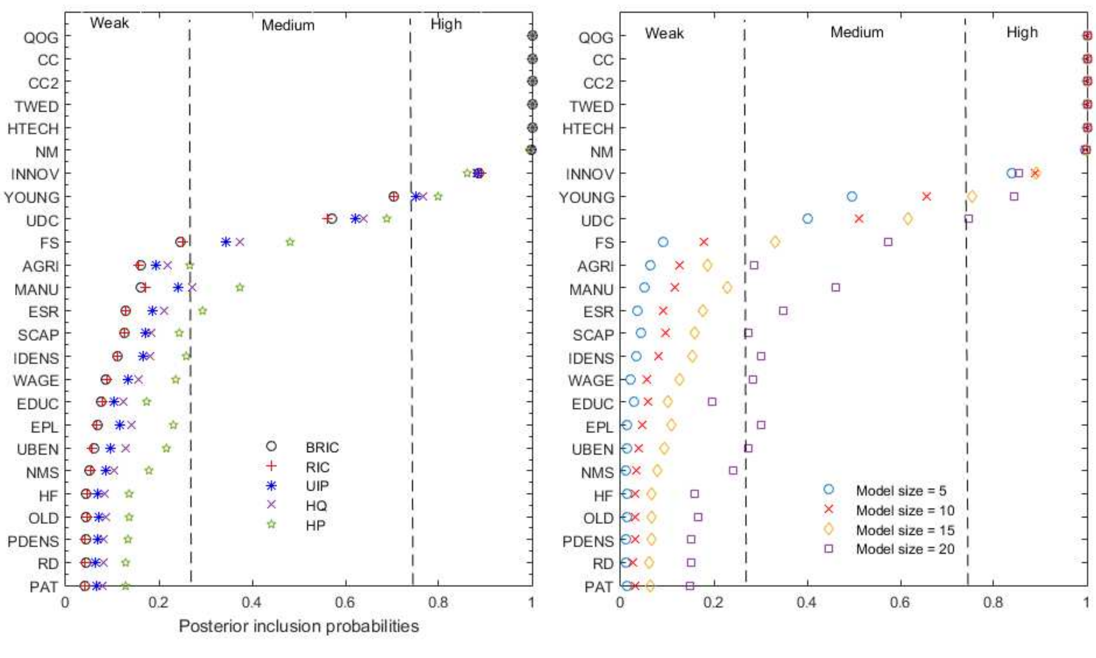
Notes: The dependent variable in all regressions is the alternative resilience index calculated with employment and GDP per cpita growth over the period 2008-2013. All the results reported here correspond to the estimation of the top 10,000 models from the 34 million possible regressions including any combination of the variables. Prior mean model size is 12.5. Variables are ranked by Column (1), the posterior inclusion probability. Columns (2) and (3) reflect the posterior mean and standard deviations for the linear marginal effect of the variable conditional on inclusion in the model, respectively. Column (4) denotes the sign certainty probability, a measure of our posterior confidence in the sign of the coefficient. Finally, Column (5) is the fraction of regressions in which the coefficient has a classical t-test greater than 1.96, with all regressions having equal sampling probability.

suggest a Beta prior on the shrinkage factor of the form $\frac{g}{1+g} \sim Beta(1, \frac{a}{2}-1)$ where in this specific case, a is set such that the prior expected value of g corresponds to the UIP case. Figure (2) below shows the PIPs for the different regressors when using different g-priors. As observed, the ranking of regressors and their relevance does not change significantly due to changes in g for the top and medium level of importance regressors whereas only minor changes arise for low level determinants.

Priors on the model space

We also check the sensitivity of our results to the Binomial prior in the model space. We depart from the baseline specification of $\phi = K/2$ and we set the parameter controlling model size ϕ to 5, 10, 15 and 20 regressors respectively. As observed in Figure (2), the effect of increasing the prior model size has a stronger effect on the PIPs than the g-prior given that the employment of priors favoring a large model size increases slightly the PIPs of most of the determinants. Importantly, for most of the regressors, the use of large model size priors do not generate a change in their classification. Overall we find that the set of top determinants and their PIPs are not significantly affected by the choice of the prior model size, thus corroborating the robustness of our main findings.

Figure 2: Robusntess Check (II): The role of priors



(a) The g-prior specification (b) Priors on the model space

VI. Conclusions and Policy Implications

This paper has examined the determinants of regional resilience in the EU during the Great Recession. They key contribution of this analysis is methodological given that we consider the effect of a great number of determinants by employing Bayesian Model Averaging techniques to account for model uncertainty in cross-regional resilience regressions. We compute the PIPs for the different indicators to generate a probabilistic ranking of relevance for the various resilience determinants. Our results point out the existence of a set of relevant determinants of resilience that explain regional differentials. The analysis reveals the quality of government is an important factor when shaping the regional reactions to the crisis in the EU. We also find that other regional level factors such as innovation, the share of employment in high-tech sectors, net migration and the age structure are of major importance. As regards labor market institutions we find that differences on tax and collective bargaining systems may affect regional resilience patterns. In particular, we find that either highly decentralized (low coordination) or highly centralized (high coordination) schemes outperform systems with a medium level of centralization and coordination. The observed connection and the degree of importance existing between these factors and regional resilience is robust to the definition of resilience and the employment of different priors. However, when considering resilience in both, the labor market and the goods market, we find that additional factors such as the strictness of employment protection legislation, regional autonomy and human capital should be considered.

The results of the paper raise potentially important policy implications, especially at a time in which there is an active public debate about what are the most appropriate instruments to reduce the impact of recessionary shocks on regional economies. Our analysis suggest that improving the quality of government may contribute to increasing the ability of regions to react to economic downturns. Accordingly, when designing effective development strategies, policy makers should pay particular attention to the way in which authority is exercised by regional governments. Actions aimed at reducing corruption or focusing in the efficiency of the judiciary might increase resilience. The relevance of the high-tech sector and the innovation variables as drivers of resilience outcomes at the regional level also suggest that policy-makers should provide incentives for firms to innovate and to attract high-tech firms. On the other hand, our results suggest that reforms of labor market institutions could have an impact strengthening the resistance and recovery capabilities of labor markets and good markets. The findings of this study suggest that policies aimed at protecting jobs or by modifying the level at which wage bargaining takes place could be beneficial. Additional extensions to our work are not difficult to conceive. For example, it would be interesting to extend the study period to the post-crisis years or to consider the existence of spatial interactions among the regional labor markets.

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