The Drivers of Regional Resilience in Europe
Evidence from the Great Recession

Vicente Rios

Universidad Pública de Navarra

Pisa, December, 2019

Introduction

Contributions of the study:

1 First analysis of relationship between quality of government and regional resilience in the EU using data on 255 NUTS2 regions from 27 countries

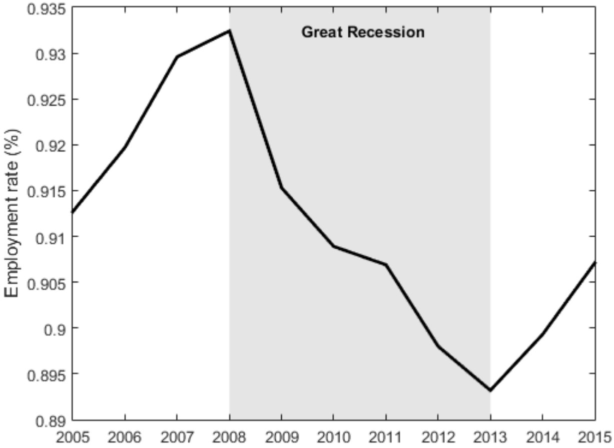
2 Methodological: modeling strategy based on spatial econometrics (regions are not treated as isolated units and spatial effects are incorporated formally in the analysis)

• SARAR(1,1) as our base-line model: allows to consider both endogenous spatial interactions and spatially correlated shocks. Omission of relevant spatial effects → biased and inefficient estimates (LeSage and Pace, 2009; Elhorst, 2014)

• Estimator: Spatial 2SLS-GMM for heteroskedastic disturbances developed by Kelejian and Prucha (2010), Arraiz et al. (2010) and Drukker, Egger and Prucha (2013) → nice features > SQML/SML, Spatial Bayesian estimation

Measuring regional resilience and QOG

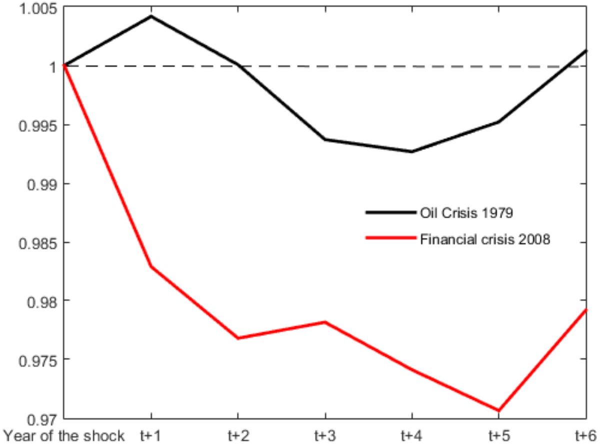
Figure: Employment rates during the recession 2008-2013



Introduction

The Great Recession that started in 2008 has affected Europe more severely than any other crisis since the end of the Second World War

Figure: European employment trajectory: Oil Crisis vs Great Recession



However, the negative effects have been very uneven across regions and across countries.

Figure: Unemployment rates increase (Δ UR)

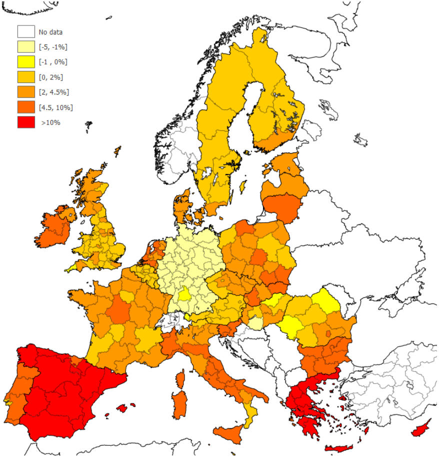


Figure: Google Trends: Growing interest in resilience.

Introduction

Martin (2012) and Martin and Sunley (2015) suggest the existence of different interpretations of the concept of resilience stemming from different disciplines of knowledge:

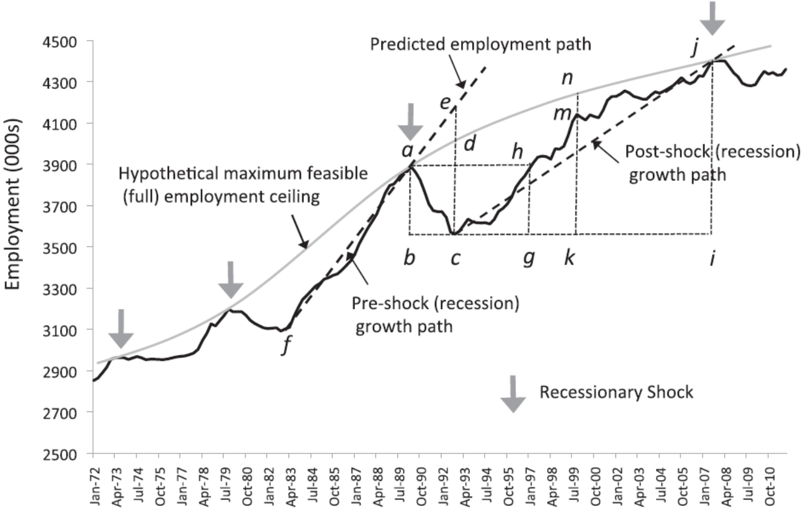
• I) *Engineering view*: ability to resist and recover/return to its steady state or equilibrium
(fun link: https://www.youtube.com/watch?v=s4C7o-HvR5s)

• II) *Ecological view*: capacity to absorb external shocks and disturbances without shifting equilibrium and/or changing its structure.

• III) *Adaptive Complex Systems view*: ability to carry out anticipatory reorganizations and to develop new paths.

Measuring Regional Resilience and QOG

Figure: The anatomy of resilience



Introduction

Literature on Regional Resilience:

• The sectoral composition of economic activity and its degree of diversity (Martin *et al*. 2016; Cuadrado-Roura and Maroto, 2016)

• The endowment of human capital (Martin, 2012) and territorial capital (Fratesi and Peucca, 2018)

• The intensity of innovation activities (Bristow and Healy, 2018)

• Urbanization patterns (Brakman et al., 2015; Giannakis and Bruggeman, 2017)

• National macroeconomic conditions (Crescenzi et al., 2016)

These studies represent substantial progress but missing link: → Regional Institutions (Quality of Governance (QoG), Economic Self-Rule)

Measuring Regional Resilience and QOG

The **measurement of resilience** displays two main approaches:

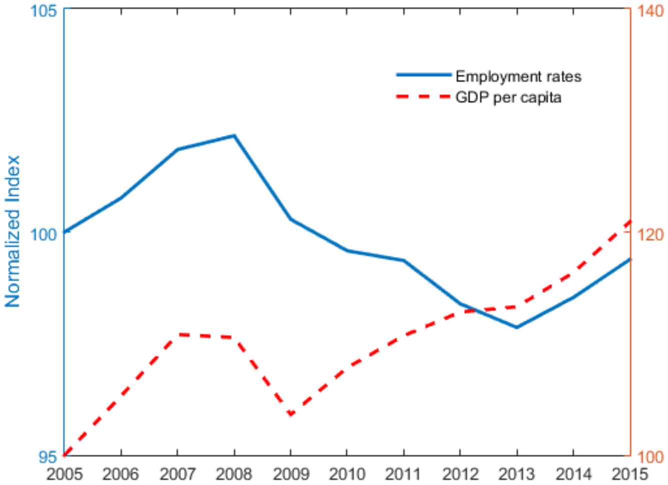
Composite indicators to measure resilience (Briguglio *et al*. 2009; Briguglio, 2014; Foster, 2007; 2012)

Univariate indicators → GDP per capita or employment rates (Cellini and Torrisi, 2014; Di Caro, 2015; Fingleton *et al*., 2012; Fingleton and Palombi, 2013; Lagravinese, 2014; Martin, 2012).

This study → univariate indicator based on *employment rate* because of:
(i) the majority of the impact of recessive shocks is directly translated into labor market variables, causing layoffs, inequality and social tension
(ii) the GDP provides a less accurate view of the state of the regional economy due to recent the jobless growth recovery phenomenon (ILO, 2014).

Measuring Regional Resilience and QOG

Figure: Jobless Growth Recovery in Europe



Measuring regional resilience and QoG

We measure regional resilience with an index of resistance to recessionary shocks (Lagravinese, 2015; Martin *et al.*, 2016; Giannakis and Bruggeman, 2017):

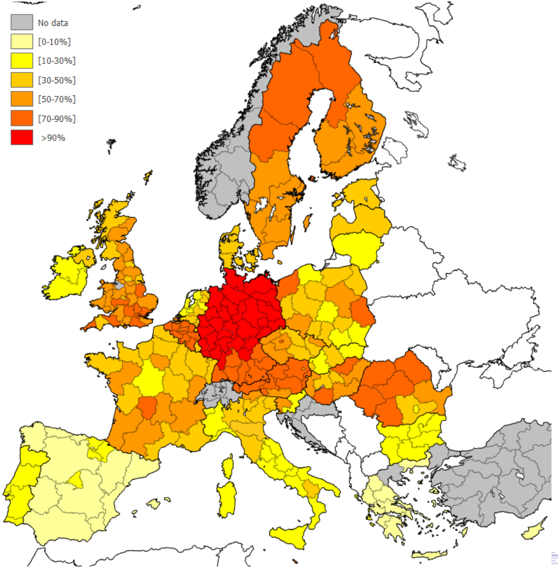
$$RES_i = \frac{\Delta E_i - \Delta E_{EU}}{|\Delta E_{EU}|} \tag{1}$$

- $RES_i > 0 \rightarrow$ resilience above average, $RES_i < 0 \rightarrow$ resilience below average
- 2nd step $\rightarrow$ max-min normalization:

$$RESN_i = 100 \left(\frac{RES_i - min(RES)}{max(RES) - min(RES)} \right) \tag{2}$$

Measuring regional resilience and QOG

Figure: The Geographical Distribution of Regional resilience



What is QoG?

Quality of Government: captures the extent to which states perform their required activities and administer public services in an impartial and uncorrupt manner (Rothstein and Teorell, 2008, Rothstein, 2009)

European Quality of government index:
- control of corruption
- impartiality
- quality of public services

- Source: QoG comes from survey data (available for the years 2010, 2013 and 2017). We employ the average of the 2010-2013 years.

- Aggregation $\rightarrow$ factor analysis

What is QoG?

Questions related to the quality of public services

- How would you rate the quality of public education in your area?

- How would you rate the quality of the public health care system in your area?

- How would you rate the quality of the police force in your area?

Measuring QOG

Questions related to the impartiality of public services

• Certain people are given special advantages in the public education system in my area.

• Certain people are given special advantages in the public health care system in my area.

• The police force gives special advantages to certain people in my area.

Measuring QOG

Questions related to the impartiality of public services

• All citizens are treated equally in the public education system in my area

• All citizens are treated equally in the public health care system in my area

• All citizens are treated equally by the police force in my area

Measuring QOG

Questions related to the corruption of public services

• Corruption is prevalent in my area local public school system

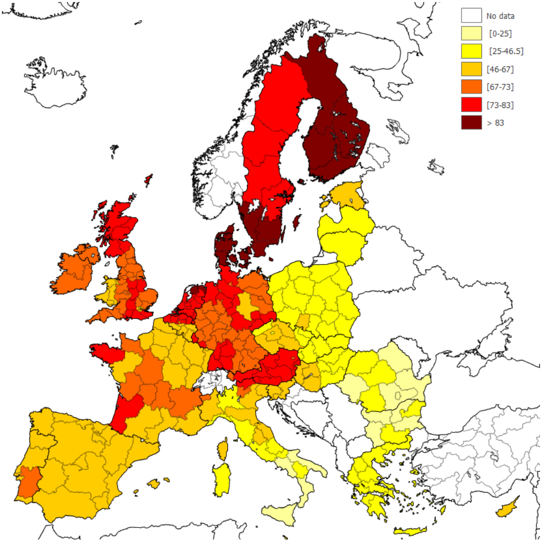
• Corruption is prevalent in the public health care system in my area

• Corruption is prevalent in the police force in my area

• In your opinion how often do you think other people in your area use bribery to obtain other special advantages that they are not entitled to?

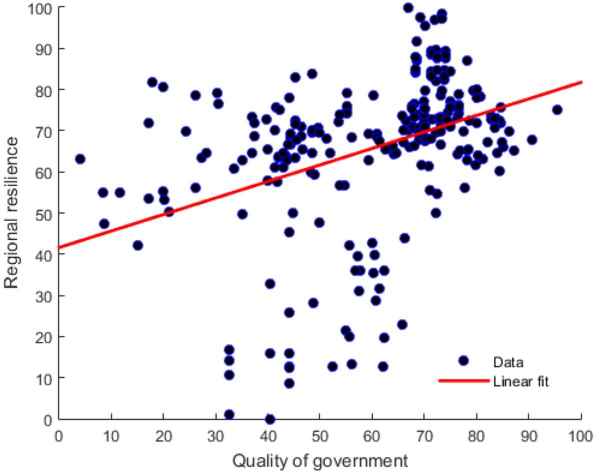
Measuring regional resilience and QOG

Figure: Quality of government



Measuring regional resilience and QOG

Figure: Quality of government and regional resilience



Why should QoG affect regional resilience?

1 Corruption $\rightarrow$ bad financial regulation and harmful/dangerous financial practices such as related lending and excess financing via debt (Laporta et al., 2003; Ahren and Goujard, 2012; Caldera-Sánchez and Gori, 2016) $\rightarrow \uparrow$ probability of severe financial collapses

$+$

Low QoG countries $\rightarrow$ implement pro-cyclical policies that exacerbate fluctuations and systemic uncertainty (Calderón et al., 2016) $\rightarrow$ bad climate for foreign investors $\rightarrow$ sudden capital stops (Honing, 2008).

- Hence, $\uparrow$ QoG $\rightarrow \uparrow$ RES

Why should QoG affect regional resilience?

2 QoG $\rightarrow$ ex-ante degree of vulnerability to external shocks:

• Low QoG $\rightarrow$ barrier to trade (Levchenko, 2007; Yu et al, 2015; Alvarez et al., 2018) and financial flows in the destination (Rodriguez-Pose and Colls, 2017)

Better QoG should:
a) $\uparrow$ connectivity $\rightarrow$ $\uparrow$ exposure to external shocks

b) $\uparrow$ connectivity $\rightarrow$ technology transfers, knowledge, competitiveness, etc

• Thus, $\uparrow$ QoG $\rightarrow$ +/- RES

Why should QoG affect regional resilience?

3a QoG $\rightarrow$ response and adaptation after the shock takes place:

QOG $\rightarrow$ $\uparrow$private sector dynamism $\rightarrow$ $\uparrow$ entrepreneurship (Nistotskaya *et al.*, (2015) and innovation (Rodríguez-Pose and Di Cataldo, 2015) if impartial legislations $\rightarrow$ $\downarrow$ barriers of entry and privileges of stablished firms

• Creative destruction (Aghion and Saint-Paul, 1998) $\rightarrow$ replacement of old technologies to develop new paths **may not work** in corrupt environments

[3b] QoG $\rightarrow$ improve bankruptcy procedures/insolvency regimes $\rightarrow$ $\uparrow$ resource reallocation and market selection (OECD, 2017)

• Thus, $\uparrow$ QoG $\rightarrow$ $\uparrow$ RES

Why should QoG affect regional resilience?

4 QoG $\rightarrow$ policy responses and the development of new growth paths:

- QoG $\rightarrow \uparrow$ investment rates (Mauro, 1996; Tanzi and Davoodi, 1997, Aidt, 2009)

- QoG $\rightarrow$ composition of public good investment (Crescenzi et al., 2016) $\rightarrow \downarrow$ unproductive opaque activities

- QoG $\rightarrow \uparrow$ investment returns and economic growth (Rodríguez-Pose and Garcilazo, 2015)

Econometric model and the data

The SARAR(1,1) model reads as:

$$\mathbf{RES} = \alpha\iota_n + \lambda\mathbf{WRES} + \beta\mathbf{QoG} + \mathbf{X}\gamma + \mathbf{u} \tag{3}$$

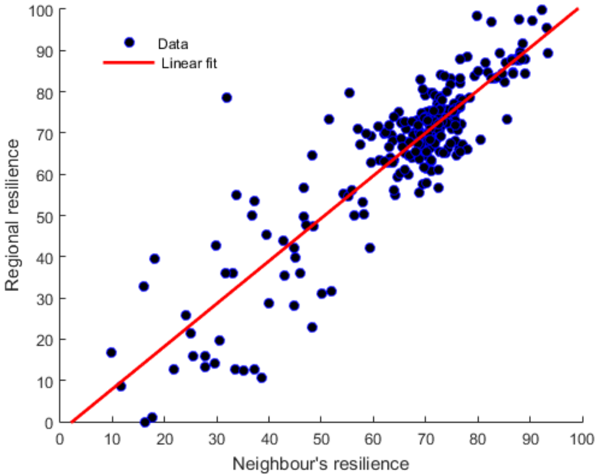
with

$$\mathbf{u} = \rho\mathbf{Wu} + \boldsymbol{\epsilon} \tag{4}$$

• **RES** and **GoQ** are, respectively, $n \times 1$ vectors consisting of one observation for each region in the sample ($i = 1, \ldots, n$) on the measures of regional resilience and quality of government
• **X** is a $n \times k$ matrix of a set of variables that control for different factors affecting regional resilience.
• **W** is a $n \times n$ spatial weights matrix with non-negative elements indicating how the regions in the sample are spatially interconnected
• **u** is a $n \times 1$ disturbance vector, while $\boldsymbol{\epsilon}$ is the corresponding $n \times 1$ innovation vector which is assumed to be heteroskedastic.

Econometric model and the data

Figure: Regional resilience: Do neighbouring regions matter?



Econometric model and the data

There are three (or four) complications with the previous model:

• a) Wy is correlated with u. Endogeneity of Wy $\rightarrow$ bias and inconsistency
• b) u is spatially correlated and it is heteroskedastic $\rightarrow$ inefficiency
• c) Endogenous interactions $\rightarrow$ parameters are not informative anymore

These issues can be solved by Spatial Maximum Likelihood (SML) and/or Spatial Bayesian Heteroskedastic (SBH) estimators and a proper algorithm to simulate the structural form of the SARAR(1,1)

• However, even if we solve a, b and c, if QoG is endogenous then, SML and SBH will be biased.

Solution: GSLS-GMM estimator developed by Kelejian and Prucha (1998, 1999) currently implemented in Stata software. (Matlab/R codes forthcoming)

Parameter estimates and t-statistics are miss-leading and cannot be interpreted.
Solution: Partial derivative interpretation and effect simulation.

1 Compute the matrix of partial derivatives with respect to the kth explanatory variable in the different units is given by:

$$\frac{\partial Y}{\partial X^k} = \left[(I - \lambda W)^{-1} \right] \left[\beta^{(k)} \right] \tag{5}$$

2 Decompose *Total Effects:* Direct Effects + Indirect Effects.
Direct Effects: Average of diagonal elements of the RHS $\rightarrow \frac{\partial Y^i}{\partial X_i^k}$
Indirect Effects: Average of row-sums/column sums of the non-diagonal elements of the RHS. $\rightarrow \frac{\partial Y^i}{\partial X_{-i}^k}$

3 To analyze the significance simulate its distribution:
$\hat{\delta}^{d\prime} = P'\hat{\delta} + \hat{\delta}'$
where $P = chol\left(\Sigma_\delta\right)$ and $\hat{\delta} = \left[\hat{\lambda}, \hat{\beta}, \hat{\rho}\right]$.

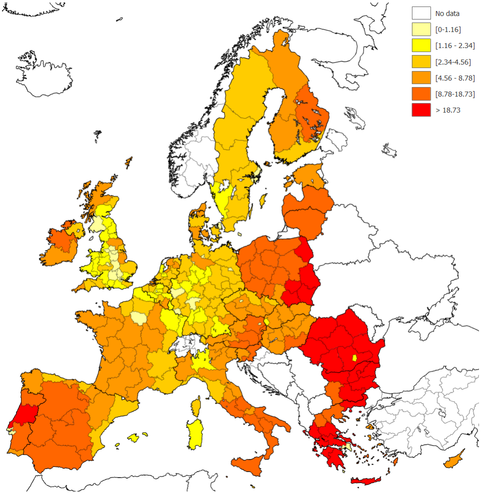
Econometric model and the data

Table: Other control variables (I).

Variable	Mean	Std. Dev.	Min	Max	Expected Effect
A.) Sectoral composition and specialization					
Agriculture	7.739	8.922	0.080	49.200	+/-
Manufacturing	18.771	6.660	5.210	36.880	+/-
Non-market services	28.574	6.065	12.000	46.460	+/-
Regional specialization	23.003	2.106	18.900	31.400	+/-
B.) Knwoledge Factors factors					
Human capital	21.459	7.805	7.170	45.980	+
Patents	3.558	1.795	-1.833	6.650	+

Econometric model and the data

Figure: Geographical Distribution of Agriculture.



Econometric model and the data

Figure: Geographical Distribution of Manufacturing.

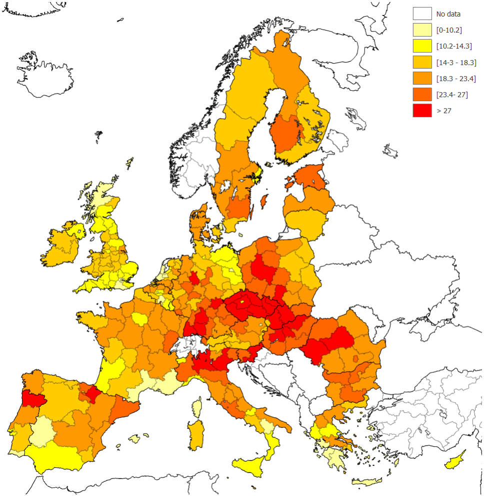


Figure: Geographical Distribution of Non-Market Services.

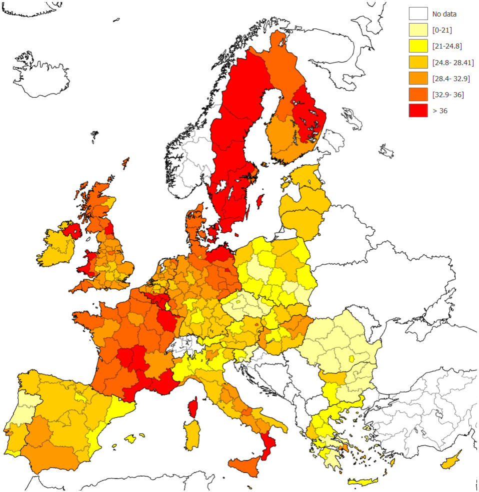
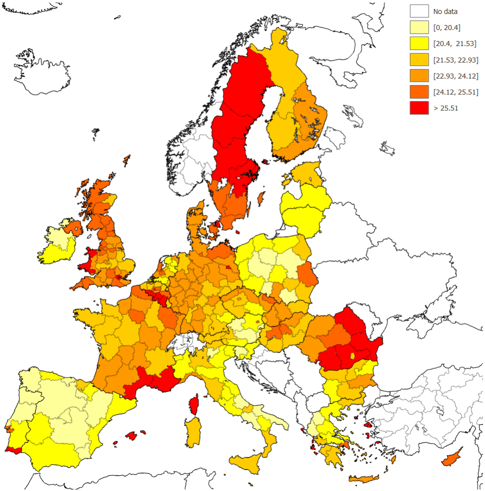


Figure: Geographical Distribution of Sectoral Specialization.



Econometric model and the data

Figure: Geographical Distribution of Human Capital (tertiary education).

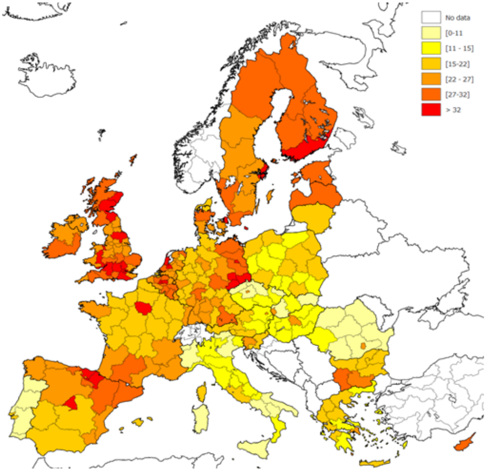
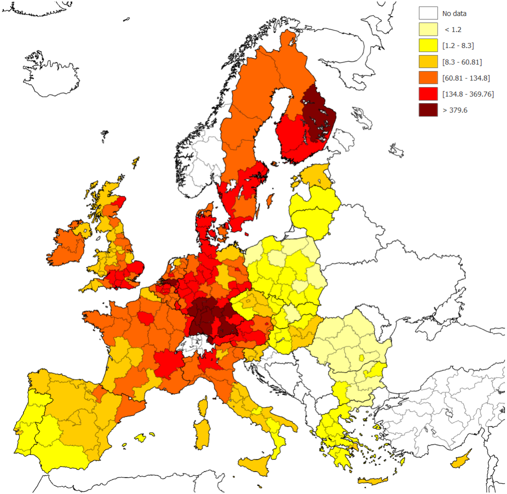


Figure: Geographical Distribution of Patent Activity.



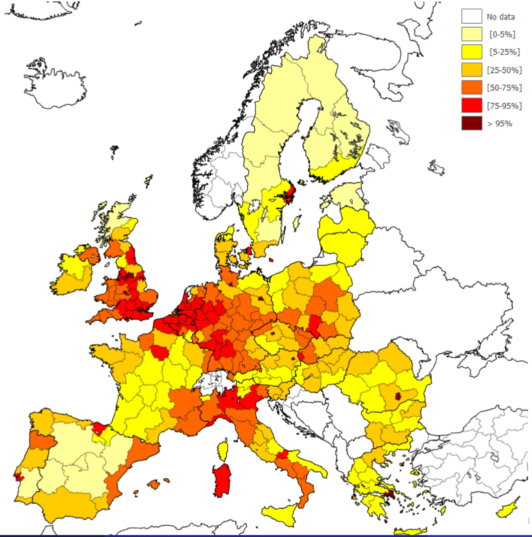
Econometric model and the data

Table: Other control variables (II).

Variable	Mean	Std. Dev.	Min	Max	Expected Effect
C) Socio-demographic characteristics					
Employment density	0.178	0.611	0.001	7.894	+/-
Young people	12.097	2.719	4.550	21.070	+
Old people	10.864	2.973	5.190	20.010	-
D) Governance					
Regional autonomy	12.824	14.220	0.000	48.000	+/-
Regional autonomy squared	365.845	512.708	0.000	2304	+/-

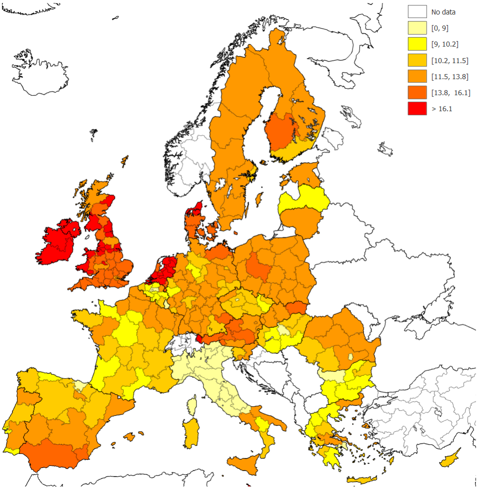
Econometric model and the data

Figure: Geographical Distribution of Employment Density.



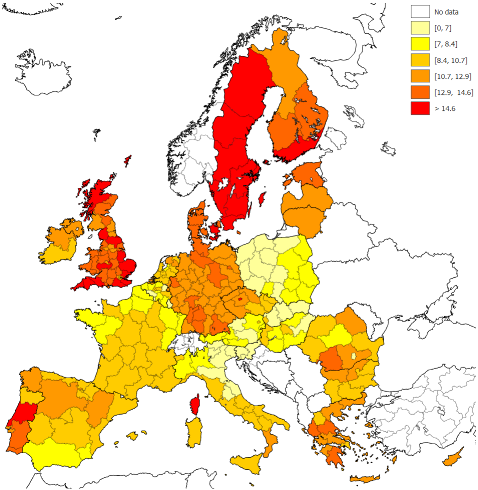
Econometric model and the data

Figure: Geographical Distribution of Young Population.



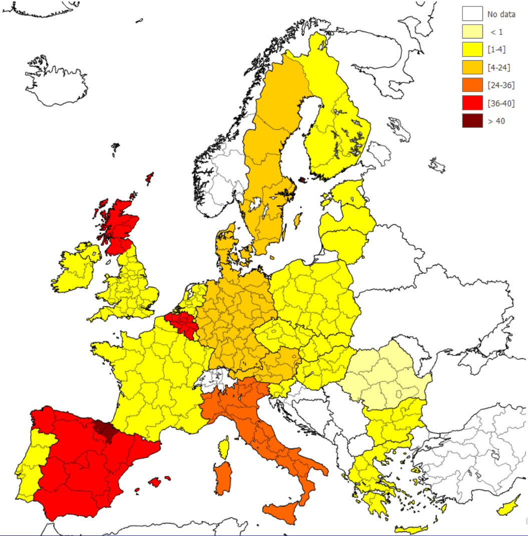
Econometric model and the data

Figure: Geographical Distribution of Old Population.



Econometric model and the data

Figure: Geographical Distribution of Economic Self-Rule.



Econometric model and the data

Table: Spatial Weights Matrix Selection.

	Log-likelihood function value	Residual variance	Posterior Inclusion
First order contiguity	-695.679	27.508	0.00
K-nearest neighbors ($K = 5$)	-687.973	29.593	0.00
K-nearest neighbors ($K = 10$)	-683.688	28.593	0.19
K-nearest neighbors ($K = 15$)	-679.280	27.203	0.73
K-nearest neighbors($K = 20$)	-680.910	27.527	0.08
K-nearest neighbors($K = 25$)	-680.963	27.469	0.00
$1/d^{\alpha}$. $\alpha = 2.00$	-688.874	29.865	0.00
$1/d^{\alpha}$. $\alpha = 2.00$ & Cut-off at Q_1	-686.958	29.329	0.00
$1/d^{\alpha}$. $\alpha = 2.00$ & Cut-off at Q_2	-685.985	29.050	0.00
$exp - (\theta d)$. $\theta = 0.01$	-689.128	29.539	0.00
$exp - (\theta d)$. $\theta = 0.01$ Cut-off at Q_1	-689.133	29.498	0.00
$exp - (\theta d)$. $\theta = 0.01$ Cut-off at Q_2	-689.128	29.478	0.00
$exp - (\theta d)$. $\theta = 0.05$	-688.611	29.295	0.00
$exp - (\theta d)$. $\theta = 0.05$ Cut-off at Q_1	-688.624	29.321	0.00
$exp - (\theta d)$. $\theta = 0.05$ Cut-off at Q_2	-688.613	29.291	0.00
Cut-off at 750 km	-685.511	28.969	0.00
Cut-off at 1000 km	-682.948	28.379	0.00
Cut-off at 1500 km	-691.565	27.283	0.00

Notes: Bayesian Markov Monte Carlo Chain (MCMC) routines developed by LeSage are employed to carry out the estimation of the SARAR model under different W specifications. Log-likelihood values reported in column (1) are obtained evaluating the likelihood of the

Results

Table: Quality of government and regional resilience: Baseline results.

	(1)	(2)	(3)	(4)	(5)	(6)
Quality of government	0.162***	0.159***	0.184***	0.149***	0.173***	0.144***
Agriculture		0.121*				0.171*
Manufacturing		-0.157*				-0.100
Non-market services		-0.086				-0.077
Regional specialization		0.207				0.127
Human capital			0.296***			0.252**
Patents			-0.981*			-0.488
Regional autonomy				-1.008***		-0.993***
Regional autonomy squared				0.023***		0.022***
Employment density					0.153	-0.807
Young people					-0.524	-0.418
Old people					0.558*	0.131
Neighbours' resilience	0.341***	0.393***	0.378***	0.330***	0.357***	0.407***
Spatial autoregressive	-0.192	-0.062	-0.418	-0.417	-0.334	-0.489
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.924	0.927	0.927	0.928	0.928	0.935

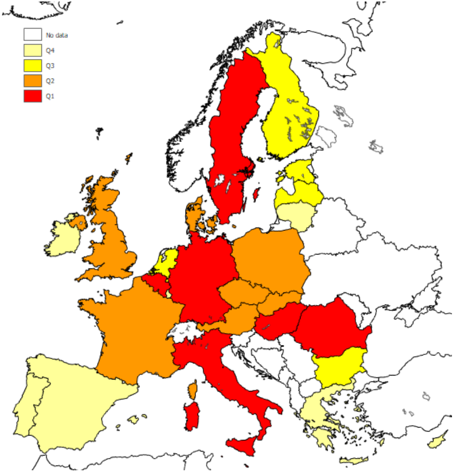
Results

Table: Baseline results: Direct, indirect and total effects.

	Direct effects	Indirect effects	Total effects
Quality of government	0.146***	0.097**	0.243***
Agriculture	0.174*	0.115	0.289*
Manufacturing	-0.101	-0.067	-0.168
Non-market services	-0.078	-0.052	-0.131
Regional specialization	0.129	0.086	0.215
Human capital	0.255**	0.169*	0.424**
Patents	-0.494	-0.328	-0.822
Regional autonomy	-1.006***	-0.669	-1.675***
Regional autonomy squared	0.022***	0.015	0.037***
Employment density	-0.818	-0.543	-1.361
Young people	-0.424	-0.282	-0.705
Old people	0.133	0.088	0.222

Results

Figure: Country-fixed effects



Results

Figure: The predicted link between ESR and Resilience

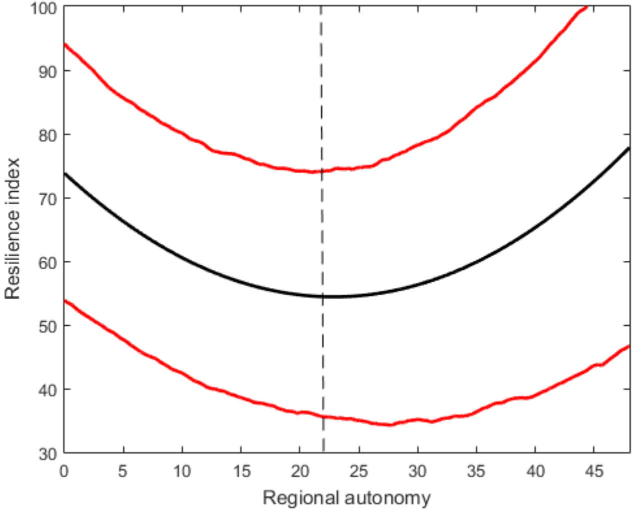
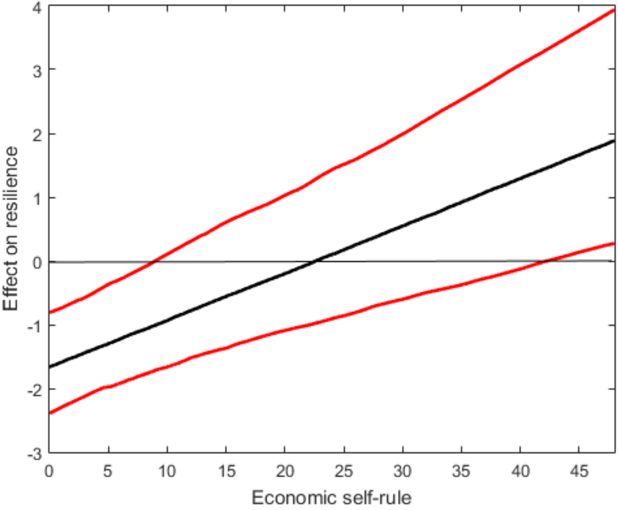


Figure: The effect of ESR on Resilience



Results

Table: Robustness analysis (I): Alternative estimation method (QML estimates).

	Direct effects	Indirect effects	Total effects
Quality of government	0.169***	0.088***	0.257***
Agriculture	0.143*	0.075	0.217*
Manufacturing	-0.103	-0.054	-0.157
Non-market services	-0.055	-0.029	-0.084
Regional specialization	0.083	0.043	0.126
Human capital	0.252**	0.131*	0.383**
Patents	-0.542	-0.283	-0.825
Regional autonomy	-1.087***	-0.567**	-1.654***
Regional autonomy squared	0.024***	0.013**	0.037***
Employment density	-0.649	-0.339	-0.987
Young people	-0.434	-0.227	-0.661
Old people	0.148	0.077	0.225

Results

Table: Robustness analysis (II): Endogeneity of the quality of government.

	Direct effects	Indirect effects	Total effects
Quality of government	0.162**	0.104**	0.266**
Agriculture	0.168*	0.107	0.275*
Manufacturing	-0.097	-0.062	-0.159
Non-market services	-0.070	-0.045	-0.115
Regional specialization	0.128	0.082	0.210
Patents	-0.518	-0.331	-0.848
Human capital	0.257**	0.164*	0.421**
Regional autonomy	-1.008***	-0.644***	-1.652***
Regional autonomy squared	0.022***	0.014**	0.037***
Employment density	-0.768	-0.491	-1.258
Young population	-0.399	-0.255	-0.654
Old population	0.164	0.105	0.269

Results

Table: Robustness analysis (III): Alternative spatial models.

	Spatial autoregressive model			Spatial Durbin model		
	Direct effects	Indirect effects	Total effects	Direct effects	Indirect effects	Total effects
Quality of government	0.133**	0.092**	0.225**	0.175***	0.930*	1.105**
Agriculture	0.198**	0.137*	0.335*	0.163*	-0.264	-0.102
Manufacturing	-0.098	-0.068	-0.166	-0.138	0.385	0.247
Non-market services	-0.107	-0.074	-0.182	-0.074	2.184	2.110
Regional specialization	0.213	0.147	0.360	-0.090	-6.505	-6.595
Human capital	0.248**	0.172*	0.420***	0.166	-1.362	-1.196
Patents	-0.356	-0.247	-0.603	-0.060	-5.197	-5.257
Regional autonomy	-0.903***	-0.624**	-1.527***	-1.270***	-8.679	-9.948
Regional autonomy squared	0.020***	0.014**	0.034***	0.029***	0.246	0.274
Employment density	-0.996	-0.689	-1.686	0.116	22.904	23.020
Young people	-0.390	-0.270	-0.660	-0.056	-0.561	-0.617
Old people	0.098	0.068	0.165	0.278	4.068	4.347

Results

Table: Robustness analysis (IV): Different dimensions of the quality of government.

	Direct effects	Indirect effects	Total effects	Direct effects	Indirect effects	Total effects	Direct effects	Indirect effects	Total effects
Quality	0.136*	0.093*	0.229**						
Impartiality				0.162**	0.105**	0.267***			
Control of corruption							0.139**	0.090**	0.229**
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Partial Conclusions

We examine analyze relationship between quality of government and regional resilience in a cross-sectional sample of 255 regions

We find a positive link partly explained by spatial spillovers (i.e, indirect effects about the 40% of the total impact)

This positive link is robust to (i) additional covariates, (ii) different measurements of resilience and dimensions QoG, (iii) alternative spatial models such as the SLM/SDM

Endogeneity concerns due to omitted variables or reverse causality are addressed by means of the 2SLS-GMM estimator.

Other X: non-linear effect of ESR, + effect of human capital and agriculture

Key Policy implication: invest in institutional quality: control of corruption, increase transparency, etc

Bayesian Model Averaging

Is the QOG effect robust to Model Uncertainty? We use one model when for k regressors there are 2^k pieces of information..

• Traditional spatial regression analysis → artificially narrow bands & silent on the relative relevance of X.

•*Implication*→ being too confident about the wrong thing.

Now: Analysis of the relationship between regional factors and resilience by means of:
Bayesian Model Averaging techniques (priors on parameters, model space, MC3 sampling)

Generates a probabilistic ranking of regressors considering a larger ata set of potential determinants including: (i) regional government factors, (ii) innovation factors, (iii) socio-demographic factors, (iv) labor-market factors and (v) macro-factors.

Bayesian Model Averaging

Not so many SBMA $\rightarrow$ LeSage and Fischer (2008), Crespo-Cuaresma et al. (2014), Hortas-Rico and Rios (2018)

For a set of size K, possible models are 2^K and $k \in \left[0, 2^K\right] \rightarrow$ there are 2^K sub-structures of the model given by subsets of coefficients $\eta^k = \left(\alpha, \beta^k\right)$ and combinations of regressors $X_k \rightarrow$ this case 16.7 million possible models

Many different candidate models for estimating the effect of X_j on y with $j \in K$. Researcher has two options:
i) Traditional: select a single model based and make inference using that selected model ignoring model uncertainty
or

ii) **SBMA**: **estimate all the candidate models** (or a relevant sample of them) **and compute a weighted average of all the estimates for the coefficient of X_j** while controlling for potential spatial interactions in a SLM

Bayesian Model Averaging

The key metrics to perform inference in this context are:

The Posterior Mean (PM):

$$E\left(\eta|y,X\right)=\sum_{k=1}^{2^K}E\left(\eta_k|M_k,y,X\right)p\left(M_k|y,X\right) \tag{6}$$

Posterior Standard Deviation (PSD):

$$PSD=\sqrt{Var\left(\eta|y,X\right)} \tag{7}$$

where the $Var\left(\eta|y,X\right)$ denotes the posterior variance.

Posterior inclusion probability (PIP) for a variable h:

$$PIP=p\left(\eta_h\neq 0|y,X\right)=\sum_{k=1}^{2K}p\left(\eta_k|M_k,y,X\right)p\left(M_k|\eta_h\neq 0,y,X\right) \tag{8}$$

Conditional posterior positivity of a variable h as:

$$p\left(\eta_h\geq 0|y,X\right)=\sum_{k=1}^{2^K}p\left(\eta_{k,h}|M_k,y,X\right)p\left(M_k|y,X\right) \tag{9}$$

The key element in the computation of all previous metrics are the PMPs $p\left(M_k|y,X\right)$ which are given by:

$$p\left(M_k|y,X\right) = p\left(y,X|M_k\right)p\left(M_k\right) \tag{10}$$

where $p\left(y,X|M_k\right)$ is the marginal likelihood and $p\left(M_k\right)$ is the prior model probability.

$$p\left(y,X|M_k\right) = \int_0^{\infty}\int_{-\infty}^{\infty} p\left(y,X|\eta_k,\sigma^2,M_k\right) p\left(\eta_k,\sigma^2|g\right) d\eta d\sigma \tag{11}$$

where $p\left(y,X|\eta,\sigma,M_k\right)$ is the likelihood of model k and $p\left(\eta_k,\sigma^2|g\right)$ is the prior distribution of the parameters in model k conditional to g.
The g-prior (Zellgern's prior) shapes the distribution of the parameters [1]

$$\eta_k|g \sim N\left(0,\sigma^2 g\left(X_k' X_k\right)^{-1}\right)$$

The prior model probability we employ a Binomial prior on the model space $p\left(M_k\right) \propto \left(\frac{\phi}{K}\right)^k\left(1-\frac{\phi}{K}\right)^{K-k}$, where ϕ is set to $K/2$ to assign an equal prior probability $p\left(M_k\right) = 2^{-K}$ to all the models under consideration.

$$p\left(M_k\right) = \phi^k\left(1-\phi\right)^{K-k}, \phi = 0.5 \tag{12}$$

[1] Intuition on g: higher values of $g \rightarrow$ less of weight to the prior-variance relative to the estimated sample variance (i.e. the researcher is very uncertain that coefficients are zero); small g $\rightarrow$ few prior coefficient variance and therefore implies the researcher is quite certain (or conservative) that the coefficients are indeed zero.The g-prior shapes the distribution of the parameters in each model M_k 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).

The key element in the computation of all previous metrics are the PMPs $p(M_k|y, X)$ which are given by:

$$p(M_k|y, X) = p(y, X|M_k)p(M_k) \tag{10}$$

where $p(y, X|M_k)$ is the marginal likelihood and $p(M_k)$ is the prior model probability.

$$p(y, X|M_k) = \int_0^{\infty} \int_{-\infty}^{\infty} p\left(y, X|\eta_k, \sigma^2, M_k\right) p\left(\eta_k, \sigma^2|g\right) d\eta d\sigma \tag{11}$$

where $p(y, X|\eta, \sigma, M_k)$ is the likelihood of model k and $p\left(\eta_k, \sigma^2|g\right)$ is the prior distribution of the parameters in model k conditional to g.
The g-prior (Zellgern's prior) shapes the distribution of the parameters [1]

$$\eta_k|g \sim N\left(0, \sigma^2 g \left(X_k' X_k\right)^{-1}\right)$$

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.

$$p(M_k) = \phi^k (1-\phi)^{K-k}, \phi = 0.5 \tag{12}$$

---

[1] Intuition on g: higher values of $g \rightarrow$ less of weight to the prior-variance relative to the estimated sample variance (i.e. the researcher is very uncertain that coefficients are zero); small g $\rightarrow$ few prior coefficient variance and therefore implies the researcher is quite certain (or conservative) that the coefficients are indeed zero.The g-prior shapes the distribution of the parameters in each model M_k 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).

Bayesian Model Averaging

BMA $\rightarrow MC^3$ algorithm

[Step 1] Draw a initial set of regressors X_i to define the model state of the chain M_i. Compute $p\left(M_i|y, X\right)$ and define neighborhood of model $nbd\left(M_i\right)$, which consists in M_i itself and M_j models with $+/-$ 1 regressors not included in i.

[Step 2] Compare M_i with $M_j \in nbd\left(M_i\right)$ and reject M_j if: $\frac{p\left(M_j|y,X\right)}{p(M_i|y,X,)} < 1$, otherwise, accept it.

[Step 3] Flip a three-faced coin and use the outcome 1 to 3 to determine the following changes in M_i:

if $[o = 1]$ Add an explanatory variable chosen randomly from those not included in the model (birth step)

if $[o = 2]$ Eliminate an explanatory variable chosen randomly from those currently (death step)

if $[o = 3]$ Eliminate one variable randomly and replaced it randomly from the set of variables not included (move step)

Extended set of Determinants of Resilience

Variables	Code	Definitions	Sources
1. Long-run Macroeconomic Factors			
Income per capita	GDPpc	Average Income per capita (in thousand euros)	CE
Volatility	VOL	Standard deviation of the output per capita gap (%)	CE
Employment growth	EMPG	Average annual growth rate of employment rates (%)	CE
2. Institutional Factors			
Quality of government	QOG	Regional quality of government index based on the indicators of corruption regulatory quality and impartiality	QOGI
Economic self-rule (a)	ESR	Economic self-rule index: policy scope, fiscal autonomy, political representation and institutional depth	Sorens (201

Notes: CE denotes the Cambridge Econometrics Database, QOGI denotes the Quality of Government Institute, (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.

Extended set of Determinants of Resilience

Variables	Code	Definitions	Sources
3. Innovation Factors			
Patents	PAT	Number of patent applications to the EPO per years (million of inhab.)	Eurostat
Innovation	INNOV	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	Research and development spending to GDP (%)	Eurostat
Infrastructure density	IDEN	Number of kilometres of motorways and railways network on usable land (in levels)	Eurostat
Human capital	EDUC	% of population with tertiary education	Eurostat
		education attainment	Eurostat

Notes: RIS refers to the Regional Innovation Scoreborad and CIS to Innovation Community Survey.

Extended set of Determinants of Resilience

Variables	Code	Definitions	Sources
4. Social-Demographic Factors			
Population density	PDENS	Thousand inhabitants per squared kilometer	CE
Old population	OLD	Population share between 55-65 years old (%)	Eurostat
Young population	YOUNG	Population share between 15-24 years old (%)	Eurostat
Social capital(c)	SCAP	Index of social capital (scale 0-1)	ESVS
Net migration(d)	NM	Net migration rate (%)	Eurostat

Notes: CE denotes the Cambridge Econometrics Database, ESVS denotes the European Social Value Survey. (c) Social capit calculated as the share of population agreeing "that most of people can be trusted". (d) The net migration rate for each year of 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 dea whereas n_{it} denotes the population.

Extended set of Determinants of Resilience

5. Labour Market Factors			
Wages	WAGE	Compensation per employee (euros)	CE
Agriculture	AGRI	Employment share in agriculture (%)	CE
Manufactures	MANU	Employment share in manufacturing (%)	CE
Financial services	FS	Employment share in financial market services (%)	CE
Non-market services	NMS	Employment share in non market services (%)	CE
High-tech employment	HTECH	Employment share in high-tech sector (%)	CE
Sectoral specialization(e)	HF	Herfhindal index calculated over the employment in 6 different sectors	CE

Notes: CE denotes the Cambridge Econometrics Database. (e) The sectors $s = 1, \ldots, S$ considered to obtain the Herfindahl I
are agriculture, manufactures, construction, distribution, non-market services and financial services.

Results BMA (I): High Relevance Determinants

Table: Main Results (I): Bayesian Model Averaged Estimates

Variable	PIP (1)	Lower 5% (2)	Cond Posterior. Mean (3)	Cond Posterior. Std (4)	Upper 95% (5)	Sign Pos. (6)
Neighbor's Resilience	1.000	0.290	0.332	0.061	0.414	1.00
Country Effects	1.000					
Volatility	1.00	-1.6760	-1.2464	0.3227	-0.9154	0.00
Quality of government	1.00	0.1642	0.2094	0.0512	0.3198	1.00
Human capital	0.63	0.1256	0.2157	0.1001	0.3281	1.00
Employment growth	0.44	-0.9941	-0.8387	0.4367	-0.6782	0.00
Young population	0.38	-0.8334	-0.6632	0.3189	-0.2905	0.00
Economic self-rule	0.49	-0.9832	-0.5568	0.3738	-0.0051	0.05
Economic self-rule squared	0.48	-0.0012	0.0119	0.0083	0.0215	0.68
Old population	0.17	0.0902	0.2945	0.1520	0.4263	0.98

Notes: The dependent variable in all regressions is the resilience index based on employment rates during the period 2008-2013. All the results reported here correspond to the estimation of the top 10,000 models from the 16.777.216 million possible regressions including any combination of the 24 regional regressors. Variables are ranked by Column (1), the posterior inclusion probability. Columns (2) to (5) reflect the lower 5% bound, the posterior mean, standard deviations and upper 95% bound for the linear marginal effect of the variable conditional on inclusion in the model, respectively. The last column denotes the sign certainty probability, a measure of our posterior confidence in the sign of the coefficient.

Results BMA (II): Medium-low Relevance Determinants

Table: Main Results (I): Bayesian Model Averaged Estimates

Variable	PIP (1)	Lower 5% (2)	Cond Posterior. Mean (3)	Cond Posterior. Std (4)	Upper 95% (5)	Sign Pos. (6)
Log Patents	0.04	-0.0464	0.5833	0.1420	1.2356	0.93
Sectoral specialization	0.10	-0.0312	0.1925	0.0888	0.3499	0.94
Non-market services	0.07	-0.1246	-0.0192	0.0325	0.1683	0.31
Innovation	0.06	-0.0802	-0.0152	0.0192	0.0974	0.28
Financial services	0.05	-0.2223	-0.0366	0.0429	0.1101	0.48
Infrastructure density	0.03	-0.0004	0.0000	0.0001	0.0004	0.50
High-tech employment	0.05	-0.5207	-0.1596	0.1027	0.1793	0.37
Manufactures	0.06	-0.1557	-0.0762	0.0260	0.0081	0.08

Notes: The dependent variable in all regressions is the resilience index based on employment rates during the period 2008-2013. All the results reported here correspond to the estimation of the top 10,000 models from the 16.777.216 million possible regressions including any combination of the 24 regional regressors. Variables are ranked by Column (1), the posterior inclusion probability. Columns (2) to (5) reflect the lower 5% bound, the posterior mean, standard deviations and upper 95% bound for the linear marginal effect of the variable conditional on inclusion in the model, respectively. The last column denotes the sign certainty probability, a measure of our posterior confidence in the sign of the coefficient.

Results BMA (III): Medium-low Relevance Determinants

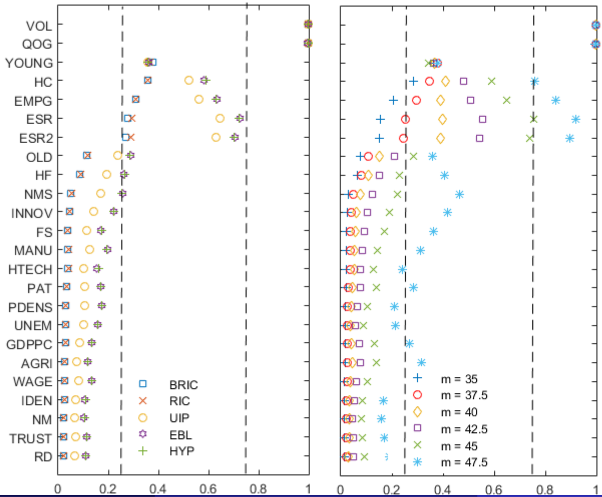
Table: Main Results (I): Bayesian Model Averaged Estimates

Variable	PIP (1)	Lower 5% (2)	Cond Posterior. Mean (3)	Cond Posterior. Std (4)	Upper 95% (5)	Sign Pos. (6)
Long term unemployment	0.04	-0.4651	-0.1442	0.0528	0.1046	0.18
Income per capita	0.04	0.0000	0.0000	0.0000	0.0001	0.78
R& D	0.03	-0.3737	-0.1238	0.0629	0.0643	0.17
Agriculture	0.03	-0.0276	0.0302	0.0166	0.0806	0.84
Population density	0.04	-0.6435	-0.2436	0.1227	0.2094	0.22
Net migration	0.03	-1.5820	-1.2530	0.2697	-0.6867	0.00
Wages	0.04	0.0000	0.0000	0.0000	0.0001	0.26
Trust	0.03	-1.6435	4.6589	1.5166	10.1107	0.91

Notes.

Results BMA (IV)

Figure: The role of priors



Conclusions

We examine an extended set of drivers of resilience by means of a large set of regressors (24) including also country-fixed effects by means of Spatial Bayesian Techniques

The positive effect of QOG is corroborated in this context (in 100% of the models explored the effect was positive)

When looking at the PIPs, as metrics of relative importance we find QOG has a 100% probability of being part of the true DGP, which implies it is a top driver of resilience together with volatility and human capital

The effect of considering different g-priors and different priors on the model size does not alter this finding.

Now we can feel even more safe saying QOG the key driver of resilience.