***Discussion Papers***

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



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*Discussion Paper* n. 201

2015

*Discussion Paper* n. 201, presentato: July **2015**

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Please cite as it follows
*Irene Brunetti, Davide Fiaschi, Lisa Gianmoena and Angela Parenti* (2015), "*Volatility in European Regions*", Discussion Papers del Dipartimento di Economia e Management – University of Pisa, n. 201 (http://www-dse.ec.unipi.it/ricerca/discussion-papers.htm).

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# Volatility in European Regions

**Abstract**

This paper examines the growth rate volatility of per capita GDP of European regions in 1992-2008. We measure the regional volatility using a new methodology based on Markov matrices and we investigate its main determinants. Volatility displays a geographical pattern and a significant spatial dependence. Output composition appears one of the main driver of volatility; among the other determinants we find a negative impact of the size of regional economies and of the flexibility of labour market, and a positive impact of the sectoral concentration, of the financialization of economy, and of the participation to EMU.

**Classificazione JEL:** C20, E32, O40

**Keywords:** Markov Matrix, Asymmetric Fluctuations, Output Composition, Size Effect, Spatial Dependence

*Contents*

## *I. Introduction*

The aim of this paper is to study the growth rate volatility (GRV) of per capita GDP in a large sample of European regions in the period 1992-2008. To this purpose we propose a new measure of GRV based on Markov matrices and we investigate the main drivers of regional volatility.

The interest in GRV derives both from its negative relationship with long-run growth (see for a review Priesmeier and Stahler 2011), and from the welfare cost associated with business cycles (see for a review Imrohoroglu 2008). However, while GRV of countries has been investigated by many researchers (starting from the pioneering contribution by Ramey and Ramey 1995), the volatility of European regions has received a limited attention[1], despite its potential key policy implications, which range from the opportunity to support the dynamics of regional output specialization deriving from European integration (Krugman and Venables 1996); to the effectiveness of public expenditure and monetary policy in stabilizing business cycle (Hansen 1941 and Goodfriend and King 1997); to the role of European Monetary Union (EMU) in exacerbating regional shocks (De Grauwe 2007); to the design of more flexible European labour markets in order to increase the capacity to absorb shocks (Nickell and Layard 1999); and, finally, to the effects of the increasing financialization of European economies, which some scholars argue to favour deep negative fluctuations (Epstein 2005 and Freeman 2010).

We depart from the literature, generally adopting as measure of GRV the standard deviation (SD) of growth rates of per capita GDP (as, e.g., Ramey and Ramey 1995), using an index of GRV based on Markov matrices inspired by the literature on social mobility: both phenomena are in fact related to the frequency and intensity of fluctuations/changes in the variable of interest (growth rates versus income/occupations) (see Bartholomew 1973). Among the advantages of the proposed approach, it allows to tune the impact on the index of GRV due to business cycle as opposed to large fluctuations, and to compute the contribution of negative fluctuations to overall GRV, i.e. to evaluate the importance of asymmetry in business cycle, a key feature of standard Keynesian model (Hai et al. 2013). Finally, our GRV index makes possible to set the *type* (frequency) of fluctuations to be considered in the calculation of the index (e.g. quarterly versus annual fluctuations), and to distinguish between *temporary* and *persistent* fluctuations, where only the first type should enter into a GRV index as pointed out by Gelb 1979 and Temple and Malik 2008.

We discuss how, despite its wide use and simplicity, SD cannot account for some of the crucial characteristics of GRV of regions. In particular, we argue that our index of GRV correctly measures high-frequency fluctuations of growth rates

[1]Fiaschi et al. 2014 deal with the same issue but taking a very different approach based on a measure of GRV inspired by McConnell and Perez Quiros 2000. Differently, Falk and Sinabell 2009 focus on the relationship between GRV and long-run growth.

being robust to other "types" of fluctuations (generally fluctuations characterized by high persistence and large jumps), more adequately referred to phenomena of "instability" (see, again, Gelb 1979 and Temple and Malik 2008).

The literature on the potential determinants of GRV is massive. In particular, Koren and Tenreyro 2007, DiGiovanni and Levchenko 2009 and Fiaschi and Lavezzi 2011 point out how output composition appears a key determinant, since some sectors (e.g. primary sectors) generally display higher level of volatility.

Another determinant of GRV is economy's size and its degree of sectoral diversification. A robust inverse relationship between country size and output volatility has been found in many contributions (Canning et al. 1998, Head 1995 and Crucini 1997). The explanation of the size-volatility relationship in Easterly and Kraay 2000, Imbs 2007 and DiGiovanni and Levchenko 2012 relies on the idea that smaller countries have fewer firms, less diversification in output and, thus, higher macroeconomic volatility. In the same vein, Mobarak 2005 finds that the concentration of output in few sectors is a source of volatility.

From a macroeconomic perspective, standard Keynesian argument is that higher shares of consumption in aggregate demand and large government expenditure increase the resilience of an economy to shocks (see, e.g., Blanchard et al. 2013). Empirical evidence in Van den Noord 2000, Bejan 2006 and Fatas and Mihov 2000 generally supports the claim that for countries a larger government size decreases their GRV. On the other hand, when associated to high public debt, a large public sector could induce macroeconomic instability by reducing the available resources to contrast adverse shocks (i.e. the impossibility to adopt an adequate fiscal stimulus in recession); evidence on the recent recessions in US and Europe seems to support this idea (Spilimbergo et al. 2009).

Recent financial crisis has opened a debate on the effect of financial deepening on economic stability of developed economies. In particular, Easterly et al. 2000 find an U-shape relationship between financial depth and GRV for a cross-section of countries, and show how GRV starts increasing when credit to private sector reaches 100% of GDP. Aghion et al. 2005 argue that a lower degree of financial development makes investment more pro-cyclical, amplifying the variation of productivity and output; on the contrary, Freeman 2010 concludes that recent financialization is at the core of the recent deep economic crisis.

Monetary policy is another potential determinant of GRV. Blanchard and Simon 2001, Cecchetti and Ehrmann 2002, Ball and Sheridan 2003 and Leduc and Sill 2007 investigate the empirical evidence on the relationship between inflation targeting and growth volatility, but no conclusive result has still been reached.

From a long-run perspective the countries' institutional arrangement has important effects on GRV (Acemoglu et al. 2003 and Mobarak 2005); in particular, a higher flexibility of labour market is generally seen as a major determinant of the response of an economy to shocks (Gnocchi et al. 2015).

Finally, a specific possible determinant of GRV of European regions is the participation to EMU. Common wisdom in literature is that Euro zone, encompassing very heterogeneous countries/regions, is more vulnerable to economic shocks (De Grauwe 2007), as also suggested by the recent Greek crisis (De Grauwe and Ji 2014). However, Canova et al. 2012 and Enders et al. 2013 find no evidence of an effect of the introduction of Euro on the business cycle of participating countries.

Our empirical evidence contributes to the literature showing how the GRV of European regions is explained by GRV of their neighbours, and pointing out the existence of high-GRV clusters of regions belonging to Greece, Eastern and Northern countries, as opposed to low-GRV clusters of regions belonging to the centre of Europe. Monetary and fiscal policies have played a negligible role; instead key determinants of volatility of European regions appear their economic size, their output composition and sectoral concentration. EMU and financialization of countries have positively contributed to GRV, while labour market flexibility has exerted a stabilizing impact.

The paper is organized as follows. Section II. discusses our index of GRV and its properties; Section III. contains an exploratory analysis of GRV in European regions and the study of its determinants. Finally, Section IV. contains some concluding remarks and policy implications of analysis.

## ***II. A New Methodology to Measure GRV***

In this section we present a novel methodology to measure GRV. The idea behind this methodology is the existence of a natural parallelism between GRV and social mobility, being both phenomena related to the frequency and intensity of fluctuations in the variable of interest (growth rates and income/occupations). In particular, inspired by a mobility index firstly advanced by Bartholomew 1973, we propose the following index of GRV:

$$I_B^\alpha \equiv \int_{\underline{y}}^{\bar{y}} \underbrace{\pi(q)}_{\text{III}} \int_{\underline{y}}^{\bar{y}} \underbrace{g(s|q)}_{\text{II}} \underbrace{\left[\frac{|s-q|^\alpha}{\max(|s-q|^\alpha)}\right]}_{\text{I}} dsdq, \tag{1}$$

where $y$ is the cyclical component of the time series of growth rates (whose range of variation is $(\underline{y}, \bar{y}))$, $q$ and $s$ are the states at periods $t$ and $t+1$ respectively, and $\alpha$ is a weight parameter greater than zero.

$I_B^\alpha$ is the result of three different components:

I. $\frac{|s-q|^\alpha}{\max(|s-q|^\alpha)}$ represents the weight of the "jump" from state $q$ to state $s$. A higher $\alpha$ means a higher weight to large "jumps";

II. $g(s|q)$ is the stochastic kernel, i.e. the conditional probability to jump to state $s$ starting from state $q$;

III. $\pi(q)$ is the ergodic distribution, which measures how much time is spent in state $q$ in equilibrium.

The sum of components $I$ and $II$ provides a sub-index of GRV of the state $q$; hence, $I_B^\alpha$ can be seen as a weighted mean of all sub-indexes of all possible states, where the weights of these different states are their mass in the ergodic distribution. We will exploit this property to propose a measure of asymmetry of GRV in Section II.A. dividing "positive" from "negative" states. It is straightforward to check that $I_B^\alpha \in [0, 1]$, with a higher value of $I_B^\alpha$ implying a higher GRV.

Implicit assumption for the application of this methodology is the possibility to disentangle cyclical and trend components in the time series of growth rates, taking only the cyclical component in the calculation of $I_B^\alpha$ (see Section III.B.).

An important difference with respect to original Bartholomew index is that $I_B^\alpha$ is defined in a continuous state space. This choice is motivated to overcome the limits of an arbitrary discretization of the state space, which could lead to remove the Markov property of the stochastic process (see Bulli 2001).

To shed light on the interpretation of index $I_B^\alpha$, Figures 1a-1f show components II and III for the annual growth rates of two European regions selected among the sample analysed in Section III.B., with the highest and the lowest $I_B^1$ (i.e. $\alpha = 1$).

The region with the highest $I_B^1$ (equals to 0.29) displays frequent and significant "jumps" of its cyclical component around zero (see Figure 1a)[2]. This graphical intuition is confirmed by the estimated stochastic kernel (i.e. the transition Markov matrix with continuous state space) reported in Figure 1b, where 6 out 16 transitions are related to passages through zero[3]. The stochastic kernel also highlights how the probability of large jumps is not negligible for a large range of initial states. Finally, the estimated ergodic distribution reported in Figure 1c appears very broadly distributed, confirming that the region is likely to visit many states far from zero.

Not surprisingly the region with the lowest $I_B^1$ displays the opposite pattern as reported in Figures 1d-1f. Its cyclical component is very close to zero; the estimated stochastic kernel is very concentrated around zero, as well as the estimated ergodic distribution.

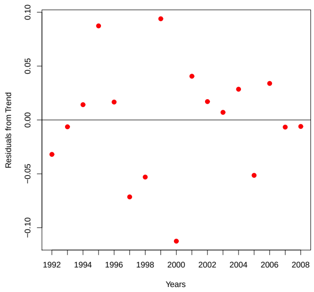
In the analysis we have considered (as we will continue to do in the rest of the paper) high-frequency fluctuations by taking 1-year lag in the estimate of the stochastic kernel; however, the methodology is flexible to incorporate also fluctuations with higher/lower frequency (e.g. 6-months versus 5-years lag)[4]. Finally, by increasing the $\alpha$ parameter the weight of large fluctuations in $I_B^\alpha$ increases, i.e. $\alpha$ tunes the impact of large fluctuations on our index of GRV.

[2]The cyclical component of growth rates is calculated applying a Hodrick-Prescott filter to regional growth rates of per capita GDP (see Section III.B. for more details).

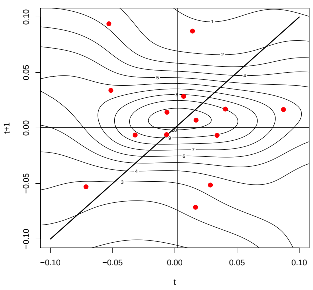
[3]These transitions are reported in upper-left and bottom-right regions in Figure1b.

[4]Here we adopt the terminology of Gelb 1979, which distinguishes between high-frequency fluctuations (equal/below 1 year) versus low-frequency fluctuations (equal/greater than 5 years).

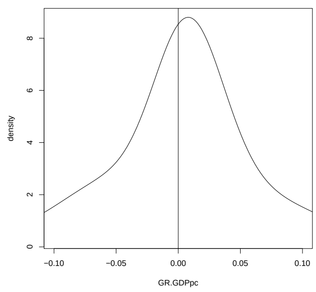
Figure 1: Left panels report the plot of the cyclical component of growth rates (calculated by de-trending the series by the Hodrick-Prescott filter); central panels the estimated stochastic kernel (the transition Markov matrix with continuous state space) of the cyclical component of growth rates; and right panels the estimated ergodic distribution of the cyclical component of growth rates.



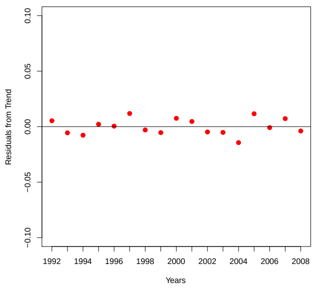

(a) Region RO42 with the highest $I_B^1 = 0.29$



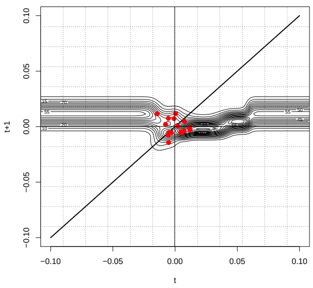

(b) Region RO42 with the highest $I_B^1 = 0.29$



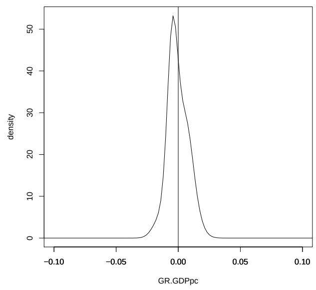

(c) Region RO42 with the highest $I_B^1 = 0.29$



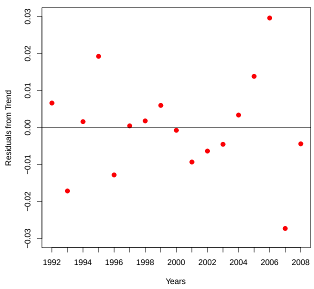

(d) Region ITG1 with the lowest $I_B^1 = 0.05$



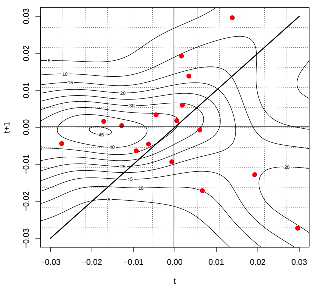

(e) Region ITG1 with the lowest $I_B^1 = 0.05$



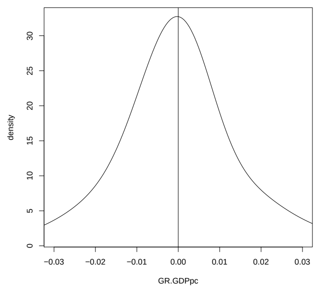

(f) Region ITG1 with the lowest $I_B^1 = 0.05$



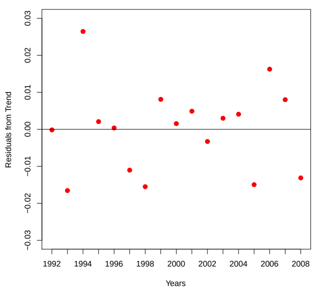

(g) Region ES11 with the highest $I_{B-}^1/I_B^1 = 0.55$



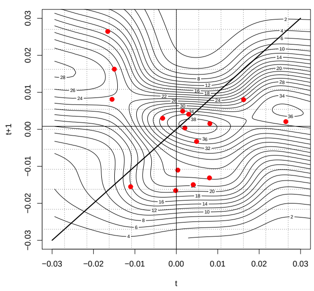

(h) Region ES11 with the highest $I_{B-}^1/I_B^1 = 0.55$



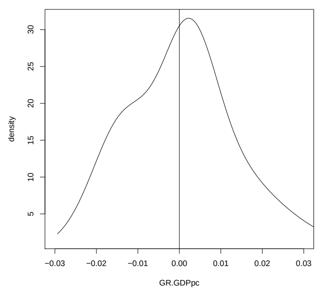

(i) Region ES11 with the highest $I_{B-}^1/I_B^1 = 0.55$




(j) Region UKH1 with the lowest $I_{B-}^1/I_B^1 = 0.41$




(k) Region UKH1 with the lowest $I_{B-}^1/I_B^1 = 0.41$




(l) Region UKH1 with the lowest $I_{B-}^1/I_B^1 = 0.41$

### II.A. A Measure of Asymmetric GRV

A prevalence of negative fluctuations, or more precisely a prevalence of deep negative fluctuations, is generally considered a further negative feature of high GRV. $I_B^\alpha$ reflects fluctuations above and below the trend in a symmetric way (as well as SD). However, exploiting the additive nature of $I_B^\alpha$, it is possible to decompose the overall index of GRV into positive and negative fluctuations (i.e. above and below the trend)[5]:

$$I_B^\alpha = I_{B_+}^\alpha + I_{B_-}^\alpha, \tag{2}$$

where

$$I_{B_+}^\alpha \equiv \int_{\underline{y}}^{\bar{y}} \pi(q) \int_0^{\bar{y}} g(s|q) \left[ \frac{|s-q|^\alpha}{\max(|s-q|^\alpha)} \right] dsdq, \tag{3}$$

and

$$I_{B_-}^\alpha \equiv \int_{\underline{y}}^{\bar{y}} \pi(q) \int_{\underline{y}}^{0} g(s|q) \left[ \frac{|s-q|^\alpha}{\max(|s-q|^\alpha)} \right] dsdq. \tag{4}$$

$I_{B_+}^\alpha$ measures the GRV due to the jumps to states above the trend (independently of initial state), while $I_{B_-}^\alpha$ to the jumps to states below the trend; the ratio $I_{B_-}^\alpha / I_B^\alpha$ measures the share of total GRV explained by fluctuations below the trend or, alternatively, the *relative* contribution of fluctuations below the trend, given that $y$ is the cyclical component.

Figures 1g-1l report the two European regions with the highest and the lowest $I_{B-}^1/I_B^1$ (equals to 0.55 and 0.41 respectively). A deep jump below the trend (corresponding to a growth rate of about $-0.03$) and several observations in the negative part of the stochastic kernel characterize the region with the highest $I_{B-}^1/I_B^1$, while the region with the lowest $I_{B-}^1/I_B^1$ displays very homogeneous negative fluctuations (never lower than $-0.02$).

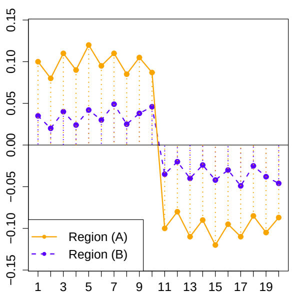
### II.B. A Comparison with Standard Deviation of Growth Rate

To illustrate the superior properties of our proposed index of GRV with respect to the use of standard deviation of growth rates (SD), consider Figure 2a, which reports two simulated (and unlikely) time series of growth rates with zero trend, equal high-frequency and persistent fluctuations, but different size. Measuring GRV by SD, Region B (dashed blue line) appears as the less volatile, whereas using the $I_B^1$ the two series show the same GRV, as it should be. This result is also confirmed by the stochastic kernel in Figures 2b-2c. This is because, differently from $I_B^1$, SD depends on the absolute size of cyclical component, but not on its fluctuations over time. $I_B^1$, on the contrary, reflects such fluctuations by recording the "jumps" between the current and the future growth rate[6].

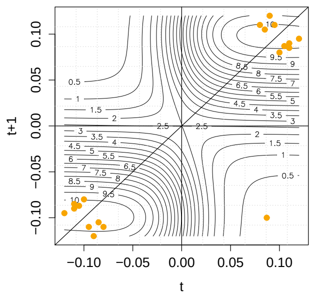
[5] We are assuming that $\underline{y} \leq 0 \leq \bar{y}$, which is trivial when $y$ is a cyclical component.

[6] A proper non-linear de-trending procedure could reduce the bias of the use of SD for the time series reported in Figure 2a.

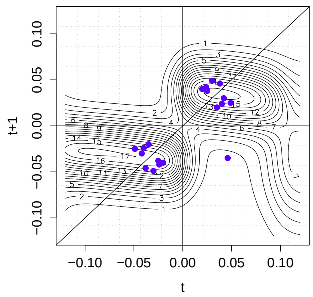
Figure 2: A comparison between $I_B^\alpha$ and SD as measure of GRV for two time series of growth rates: Region A with a $SD = 0.101$ and $I_B^1 = 0.257$, and Region B with $SD = 0.037$ and $I_B^1 = 0.268$.




(a) Time path of Region A (orange line) and Region B (blue dashed line).



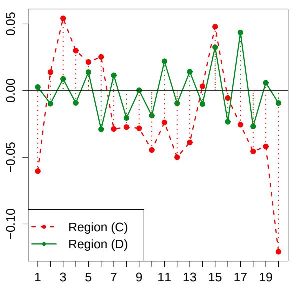

(b) Stochastic kernel of Region A.



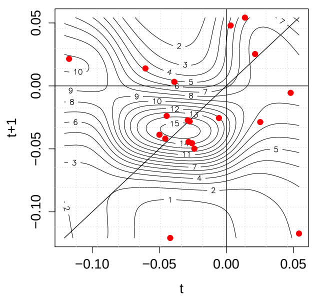

(c) Stochastic kernel of Region B.

To grasp more the advantage of our methodology on the use of SD, let consider Figure 3a, where growth of Region C (red dashed line) appears less volatile but more persistent than the one in Region D (green line), being characterized by high-frequency fluctuations.

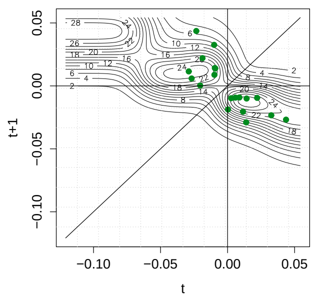
Figure 3: A comparison between $I_B^\alpha$ and SD as measure of GRV for two time series of growth rates: Region C (red dashed line) with $SD = 0.05$ and $I_B^1 == 0.045$, and Region D with (green line) with $SD = 0.02$ and $I_B^1 = 0.076$.




(a) Time path of Region C (red dashed line) and Region D (green line).




(b) Stochastic kernel of Region C.




(c) Stochastic kernel of Region D.

The SD of the growth path of Region C is higher than the one of Region D, suggesting, erroneously, that Region C has a higher GRV; on the contrary, $I_B^1$ leads to the opposite (true) conclusion. The estimated stochastic kernels for the two series reported in Figures 3b and 3c help to understand this finding. Region D shows a concentration of transitions in the bottom-right and upper-left regions,

Table 1: **List of variables used in the analysis, their sources and main references.**

| Variable | Label | Definition and source | Main reference |
|---|---|---|---|
| Output composition (regional level) | SHARE.AGRI<br>SHARE.MIN<br>SHARE.MANU<br>SHARE.FIN<br>SHARE.NMS<br>SHARE.CONSTS<br>SHARE.WHOLESALE<br>SHARE.HOTEL<br>SHARE.OTHER | Share of agriculture in total GVA<br>Share of mining and energy in total GVA<br>Share of manufacturing in total GVA<br>Share of financial intermediation in total GVA<br>Share of non-market services in total GVA<br>Share of construction in total GVA<br>Share of wholesale and retails in total GVA<br>Share of hotels in total GVA<br>Share of other services sector in total GVA (Cambridge Econometrics) | Koren and Tenreyro 2007 |
| Size of the economy and sectoral diversification (regional level) | LOG.GDP<br>HERFINDAL | Log of total GDP at constant level 2000 (mln of Euros) (Cambridge Econometrics)<br>Herfindal index of sectoral concentration (Cambridge Econometrics) | Canning et al. 1998<br>Mobarak 2005 |
| Composition of aggregate demand (regional level) | INV.RATE<br>HOUSE.EXP.on.GDP | Investment rate (Cambridge Econometrics)<br>Household expenditure on total GDP (Cambridge Econometrics) | Blanchard et al. 2013 |
| Fiscal policy (country level) | GOV.EXP.on.GDP | General government final consumption expenditure on total GDP (World Bank Indicators) | Gali 1994 |
| Financial deepening (country level) | DOM.CREDIT.on.GDP | Domestic credit to private sector on GDP (World Bank Indicators) | Kaminsky and Reinhart 1999 |
| Monetary policy (country level) | INFLATION | Inflation (World Bank Indicators) | Blanchard and Simon 2001 |
| Participation to European Monetary Union (country level) | EMU | The number of years of participation to European Monetary Union on total number of years in the sample (16) | De Grauwe 2007 |
| Labour market flexibility (regional level) | LOG.PART.TIME | Log of share of part-time workers on total employment (European Labour Force Survey) | Gnocchi et al. 2015 |
| Household income (regional level) | HOUSE.INCOME.on.GDP | Household income on GDP (Cambridge Econometrics) | |
| Tax revenue (country level) | TAX.on.GDP | Total tax revenue on GDP (World Bank Indicators) | |
| Market capitalization (country level) | MARKET.CAPIT.on.GDP | Total market value of the shares outstanding of publicly traded companies (World Bank Indicators) | |
| Growth of compensations per employee (regional level) | DELTA.LOG.COMP.EMP | Growth rate of compensation per employee (Cambridge Econometrics) | |
| Participation to European Monetary System (country level) | EMS | Number of years of participation to European Monetary System | |

but very concentrated around zero-trend, i.e. Region D displays intensive high-frequency fluctuations but of limited size. The opposite holds for Region C, where there is a prevalence of observations around the bisector (high persistence) and few large deviations (the cause of its higher SD).

## *III. Empirical Analysis*

In this section we first describe the data sources and the variables used in the analysis; then we conduct an exploratory analysis of our index of GRV; and, finally, we present our econometric model and the result of estimates.

### III.A. Data Sources and Variables Used in the Analysis

Table 1 summarizes the list of the variables used in the empirical analysis, together with the labels used in the estimation in Section III.C., the definitions and sources, and the main references.

Data for European regions are drawn from the European regions database of Cambridge Econometrics (Cambridge Econometrics 2010), the World Development Indicators[7], and from the European Labour Force Survey[8]. In particular, we consider a first sample of 248 European regions from 19 countries, i.e. EU 27 less Denmark, Luxembourg, Cyprus, Latvia, Estonia, Lithuania and Malta, for which some data are missing over the period $1992-2008$, and Bulgaria, which had experienced extreme and anomalous fluctuations over the period $1991-2001$ (see Fanelli and Lyn 2008, p. 52-55); and a second sample, for which we have data only for 217 regions, including also a proxy for the flexibility of labour market (data for regions belonging to Hungary, Ireland, Netherlands, Romania, and Slovenia are missing, see Appendix A).

The literature discussed in the introduction suggests a wide set of determinants of GRV; the choice of which determinants to include in the analysis is the outcome of a trade-off between the attempt to encompass the most relevant determinants and the need to maintain a sufficiently representative sample of European regions. In particular, we use regional proxies for the *output composition*, considering the average shares of agriculture, mining and energy, manufacturing, financial intermediation, non-market service, construction, wholesale and retail, hotel and transport in total GVA for the period 1992-2008; the *sectoral concentration*, using the average Herfindal index of sectoral concentration of output for the period 1992-2008; the *size of the economy*, proxied by the logarithm of the average (total) GDP over the sample period; the *composition of aggregate demand*, taking into account the average investment rate, and the shares of household expenditure on total GDP over the period 1992-2008. Moreover, we use country-level variables to proxy for the *fiscal policy*, using the average government expenditure as share of GDP in the period 1992-2008; the *financial deepening*, proxied by the average value of the ratio between total credit from financial intermediaries to the private sector and GDP in the period 1992-2008[9]; the *monetary policy*, proxied by the average inflation rates in the period 1992-2008; the *participation to EMU* calculated as the number of years a region has been participating to EMU over the total number of years in the sample (16); finally, the *labour market flexibility*, proxied at regional level by the logarithm of the ratio between part-time workers and total employment[10].

The choice to include determinants at country level for the government consumption expenditure and the domestic credit is motivated by the impossibility to retrieve data for a sufficient large sample of regions; on the contrary, for the monetary policy and the participation to EMU by the fact that the determinants of interest have a genuine country component. The lack of regional data

[7]See `http://data.worldbank.org/data-catalog/world-development-indicators`.

[8]See `http://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey`.

[9]This ratio is commonly used in the literature because it includes only credits issued by banks and other financial intermediaries and excludes credits issued by the central bank (see, e.g., Levine et al. 2000).

[10]See OECD 2004; the correlation of this variable with the OECD index of Employment Protection Legislation (EPL) (available only at country level) is equal to 0.33.

on government expenditure does not appear an important limitation of analysis because the between-country variability is remarkable high in Europe[11], and anecdotal evidence suggests a relatively low within-country variability (see, e.g., for Italy Daniele 2009, and for a large sample of European countries OECD 2011). On the contrary, the within-country variability of domestic credit on GDP can be remarkable high in some countries (see, e.g., Hasan et al. 2009); hence, our results on the effect of financial deepening should be taken with some caution.

Finally, to account for their potential endogeneity investment rate has been instrumented by its lagged value, household expenditure by household income, government consumption expenditure by tax revenue and lagged government consumption expenditure, domestic credit to private sector by market capitalization, inflation by the growth of compensations per employee, and the participation to EMU by the participation to European Monetary System (EMS). Below we discuss in details the quality of the proposed instrumental variables in terms of their strength and validity (see Section III.C. and Appendix C).

## III.B. Exploratory Analysis of $I_B^1$, $I_B^2$, and $I_{B-}^1/I_B^1$

The calculation of $I_B^\alpha$ for each region is the result of a two-step procedure. Firstly, we extract the cyclical component by de-trending the series of the yearly growth rates of GDP per capita with the Hodrick-Prescott filter[12]; the estimated cyclical component is then used to estimate the stochastic kernel, the associated ergodic distribution[13] and, finally, $I_B^1$, $I_B^2$ and $I_{B-}^1/I_B^1$.[14]

Figures 4a-4i show the geographical pattern, Moran scatter plot, Moran's I, and LISA statistics of $I_B^1$, $I_B^2$, $I_{B-}^1/I_B^1$ for our sample, while Tables 6 and 7 in Appendix B report some descriptive statistics.

The spatial weights matrix $\mathbf{W}$ used in the analysis is a row-standardized matrix based on the inverse of great circle distance between regional centroids (denoted by $d(i,j)$) with a cut-off equals to the first quantile of the distance distribution (denoted by $d_{Q1}$) corresponding to 648 kilometres. In particular, for

[11]For some evidence see `http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gov_10a_main&lang=en`.

[12]For details see Hodrick and Prescott 1997. Using two alternative methods to filter out the trend component proposed by Baxter and King 1999 and Christiano and Fitzgerald 2003, we obtain very similar estimates of $I_B^1$ (with a correlation equal to 0.92 and 0.99 with the one resulting from the Hodrick-Prescott filter respectively).

[13]See Fiaschi and Romanelli 2009 for more technical details on the estimate of stochastic kernel by an *adaptive kernel*, and on the procedure for the calculation of the ergodic distribution with continuous state space.

[14]As robustness check we calculate all indexes excluding 2008 (the year of global financial crisis); the correlation between these indexes and the ones used in the analysis is about one.

any couple of regions $i$ and $j$, the value of the element $w(i,j)$ of $\mathbf{W}$ is given by:

$$w(i,j) = w^*(i,j)/\sum_j w^*(i,j),$$
$$w^*(i,j) = \begin{cases} 0 & \text{if } i = j \\ d(i,j)^{-2} & \text{if } d(i,j) \leq d_{Q1} \\ 0 & \text{if } d(i,j) > d_{Q1}. \end{cases} \tag{5}$$

Geographical pattern and spatial dependence appears pervasive characteristics of regional GRV. $I_B^1$ shows a high cross-sectional variance, with a clear country component (see Figures 4a, 4d, and 4g). This pattern agrees with the idea that some determinants should be taken at country level. The decomposition of total variability of GRV measured by Theil index indicates that the between-country component amounts at 49% of total variability, while the within-country component to 51%.

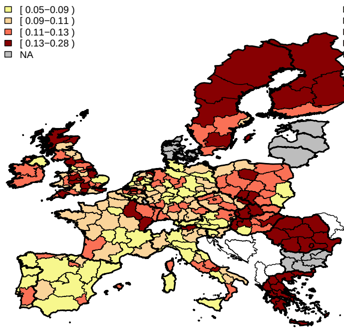
The estimated Moran's I and LISA statistics show strong evidence of spatial dependence in GRV. The non-parametric regression reported in the Moran scatter plot in Figure 4d highlights positive spatial dependence at any level of $I_B^1$[15]. Estimated LISA statistic for $I_B^1$ in Figure 4g shows two clusters of regions of high-high and low-low GRV: the high-high-GRV cluster is populated by regions belonging to Greece, Romania and Scandinavian countries while, the low-low-GRV cluster is populated by regions belonging to the core of Europe.

Moreover, regions with high business cycle fluctuations also display large fluctuations, but with some notable differences. Geographical patterns of $I_B^1$ and $I_B^2$ look very similar (compare Figures 4a and 4b) as well as spatial dependence (compare the estimated Moran's I, the Moran scatter plots and LISA statistics); $I_B^1$ and $I_B^2$ have also a very high correlation equals to 0.97 (see Table 7 in Appendix B). Nonetheless, we will see in Section III.C. that some significant differences emerge in the analysis of the determinants of $I_B^1$ and $I_B^2$.

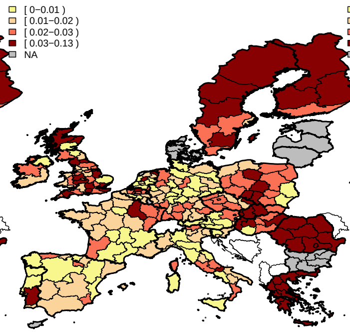
Finally, Figure 4c shows that regions with higher contribution of negative fluctuations are geographically concentrated in the regions of Spain, Central and Northern Europe; there is no evident correlation with the level of GRV. With a Moran's I equals to 0.19 the overall spatial dependence is weak, although this is the result of a null or very weak spatial dependence at low/medium levels of $I_{B-}^1/I_B^1$, and a positive relationship at high levels (see Figure 4f). The LISA statistic shows a cluster of regions with high-high $I_{B-}^1/I_B^1$ belonging to Spain and Portugal (see Figure 4i). Finally, $I_{B-}^1/I_B^1$ displays a very different geographical pattern with respect to $I_B^1$ (compare Figures 4d and 4f), confirmed by the low correlation between $I_{B-}^1/I_B^1$ and $I_B^1$ equals to $-0.13$ (see Table 7 in Appendix B).

[15] All non-parametric estimations are made by Bowman and Azzalini 2014.

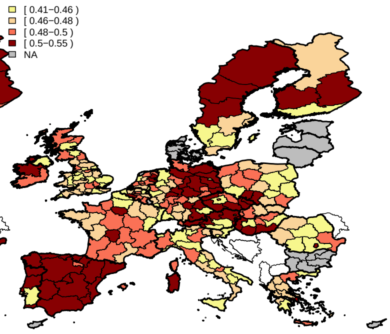
Figure 4: Geographical pattern of $I_B^1$, $I_B^2$ and $I_{B-}^1/I_B^1$ for the sample of 248 European regions.



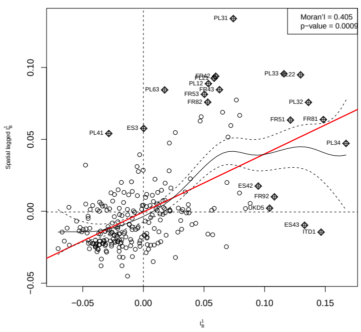

(a) $I_B^1$



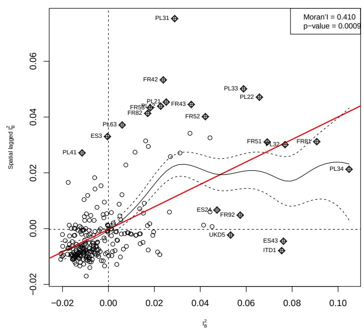

(b) $I_B^2$



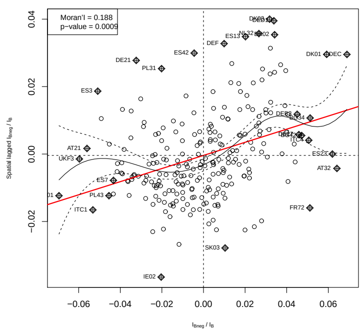

(c) $I_{B-}^1/I_B^1$



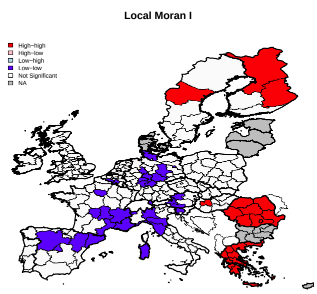

(d) Moran Scatter-plot of $I_B^1$



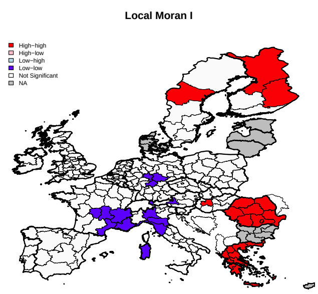

(e) Moran Scatter-plot of $I_B^2$



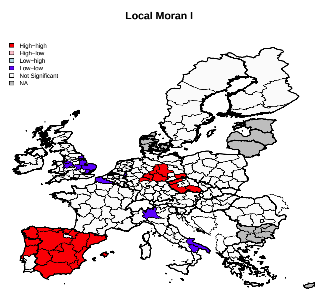

(f) Moran Scatter-plot of $I_{B-}^1/I_B^1$




(g) LISA statistics of $I_B^1$




(h) LISA statistics of $I_B^2$




(i) LISA statistics of $I_{B-}^1/I_B^1$

### III.C. A Cross-region Analysis of the Determinants of GRV

Empirical evidence discussed in Section III.B. suggests that the econometric model of regional GRV should take into account the presence of spatial dependence. Hence, we start with the most general model, i.e. the model that includes a spatially lagged dependent variable and spatially lagged independent variables, but excluding the spatially autocorrelated error term for the potential lack of identifiability of parameters as discussed in LeSage and Pace 2009, pp. 155-158 and Elhorst 2010:

$$\begin{aligned} \mathbf{y} &= \mathbf{c} + \lambda \mathbf{W}\mathbf{y} + \mathbf{X_1}\beta_1 + \mathbf{W}\mathbf{X_1}\theta_1 + \mathbf{X_2}\beta_2 + \mathbf{e} \\ \mathbf{e} &\sim iid\left(0, \sigma^2 \mathbf{I}\right), \end{aligned} \tag{6}$$

where $\mathbf{y}$ is the $(N \times 1)$ vector of observations of the dependent variable[16], i.e. GRV; $\mathbf{c}$ is the constant; $\mathbf{W}$ is the $(N \times N)$ spatial weight matrix, $\mathbf{Wy}$ denotes the endogenous interaction effects among the dependent variables; $\lambda$ is the spatial-autoregressive parameters; $\mathbf{X_1}$ is the $(N \times k_1)$ matrix of regressors at regional level while $\mathbf{WX_1}$ denotes the interaction effects among the regional independent variables; $\mathbf{X_2}$ is the $(N \times k_2)$ matrix of regressors at country level, $\beta_1$ as $\theta_1$ are the $(N \times k_1)$ vectors of fixed but unknown parameters for regional determinants while $\beta_2$ the $(N \times k_2)$ vector of parameters for country determinants, and, finally, $\mathbf{e}$ is the $(N \times 1)$ vector of innovations assumed to be independently identically distributed with variance $\sigma^2$. The interaction effects among the independent variables at country level are not included in the model, because of their high collinearity with $\mathbf{X_2}$ deriving by the geographical definition of the $W$ matrix. In the model selection we follow LeSage and Pace 2009 and sequentially test for the presence of spatial lag dependence and spatial lags of the explanatory variable.

In our model investment rates, household expenditure, government consumption expenditure, domestic credit, inflation and participation to EMU are potential endogenous variables. Two methods have been developed in the literature to estimate models that include spatial interaction effects and endogenous explanatory variables (other than the spatially lagged dependent variable), that is IV/GMM estimator (Fingleton and Le Gallo 2008), and 2SLS estimator (Drukker et al. 2013). In both approaches the spatially lagged dependent variable is instrumented by $[X, WX, W^g X]$, where $g$ is a pre-selected constant (see Kelejian et al 2004). However, as Gibbon and Overman 2012 have shown, serious estimation problems can be caused by the high correlation of $[X, WX, W^2 X, ...]$, implying that the little independent variation leads to a "weak instruments/identification" problem. In order to avoid this problem, inspired by Murphy and Topel 1985, we use a Two-Stage Maximum Likelihood (TSML) estimation where: i) first we regress each endogenous variable (apart from the spatially lagged dependent variable) on the exogenous variables and the instruments; then, ii) we insert the

[16] In particular, $y$ will be specified as $I_B^1$, $I_B^2$, and $I_{B-}^1/I_B^1$.

first-stage fitted values in the main regression. In particular, in the first-stage regressions we neglect any spatial dependence and, therefore, we estimate via OLS. On the contrary, in the second-stage regression we estimate the model in Eq. (6) via Maximum Likelihood[17].

The Hausman test for endogenity and the Sargan test for instrument validity are reported in Tables 2-4, together with the results of the second-stage estimation, while the results of the first-stage estimations as well as the $F$-test for the strength of instruments are reported in Tables 8 and 9 in Appendix C (Hill et al. 2012, pp. 418-422).

As pointed out by LeSage and Pace 2009, in a spatial model the impact on $\mathbf{y}$ of each determinant included in $\mathbf{X}$ must take into account the spatial interdependencies and simultaneous feedback embodied in the model. In particular, the *total effect* on the GRV of region $i$ of a change in one of explanatory variables (e.g. investment rate) is the sum of a *direct effect* (the change in the investment rate of region $i$), and of an *indirect effect* through spatial dependence (the change in the investment rates of its neighbouring regions). Averaging out across different regions these two types of effects we get the *average direct effect* (ADE) and the *average indirect effect* (AIE); in turn, the sum of these two effects gives the *average total effect* (ATE).

### *III.C.i. Model Estimates*

According to Hausman test, endogeneity is present in all estimated models (see Tables 2-4); instruments used in the first-stage regressions are always valid according to Sargan test (see Tables 2-4) and not weak according to $F$-test for weak IV, taking as reference the standard threshold $F = 10$ (except marginally for household expenditure, see Appendix C).

The best specification for Model (1) with $I_B^1$ includes spatially lags of the regional explanatory variables, but not spatial lag dependence (see Table 2)[18]. As for countries (see Koren and Tenreyro 2007), output composition matters for GRV. In particular, the average GVA share of non-market services have the highest cumulative negative effect (ATE) on the GRV of all its neighbouring regions (the omitted category is Transport sector); its stabilizing effect plausibly derives from the fact that these services mostly refer to the public sector, where fluctuations are generally small. The average GVA share of financial intermediation has the highest negative direct effect (ADE), pointing out that regions with a specialization in the financial and banking services should be less subject to fluctuations. Agricultural sector emerges as the most conducive sector to GRV; a part of explanation should be found in the very large fluctuations of food prices

[17]Murphy and Topel 1985 show that the TSML estimator is consistent under regularity conditions, although the asymptotic standard errors can be underestimated.

[18]For comparison Appendix D reports the estimate of Model (1) with the $SD$ of growth rates of per capita GDP.

(like in Fiaschi and Lavezzi 2011). The size of region proxied by LOG.GDP has a negative and strongly significant ADE: the negative size effect on GRV highlighted by Canning et al. 1998 at country level also holds for European regions. In the same respect, also sectoral concentration at regional level exerts a positive direct effect on GRV in line with the findings of Mobarak 2005. Finally, financial deepening proxied by DOM.CREDIT.on.GDP displays a positive effect in agreement with the Easterly et al. 2000's findings on countries.

When we also include the control for labour market flexibility proxied by LOG.PART.TIME the sample reduces to 217 regions as we discussed above. The most of the results with the full sample are confirmed, but new evidence appears. Household expenditure has a negative impact on GRV in accordance with the expected stabilizing role of consumption; however, this finding should be consider with caution because crucially derives from the estimated negative indirect effect, which can be affected by the reduction in the sample. Government expenditure favours fluctuations; this suggests that our proxy for fiscal policy could also reflect the impact of public debt on GRV (that is expected to be positive, see Spilimbergo et al. 2009), and not only the stabilizing role of government consumption expenditure generally founded in the cross-country literature (see Fatas and Mihov 2000). Unfortunately, public debt is not available for all countries in the sample for the whole period 1992-2008. Labour market flexibility has the expected negative sign on GRV: economies with a more efficient labour market adjust more promptly to shocks as reported by Gnocchi et al. 2015 for countries. Finally, the participation to EMU becomes a positive determinant of GRV, conforming to the idea that a fixed exchange-rate regime makes economies more vulnerable to shocks (De Grauwe 2007). This potential important finding can be the result of the lack in the sub-sample of three countries participating in EMU (Ireland, Netherlands and Slovenia), or a signal that the estimate with full sample can be affected by an omitted-variable bias. In this regard De Grauwe 2007 discusses how the macroeconomic implications of the participation to a monetary union crucially depends on the characteristics of good and labour markets; in particular, flexible labour market increases the capacity of an economy to absorb shocks in a fixed exchange-rate regime.

Overall the estimated model specification for GRV due to business cycle fluctuations accounts for about one half of total variance of GRV across regions ($\bar{R}^2 = 0.566$ and $\bar{R}^2 = 0.524$).

Table 2: **The estimated coefficients and the average direct, indirect, and total effects via TSML**.

| | *Model (1). Dependent variable: $y = I_B^1$* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | coeff. | W coeff. | ADE | AIE | ATE | coeff. | W coeff. | ADE | AIE | ATE |
| SHARE.AGRI | 0.128 | 0.558*** | 0.128 | 0.558*** | 0.684** | −0.413* | 0.943*** | −0.414* | 0.939*** | 0.526 |
| SHARE.MIN | −0.150 | 0.281 | −0.151 | 0.280 | 0.130 | −0.075 | 1.425*** | −0.075 | 1.419*** | 1.344*** |
| SHARE.MAN | −0.300*** | −0.104 | −0.300*** | −0.104 | −0.404** | −0.593*** | −0.178 | −0.593*** | −0.177 | −0.771*** |
| SHARE.FIN | −0.824*** | 0.289 | −0.824*** | 0.288 | −0.536 | −1.089*** | −2.707*** | −1.090*** | −2.695*** | −3.784*** |
| SHARE.NMS | −0.384* | −0.353 | −0.384 | −0.352 | −0.736*** | −1.090*** | −0.338 | −1.090*** | −0.337 | −1.426*** |
| SHARE.CONST | −0.205 | 0.161 | −0.205 | 0.16 | −0.045 | −1.188*** | 1.273*** | −1.188*** | 1.268*** | 0.080 |
| SHARE.WS | −0.180 | −0.341 | −0.180 | −0.34 | −0.52** | −0.303 | 1.047** | −0.303 | 1.042** | 0.739 |
| SHARE.HOTEL | −0.435*** | −0.169 | −0.435*** | −0.169 | −0.604** | −0.710*** | −0.219 | −0.711*** | −0.219 | −0.929*** |
| SHARE.OTHER | −0.390*** | 0.306 | −0.390*** | 0.305 | −0.085 | −0.468*** | 0.371* | −0.468*** | 0.369* | −0.098 |
| LOG.GDP | −0.012*** | −0.001 | −0.012*** | −0.001 | −0.013 | −0.020*** | −0.002 | −0.021*** | −0.002 | −0.023** |
| HERFINDAL | 0.450*** | −0.020 | 0.450*** | −0.021 | 0.43 | 0.236 | 0.693* | 0.236 | 0.690* | 0.926*** |
| INV.RATE | 0.069 | −0.255 | 0.069 | −0.254 | −0.185 | 0.003 | −0.126 | 0.003 | −0.126 | −0.123 |
| HOUSE.EXP.on.GDP | −0.149 | 0.173 | −0.149 | 0.173 | 0.024 | 0.094 | −0.246*** | 0.094 | −0.245*** | −0.152* |
| GOV.EXP.on.GDP | 0.037 | – | 0.037 | – | 0.037 | 2.161** | – | 2.161** | – | 2.161** |
| DOM.CREDIT.on.GDP | 0.042** | – | 0.042** | – | 0.042** | 0.248** | – | 0.249** | – | 0.249** |
| INFLATION | −0.035 | – | −0.035 | – | −0.035 | 1.261 | – | 1.261 | – | 1.261 |
| EMU | −0.010 | – | −0.010 | – | −0.010 | 0.255** | – | 0.255** | – | 0.255** |
| LOG.PART.TIME | – | – | – | – | – | −0.014 | −0.031** | −0.014 | −0.030** | −0.045** |
| Constant | 0.540*** | – | – | – | – | 0.036 | – | – | – | – |
| $\lambda$ | – | – | – | – | – | – | – | – | – | – |
| $H_0 : \theta_1 = 0$ | 49.189*** | | | | | 58.234*** | | | | |
| Hausman test | 16.45** | | | | | 23.26*** | | | | |
| Sargan test | 0.323 | | | | | 0.213 | | | | |
| $\bar{R}^2$ | 0.566 | | | | | 0.524 | | | | |
| AIC_c | −1036.41 | | | | | −949.63 | | | | |
| N.Obs | 248 | | | | | 217 | | | | |

*Note:* *p<0.1; **p<0.05; ***p<0.01

The estimate of Model (2) with $I_B^2$ shows how non-market services and financial sectors, the size of regions, sectoral concentration and domestic credit (but only in the full sample) have similar impacts on large fluctuations (compare Tables 2 and 3). On the contrary, household expenditure, government consumption, participation to EMU and labour market flexibility loose their explanatory power in the restricted sample, suggesting that $I_B^1$ and $I_B^2$ are effectively measuring two different phenomena. As for $I_B^1$, the estimated model for $I_B^2$ accounts for more than one half of total variance of GRV across regions ($\bar{R}^2 = 0.579$ and $\bar{R}^2 = 0.551$).

Table 3: **The estimated coefficients and the average direct, indirect, and total effects via TSML**.

| | *Model (2). Dependent variable:* $y = I_B^2$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | coeff. | W coeff. | ADE | AIE | ATE | coeff. | W coeff. | ADE | AIE | ATE |
| SHARE.AGRI | $-0.005$ | $0.258^{***}$ | $-0.005$ | $0.257^{*}$ | $0.252^{*}$ | $-0.163$ | $0.416^{***}$ | $-0.163$ | $0.414^{***}$ | $0.251^{*}$ |
| SHARE.MIN | $-0.083$ | $0.101$ | $-0.083$ | $0.101$ | $0.017$ | $-0.046$ | $0.501^{***}$ | $-0.046$ | $0.499^{***}$ | $0.453^{***}$ |
| SHARE.MAN | $-0.192^{***}$ | $-0.043$ | $-0.192^{***}$ | $-0.043$ | $-0.235^{**}$ | $-0.273^{***}$ | $-0.070^{**}$ | $-0.273^{***}$ | $-0.070$ | $-0.343^{***}$ |
| SHARE.FIN | $-0.358^{***}$ | $0.120$ | $-0.358^{***}$ | $0.12$ | $-0.238$ | $-0.374^{**}$ | $-0.897^{**}$ | $-0.374^{**}$ | $-0.893$ | $-1.267^{**}$ |
| SHARE.NMS | $-0.238^{**}$ | $-0.139$ | $-0.238^{**}$ | $-0.140$ | $-0.377^{***}$ | $-0.456$ | $-0.120$ | $-0.456^{***}$ | $-0.119$ | $-0.575^{***}$ |
| SHARE.CONST | $-0.072$ | $0.063$ | $-0.072$ | $0.063$ | $-0.009$ | $-0.42^{***}$ | $0.582^{***}$ | $-0.421^{***}$ | $0.579^{***}$ | $0.158$ |
| SHARE.WS | $-0.151^{**}$ | $-0.190$ | $-0.151^{**}$ | $-0.189$ | $-0.34^{***}$ | $-0.189^{**}$ | $0.326$ | $-0.189^{**}$ | $0.324$ | $0.135$ |
| SHARE.HOTEL | $-0.266^{***}$ | $-0.105$ | $-0.266^{***}$ | $-0.105$ | $-0.37^{***}$ | $-0.326^{***}$ | $-0.120$ | $-0.326^{***}$ | $-0.120$ | $-0.446^{***}$ |
| SHARE.OTHER | $-0.057$ | $0.135$ | $-0.057$ | $0.071$ | $0.014$ | $-0.221$ | $0.096$ | $-0.221^{***}$ | $0.096$ | $-0.126$ |
| LOG.GDP | $-0.006^{***}$ | $-0.001$ | $-0.006^{***}$ | $-0.001$ | $-0.006$ | $-0.008^{***}$ | $0.001$ | $-0.008^{***}$ | $0.001$ | $-0.007$ |
| HERFINDAL | $0.226^{***}$ | $-0.065$ | $0.226^{***}$ | $-0.065$ | $0.161$ | $0.132^{*}$ | $0.260$ | $0.132^{*}$ | $0.259$ | $0.391^{***}$ |
| INV.RATE | $-0.005$ | $-0.079$ | $-0.005$ | $-0.079$ | $-0.084$ | $-0.031$ | $-0.093$ | $-0.031$ | $-0.093$ | $-0.124$ |
| HOUSE.EXP.on.GDP | $-0.057$ | $0.071$ | $-0.057$ | $0.071$ | $0.014$ | $0.035$ | $-0.093^{**}$ | $0.035$ | $-0.092$ | $-0.057$ |
| GOV.EXP.on.GDP | $-0.011$ | – | $-0.011$ | – | $-0.011$ | $0.612$ | – | $0.612$ | – | $0.612$ |
| DOM.CREDIT.on.GDP | $0.018^{**}$ | – | $0.018^{**}$ | – | $0.018^{**}$ | $0.072$ | – | $0.072$ | – | $0.072$ |
| INFLATION | $-0.010$ | – | $-0.010$ | – | $-0.010$ | $0.267$ | – | $0.267$ | – | $0.267$ |
| EMU | $-0.003$ | – | $-0.003$ | – | $-0.003$ | $0.077$ | – | $0.077$ | – | $0.077$ |
| LOG.PART.TIME | – | – | – | – | – | $-0.003$ | $-0.011$ | $-0.003$ | $-0.011$ | $-0.014$ |
| Constant | $0.269^{***}$ | – | – | – | – | $0.118$ | – | – | – | – |
| $\lambda$ | – | – | – | – | – | – | – | – | – | – |
| $H_0 : \theta_1 = 0$ | $46.91^{***}$ | | | | | $56.23^{***}$ | | | | |
| Hausman test | $13.94^{*}$ | | | | | $17.85^{**}$ | | | | |
| Sargan test | $0.393$ | | | | | $0.010$ | | | | |
| $\bar{R}^2$ | $0.579$ | | | | | $0.551$ | | | | |
| AIC_c | $-1410.39$ | | | | | $-1302.01$ | | | | |
| N.Obs | 248 | | | | | 217 | | | | |

*Note:* $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01

In the estimate of Model (3) with $I^1_{B-}/I^1_B$ we find evidence of a significant negative spatial dependence, although of very limited magnitude ($\hat{\lambda} = -0.132$, see Table 4).

Construction is the sector with the highest positive impact on the contribution of negative fluctuations (but not in the restricted sample), in agreement with the common wisdom that this sector is a potential source of strong downturns of economic activity (see Boldrin et al. 2013 for some evidence on this for the recent "Great Recession" in US). Investment rate has a positive direct impact, while household expenditure has a negative indirect effect in agreement with the Keynesian view of an asymmetry of business cycle determined by the composition of aggregate demand. Finally, labour market flexibility seems to favour the contribution of negative fluctuations, a feature to our knowledge not discussed yet in the literature: this asymmetric effect on fluctuations can be justified by the consideration that in practice a higher labour market flexibility translates into higher possibility of dismissals than of hirings (hirings are not generally constrained by a rigid labour market).

The estimated model specification accounts for more than 20% of total variance of GRV across regions ($\bar{R}^2 = 0.235$ and $\bar{R}^2 = 0.268$).

Table 4: **The estimated coefficients and the average direct, indirect, and total effects via TSML.**

| | *Model (3). Dependent variable:* $y = I^1_{B-}/I^1_B$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | coeff. | W coeff. | ADE | AIE | ATE | coeff. | W coeff. | ADE | AIE | ATE |
| SHARE.AGRI | −0.233 | 0.438*** | −0.242 | 0.420*** | 0.179 | 0.028 | 0.071 | 0.027 | 0.060 | 0.087 |
| SHARE.MIN | −0.078 | 0.151 | −0.081 | 0.145 | 0.064 | −0.119 | 0.032 | −0.120 | 0.043 | −0.077 |
| SHARE.MAN | −0.149* | 0.206** | −0.153** | 0.203 | 0.050 | −0.034 | 0.153 | −0.037 | 0.141 | 0.104 |
| SHARE.FIN | −0.174 | −0.605 | −0.164 | −0.522 | −0.686* | −0.094 | 1.539* | −0.123 | 1.386* | 1.263 |
| SHARE.NMS | −0.078 | 0.588*** | −0.088 | 0.537*** | 0.448** | 0.279 | 0.323* | 0.273 | 0.254 | 0.528* |
| SHARE.CONST | −0.085 | 1.799*** | −0.117 | 1.624*** | 1.507*** | 0.200 | 0.362 | 0.194 | 0.298 | 0.492 |
| SHARE.WS | −0.135 | 0.281 | −0.141 | 0.268 | 0.127 | −0.275* | −0.956** | −0.257* | −0.820** | −1.077*** |
| SHARE.HOTEL | −0.030 | 0.052 | −0.032 | 0.051 | 0.019 | 0.027 | −0.127 | 0.029 | −0.116 | −0.087 |
| SHARE.OTHER | −0.069 | 0.158 | −0.072 | 0.150 | 0.078 | −0.095 | 0.139 | −0.098 | 0.136 | 0.038 |
| LOG.GDP | 0.003 | −0.006 | 0.003 | −0.006 | −0.003 | 0.008** | −0.003 | 0.008** | −0.004 | 0.005 |
| HERFINDAL | −0.082 | 0.196 | −0.086 | 0.186 | 0.100 | −0.006 | −0.197 | −0.002 | −0.176 | −0.178 |
| INV.RATE | 0.124* | −0.233 | 0.128* | −0.223 | −0.095 | 0.212*** | −0.136 | 0.215*** | −0.148 | 0.068 |
| HOUSE.EXP.on.GDP | 0.033 | −0.316*** | 0.039 | −0.288*** | −0.248*** | −0.115** | 0.022 | −0.116** | 0.034 | −0.082 |
| GOV.EXP.on.GDP | −0.114 | – | −0.114 | 0.014 | −0.101 | −1.105 | – | −1.108 | 0.137 | −0.972 |
| DOM.CREDIT.on.GDP | −0.001 | – | −0.001 | 0.000 | −0.001 | −0.064 | – | −0.064 | 0.008 | −0.056 |
| INFLATION | 0.122 | – | 0.122 | −0.015 | 0.108 | 0.363 | – | 0.363 | −0.045 | 0.319 |
| EMU | 0.000 | – | 0.000 | 0.000 | 0.000 | −0.070 | – | −0.070 | 0.009 | −0.061 |
| LOG.PART.TIME | – | – | – | – | – | 0.023** | 0.010 | 0.023** | 0.006 | 0.029** |
| Constant | 0.543*** | – | – | – | – | 0.799*** | – | – | – | – |
| $\lambda$ | −0.132** | | | | | −0.138*** | | | | |
| $H_0 : \theta_1 = 0$ | 37.81*** | | | | | 34.83*** | | | | |
| Hausman test | 28.95*** | | | | | 34.38*** | | | | |
| Sargan test | 0.000 | | | | | 0.522 | | | | |
| $\bar{R}^2$ | 0.235 | | | | | 0.268 | | | | |
| AIC_c | −1156.99 | | | | | −1013.7 | | | | |
| N.Obs | 248 | | | | | 217 | | | | |

*Note:* *p<0.1; **p<0.05; ***p<0.01

In summary, output composition of European regions results as the main determinant of GRV. In particular, non-market services, referring to the industries of government administration and defence, and industries such as health and education, emerges as the sector with the highest impact on GRV in the full sample: an increase in the share of non-market services of one-standard deviation has an estimated impact on GRV due to business cycle of $-0.03$ (that would imply a fall of 27% with respect to the average GRV), and on GRV due to large fluctuations of $-0.01$ (that would imply a fall of 31% with respect to the average GRV). Financial Intermediation sector has the same sizeable negative (direct) impact on GRV, although it should be borne in mind that our estimates refer to years before the 2008 financial crisis. Construction sector appears particularly important for the contribution of negative fluctuations: an increase in the share of Construction sector of one-standard deviation has an estimated impact of 4% on the percentage of negative fluctuations.

The size of economy and its sectoral concentration are also two important determinants: an increase of one-standard deviation has an estimated impact on GRV due to business cycle of $-0.001$ and 0.02, that would lead a fall of 1% and an increase of 17% with respect to the average GRV respectively. Sectoral concentration therefore appears a key determinant of GRV in terms of magnitude.

Other significant determinants are domestic credit, whose increase of one-standard deviation has an impact of 0.002 on GRV due to business cycle (corresponding to an increase of 2% with respect to the average GRV) and of 0.0004 on GRV due to large fluctuations (corresponding to an increase of 1.5% with respect to the average GRV); and the (log of) share of part-time worker on total employment, whose increase of one-standard deviation has an impact of 0.002 on GRV due to business cycle (corresponding to an increase of 2% with respect to the average GRV), and of 0.1% on the percentage of negative fluctuations.

Finally, an additional year of participation to EMU (1/16) has an impact of 0.02 on GRV due to business cycle, corresponding to an increase of 14% with respect to the average GRV.

On the contrary, composition of aggregate demand, government expenditure and monetary policy seem to have mixed support for their effect on GRV.

## *IV. Concluding Remarks*

We find that GRV due to both business cycle and large fluctuations displays a significant geographical pattern, with high-GRV clusters of regions belonging to Greece, Eastern and Northern countries, as opposed to low-GRV clusters of regions belonging to the centre of Europe. Spanish regions, together with some regions belonging to Eastern and Northern countries, display the highest shares of GRV due to negative fluctuations. Apart from this country component, we find that spatial dependence is a pervasive phenomenon of the GRV of European regions.

As regards determinants, the economic size of regions, their output composition and sectoral concentration reduce GRV due to business cycle fluctuations; in particular, higher shares of output in Non-market Services and Financial Intermediation sectors have a stabilizing effect on business cycle, while higher sectoral concentration leads to higher GRV. The share of credit on GDP favours GRV, as well as a lower labour market flexibility and the participation to EMU. GRV due to large fluctuations is mostly explained by the same determinants, but no significant role is found for lower labour market flexibility and the participation to EMU. Finally, Construction sector, investment rate and labour market flexibility increase the contribution of negative fluctuations to GRV, while household expenditure has the opposite effect.

Our findings have several policy implications. First, the support to regional (smart) specialization, which represents a key line of action of the current European policy to enhance long-run growth, should be evaluated in light of its potential trade-off with a higher GRV, given our result that sectoral concentration leads to higher GRV; in this respect our analysis provides further help for the design of an effective welfare-enhancing policy by indicating the sectors less conducive to GRV. Second, we find little support that fiscal and monetary policy can curb business cycles and large fluctuations in European regions, but some evidence in favour that the participation to EMU amplifies business cycle fluctuations. Third, our findings suggest that reforms aiming at increasing flexibility of labour markets could reduce business cycle fluctuations, but at the same time, favour deeper negative fluctuations. Finally, we provide additional evidence that higher degrees of financialization imply wider fluctuations; this result is still more important given that the last global financial crisis is out of the period considered in the analysis.

So far, the dynamics of European regions has been generally analysed in terms of long-run growth and regional inequality, to the detriment of other crucial features as growth volatility. We believe that such a study offers a more comprehensive view of the welfare of European regions for a more inclusive appraisal of the actual and future regional policies.

**Acknowledgements** We are very grateful to PRIN meeting participants in Pisa and Alessandria for their comments. The usual disclaimers apply. I. B., D.F. and A.P. have been supported by the Italian Ministry of University and Research as a part of the PRIN 2009 program (grant protocol number 2009H8WPX5).

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## A Region List

Table 5: **List of 248 EU regions in the sample (the excluded regions in the sub-sample of 217 regions are indicated by "*").**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Austria** | DE13 | DEE | FR24 | HU21* | NL13* | RO11* | UKE2 |
| AT11 | DE14 | DEF | FR25 | HU22* | NL21* | RO12* | UKE3 |
| AT12 | DE21 | DEG | FR26 | HU23* | NL22* | RO21* | UKE4 |
| AT13 | DE22 | **Spain** | FR3 | HU31* | NL23* | RO22* | UKF1 |
| AT21 | DE23 | ES11 | FR41 | HU32* | NL31* | RO31* | UKF2 |
| AT22 | DE24 | ES12 | FR42 | HU33* | NL32* | RO32* | UKF3 |
| AT31 | DE25 | ES13 | FR43 | **Ireland*** | NL33* | RO41* | UKG1 |
| AT32 | DE26 | ES21 | FR51 | IE01* | NL34* | RO42* | UKG2 |
| AT33 | DE27 | ES22 | FR52 | IE02* | NL41* | **Sweden** | UKG3 |
| AT34 | DE3 | ES23 | FR53 | **Italy** | NL42* | SE11 | UKH1 |
| **Belgium** | DE41 | ES24 | FR61 | ITC1 | **Poland** | SE12 | UKH2 |
| BE1 | DE42 | ES3 | FR62 | ITC2 | PL11 | SE21 | UKH3 |
| BE21 | DE5 | ES41 | FR63 | ITC3 | PL12 | SE22 | UKI1 |
| BE22 | DE6 | ES42 | FR71 | ITC4 | PL21 | SE23 | UKI2 |
| BE23 | DE71 | ES43 | FR72 | ITD1 | PL22 | SE31 | UKJ1 |
| BE24 | DE72 | ES51 | FR81 | ITD2 | PL31 | SE32 | UKJ2 |
| BE25 | DE73 | ES52 | FR82 | ITD3 | PL32 | SE33 | UKJ3 |
| BE31 | DE8 | ES53 | FR83 | ITD4 | PL33 | **Slovenia*** | UKJ4 |
| BE32 | DE91 | ES61 | **Greece** | ITD5 | PL34 | SI01* | UKK1 |
| BE33 | DE92 | ES62 | GR11 | ITE1 | PL41 | SI02* | UKK2 |
| BE34 | DE93 | ES63 | GR12 | ITE2 | PL42 | **Slovakia** | UKK3 |
| BE35 | DE94 | ES64 | GR13 | ITE3 | PL43 | SK01 | UKK4 |
| **Czech Rep.** | DEA1 | ES7 | GR14 | ITE4 | PL51 | SK02 | UKL1 |
| CZ01 | DEA2 | **Finland** | GR21 | ITF1 | PL52 | SK03 | UKL2 |
| CZ02 | DEA3 | FI13 | GR22 | ITF2 | PL61 | SK04 | UKM2 |
| CZ03 | DEA4 | FI18 | GR23 | ITF3 | PL62 | **United Kingdom** | UKM3 |
| CZ04 | DEA5 | FI19 | GR24 | ITF4 | PL63 | UKC1 | UKM5 |
| CZ05 | DEB1 | FI1A | GR25 | ITF5 | **Portugal** | UKC2 | UKM6 |
| CZ06 | DEB2 | FI2 | GR3 | ITF6 | PT11 | UKD1 | UKN |
| CZ07 | DEB3 | **France** | GR41 | ITG1 | PT15 | UKD2 | |
| CZ08 | DEC | FR1 | GR42 | ITG2 | PT16 | UKD3 | |
| **Germany** | DED1 | FR21 | GR43 | **Netherlands*** | PT17 | UKD4 | |
| DE11 | DED2 | FR22 | **Hungary*** | NL11* | PT18 | UKD5 | |
| DE12 | DED3 | FR23 | HU1* | NL12* | **Romania*** | UKE1 | |

## B Descriptive Statistics

Table 6: **Descriptive statistics.**

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| $I_B^1$ | 248 | 0.116 | 0.043 | 0.045 | 0.283 |
| $I_B^2$ | 248 | 0.024 | 0.020 | 0.004 | 0.129 |
| $I_{B-}^1/I_B^1$ | 248 | 0.482 | 0.025 | 0.412 | 0.551 |
| SD | 248 | 0.019 | 0.009 | 0.007 | 0.063 |
| LOG.GDP | 248 | 9.958 | 1.065 | 6.723 | 12.891 |
| HERFINDAL | 248 | 0.063 | 0.025 | 0.010 | 0.223 |
| INV.RATE | 248 | 0.216 | 0.046 | 0.128 | 0.404 |
| SHARE.AGRI | 248 | 0.041 | 0.039 | 0.00004 | 0.192 |
| SHARE.MIN | 248 | 0.035 | 0.030 | 0.002 | 0.330 |
| SHARE.MAN | 248 | 0.194 | 0.070 | 0.017 | 0.340 |
| SHARE.FIN | 248 | 0.040 | 0.017 | 0.011 | 0.164 |
| SHARE.NMS | 248 | 0.227 | 0.053 | 0.106 | 0.520 |
| SHARE.CONST | 248 | 0.065 | 0.018 | 0.021 | 0.125 |
| SHARE.WH | 248 | 0.121 | 0.028 | 0.061 | 0.233 |
| SHARE.HOTEL | 248 | 0.032 | 0.032 | 0.009 | 0.269 |
| SHARE.OTHER | 248 | 0.175 | 0.051 | 0.073 | 0.407 |
| HOUSE.EXP.on.GDP | 248 | 0.652 | 0.156 | 0.225 | 1.099 |
| GOV.EXP.on.GDP | 248 | 0.199 | 0.028 | 0.108 | 0.268 |
| DOM.CREDIT.on.GDP | 248 | 0.905 | 0.355 | 0.171 | 1.373 |
| INFLATION | 248 | 0.060 | 0.104 | 0.014 | 0.590 |
| EMU | 248 | 0.335 | 0.252 | 0.000 | 0.529 |
| W.LOG.GDP | 248 | 9.958 | 0.693 | 8.621 | 10.665 |
| W.HERFINDAL | 248 | 0.063 | 0.015 | 0.031 | 0.085 |
| W.INV.RATE | 248 | 0.216 | 0.029 | 0.174 | 0.286 |
| W.SHARE.AGRI | 248 | 0.041 | 0.030 | 0.016 | 0.146 |
| W.SHARE.MIN | 248 | 0.035 | 0.016 | 0.012 | 0.069 |
| W.SHARE.MAN | 248 | 0.194 | 0.037 | 0.109 | 0.276 |
| W.SHARE.FIN | 248 | 0.040 | 0.006 | 0.021 | 0.064 |
| W.SHARE.NMS | 248 | 0.227 | 0.032 | 0.117 | 0.263 |
| W.SHARE.CONST | 248 | 0.065 | 0.011 | 0.046 | 0.087 |
| W.SHARE.WH | 248 | 0.121 | 0.021 | 0.081 | 0.189 |
| W.SHARE.HOTEL | 248 | 0.032 | 0.022 | 0.011 | 0.087 |
| W.SHARE.OTHER | 248 | 0.175 | 0.038 | 0.102 | 0.224 |
| W.HOUSE.EXP.on.GDP | 248 | 0.652 | 0.083 | 0.457 | 0.818 |
| W.GOV.EXP.on.GDP | 248 | 0.199 | 0.028 | 0.108 | 0.268 |
| W.DOM.CREDIT.on.GDP | 248 | 0.905 | 0.355 | 0.171 | 1.373 |
| W.INFLATION | 248 | 0.060 | 0.104 | 0.014 | 0.590 |
| W.EMU | 248 | 0.335 | 0.252 | 0.000 | 0.529 |

Table 7: **Correlation matrix**

| | $I_B^1$ | $I_B^2$ | $I_{B-}^1/I_B^1$ | SD | LOG. GDP | HERFINDAL | INV. RATE | SHARE. AGRI | SHARE. MIN | SHARE. MAN | SHARE. FIN | SHARE. NMS | SHARE. CONST | SHARE. WH | SHARE. HOTEL | SHARE. OTHER | HOUSE. EXP.on.GDP | GOV EXP.on.GDP | DOM. CREDIT.on.GDP | INFLA- TION | EMU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $I_B^1$ | 1 | 0.971 | -0.141 | 0.940 | -0.502 | -0.141 | 0.028 | 0.451 | 0.367 | -0.002 | -0.192 | -0.276 | 0.041 | -0.053 | 0.033 | -0.400 | 0.139 | -0.226 | -0.337 | 0.470 | -0.303 |
| $I_B^2$ | 0.971 | 1 | -0.110 | 0.963 | -0.489 | -0.142 | 0.030 | 0.453 | 0.361 | -0.034 | -0.133 | -0.278 | 0.058 | -0.071 | 0.025 | -0.387 | 0.127 | -0.269 | -0.358 | 0.494 | -0.256 |
| $I_{B-}^1/I_B^1$ | -0.141 | -0.110 | 1 | -0.043 | -0.022 | -0.029 | 0.282 | -0.057 | -0.028 | -0.077 | 0.064 | 0.082 | 0.249 | -0.065 | 0.147 | -0.116 | -0.102 | 0.006 | 0.053 | -0.095 | 0.200 |
| SD | 0.940 | 0.963 | -0.043 | 1 | -0.488 | -0.165 | 0.055 | 0.468 | 0.335 | 0.001 | -0.131 | -0.306 | 0.086 | -0.042 | 0.015 | -0.415 | 0.143 | -0.319 | -0.378 | 0.543 | -0.276 |
| LOG.GDP | -0.502 | -0.489 | -0.022 | -0.488 | 1 | 0.127 | -0.364 | -0.550 | -0.212 | 0.102 | 0.326 | 0.016 | -0.321 | -0.045 | -0.168 | 0.679 | -0.367 | 0.216 | 0.492 | -0.382 | 0.236 |
| HERFINDAL | -0.141 | -0.142 | -0.029 | -0.165 | 0.127 | 1 | -0.218 | -0.455 | -0.158 | 0.089 | -0.124 | 0.526 | -0.372 | -0.256 | -0.301 | 0.320 | -0.074 | 0.293 | 0.242 | -0.289 | 0.153 |
| INV.RATE | 0.028 | 0.030 | 0.282 | 0.055 | -0.364 | -0.218 | 1 | 0.211 | -0.056 | -0.062 | -0.066 | -0.058 | 0.598 | -0.110 | 0.246 | -0.312 | 0.119 | -0.152 | -0.168 | -0.007 | 0.255 |
| SHARE.AGRI | 0.451 | 0.453 | -0.057 | 0.468 | -0.550 | -0.455 | 0.211 | 1 | 0.090 | -0.043 | -0.215 | -0.274 | 0.286 | -0.057 | 0.090 | -0.569 | 0.412 | -0.383 | -0.554 | 0.598 | -0.138 |
| SHARE.MIN | 0.367 | 0.361 | -0.028 | 0.335 | -0.212 | -0.158 | -0.056 | 0.090 | 1 | -0.010 | -0.210 | -0.172 | -0.038 | -0.052 | -0.081 | -0.288 | -0.028 | -0.024 | 0.017 | 0.162 | -0.361 |
| SHARE.MAN | -0.002 | -0.034 | -0.077 | 0.001 | 0.102 | 0.089 | -0.062 | -0.043 | -0.010 | 1 | -0.310 | -0.464 | -0.130 | -0.245 | -0.384 | -0.202 | -0.183 | 0.008 | -0.069 | 0.094 | -0.152 |
| SHARE.FIN | -0.192 | -0.133 | 0.064 | -0.131 | 0.326 | -0.124 | -0.066 | -0.215 | -0.210 | -0.310 | 1 | -0.114 | -0.201 | 0.132 | 0.045 | 0.337 | -0.474 | -0.034 | 0.043 | -0.007 | 0.219 |
| SHARE.NMS | -0.276 | -0.278 | 0.082 | -0.306 | 0.016 | 0.526 | -0.058 | -0.274 | -0.172 | -0.464 | -0.114 | 1 | 0.040 | -0.129 | -0.078 | 0.158 | 0.324 | 0.354 | 0.407 | -0.460 | 0.260 |
| SHARE.CONST | 0.041 | 0.058 | 0.249 | 0.086 | -0.321 | -0.372 | 0.598 | 0.286 | -0.038 | -0.130 | -0.201 | 0.040 | 1 | -0.039 | 0.260 | -0.444 | 0.431 | -0.306 | -0.046 | -0.010 | 0.145 |
| SHARE.WH | -0.053 | -0.071 | -0.065 | -0.042 | -0.045 | -0.256 | -0.110 | -0.057 | -0.052 | -0.245 | 0.132 | -0.129 | -0.039 | 1 | -0.055 | -0.024 | 0.110 | -0.164 | -0.217 | 0.141 | -0.347 |
| SHARE.HOTEL | 0.033 | 0.025 | 0.147 | 0.015 | -0.168 | -0.301 | 0.246 | 0.090 | -0.081 | -0.384 | 0.045 | -0.078 | 0.260 | -0.055 | 1 | -0.187 | 0.032 | -0.276 | 0.031 | -0.035 | 0.200 |
| SHARE.OTHER | -0.400 | -0.387 | -0.116 | -0.415 | 0.679 | 0.320 | -0.312 | -0.569 | -0.288 | -0.202 | 0.337 | 0.158 | -0.444 | -0.024 | -0.187 | 1 | -0.388 | 0.358 | 0.354 | -0.398 | 0.283 |
| HOUSE. EXP.on.GDP | 0.139 | 0.127 | -0.102 | 0.143 | -0.367 | -0.074 | 0.119 | 0.412 | -0.028 | -0.183 | -0.474 | 0.324 | 0.431 | 0.110 | 0.032 | -0.388 | 1 | -0.286 | -0.129 | 0.136 | -0.153 |
| GOV. EXP.on.GDP | -0.226 | -0.269 | 0.006 | -0.319 | 0.216 | 0.293 | -0.152 | -0.383 | -0.024 | 0.008 | -0.034 | 0.354 | -0.306 | -0.164 | -0.276 | 0.358 | -0.286 | 1 | 0.289 | -0.609 | 0.035 |
| DOM. CREDIT.on.GDP | -0.337 | -0.358 | 0.053 | -0.378 | 0.492 | 0.242 | -0.168 | -0.554 | 0.017 | -0.069 | 0.043 | 0.407 | -0.046 | -0.217 | 0.031 | 0.354 | -0.129 | 0.289 | 1 | -0.606 | 0.194 |
| INFLATION | 0.470 | 0.494 | -0.095 | 0.543 | -0.382 | -0.289 | -0.007 | 0.598 | 0.162 | 0.094 | -0.007 | -0.460 | -0.010 | 0.141 | -0.035 | -0.398 | 0.136 | -0.609 | -0.606 | 1 | -0.414 |
| EMU | -0.303 | -0.256 | 0.200 | -0.276 | 0.236 | 0.153 | 0.255 | -0.138 | -0.361 | -0.152 | 0.219 | 0.260 | 0.145 | -0.347 | 0.200 | 0.283 | -0.153 | 0.035 | 0.194 | -0.414 | 1 |

| | W.LOG. GDP | W. HER- FINDAL | W.INV. RATE | W.SHARE. AGRI | W.SHARE. MIN | W.SHARE. MAN | W.SHARE. FIN | W.SHARE. NMS | W.SHARE. CONST | W.SHARE. WH | W.SHARE. HOTEL | W.SHARE. OTHER | W.HOUSE. EXP.on.GDP | W.GOV. EXP.on.GDP | W.DOME. CREDIT.on.GDP | W.INFLA- TION | W.EMU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W.LOG.GDP | 1 | 0.694 | -0.448 | -0.784 | -0.387 | 0.006 | 0.044 | 0.782 | -0.356 | -0.303 | -0.250 | 0.835 | -0.275 | 0.332 | 0.755 | -0.588 | 0.363 |
| W.HERFINDAL | 0.694 | 1 | -0.222 | -0.709 | -0.503 | 0.465 | -0.182 | 0.607 | -0.523 | -0.389 | -0.604 | 0.721 | -0.462 | 0.507 | 0.419 | -0.499 | 0.264 |
| W.INV.RATE | -0.448 | -0.222 | 1 | 0.253 | -0.161 | 0.085 | 0.259 | -0.317 | 0.611 | -0.199 | 0.488 | -0.451 | -0.096 | -0.237 | -0.263 | -0.011 | 0.397 |
| W.SHARE.AGRI | -0.784 | -0.709 | 0.253 | 1 | 0.179 | -0.206 | 0.102 | -0.680 | 0.297 | 0.109 | 0.332 | -0.689 | 0.395 | -0.494 | -0.715 | 0.772 | -0.178 |
| W.SHARE.MIN | -0.387 | -0.503 | -0.161 | 0.179 | 1 | -0.057 | -0.192 | -0.448 | -0.038 | 0.386 | -0.030 | -0.403 | 0.020 | -0.045 | 0.031 | 0.302 | -0.673 |
| W.SHARE.MAN | 0.006 | 0.465 | 0.085 | -0.206 | -0.057 | 1 | -0.282 | -0.307 | -0.311 | -0.139 | -0.624 | -0.033 | -0.331 | 0.015 | -0.131 | 0.178 | -0.288 |
| W.SHARE.FIN | 0.044 | -0.182 | 0.259 | 0.102 | -0.192 | -0.282 | 1 | 0.148 | 0.215 | -0.119 | 0.225 | -0.059 | -0.263 | -0.091 | 0.116 | -0.018 | 0.590 |
| W.SHARE.NMS | 0.782 | 0.607 | -0.317 | -0.680 | -0.448 | -0.307 | 0.148 | 1 | -0.237 | -0.261 | -0.049 | 0.689 | -0.290 | 0.589 | 0.677 | -0.767 | 0.434 |
| W.SHARE.CONST | -0.356 | -0.523 | 0.611 | 0.297 | -0.038 | -0.311 | 0.215 | -0.237 | 1 | 0.032 | 0.816 | -0.555 | 0.353 | -0.512 | -0.078 | -0.017 | 0.244 |
| W.SHARE.WH | -0.303 | -0.389 | -0.199 | 0.109 | 0.386 | -0.139 | -0.119 | -0.261 | 0.032 | 1 | -0.150 | -0.277 | 0.369 | -0.217 | -0.287 | 0.187 | -0.459 |
| W.SHARE.HOTEL | -0.250 | -0.604 | 0.488 | 0.332 | -0.030 | -0.624 | 0.225 | -0.049 | 0.816 | -0.150 | 1 | -0.416 | 0.365 | -0.402 | 0.045 | -0.052 | 0.291 |
| W.SHARE.OTHER | 0.835 | 0.721 | -0.451 | -0.689 | -0.403 | -0.033 | -0.059 | 0.689 | -0.555 | -0.277 | -0.416 | 1 | -0.250 | 0.484 | 0.478 | -0.538 | 0.383 |
| W.HOUSE EXP.on.GDP | -0.275 | -0.462 | -0.096 | 0.395 | 0.020 | -0.331 | -0.263 | -0.290 | 0.353 | 0.369 | 0.365 | -0.250 | 1 | -0.540 | -0.244 | 0.256 | -0.290 |
| W.GOV. EXP.on.GDP | 0.332 | 0.507 | -0.237 | -0.494 | -0.045 | 0.015 | -0.091 | 0.589 | -0.512 | -0.217 | -0.402 | 0.484 | -0.540 | 1 | 0.289 | -0.609 | 0.035 |
| W.DOM. CREDIT.on.GDP | 0.755 | 0.419 | -0.263 | -0.715 | 0.031 | -0.131 | 0.116 | 0.677 | -0.078 | -0.287 | 0.045 | 0.478 | -0.244 | 0.289 | 1 | -0.606 | 0.194 |
| W.INFLATION | -0.588 | -0.499 | -0.011 | 0.772 | 0.302 | 0.178 | -0.018 | -0.767 | -0.017 | 0.187 | -0.052 | -0.538 | 0.256 | -0.609 | -0.606 | 1 | -0.414 |
| W.EMU | 0.363 | 0.264 | 0.397 | -0.178 | -0.673 | -0.288 | 0.590 | 0.434 | 0.244 | -0.459 | 0.291 | 0.383 | -0.290 | 0.035 | 0.194 | -0.414 | 1 |

## C First-stage regressions

Table 8: Results of the first-stage regressions with 248 regions

| | *Dependent variable:* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | INV.RATE | HOUSE.EXP.on.GDP | GOV.EXP.on.GDP | DOM.CREDIT.on.GDP | INFLATION | EMU | W.INV.RATE | W.HOUSE.EXP.on.GDP |
| LOG.GDP | −0.010*** | 0.013 | −0.003*** | 0.021* | 0.021* | −0.017** | 0.0002 | 0.004 |
| HERFINDAL | −0.327*** | −0.073 | 0.025 | −0.353 | −0.353 | 0.705* | −0.023 | −0.104 |
| SHARE.AGRI | 0.066 | 1.109*** | 0.084* | 1.232** | 1.232** | 0.426 | −0.012 | −0.082 |
| SHARE.MIN | 0.182** | −0.613* | 0.048 | 2.691*** | 2.691*** | −0.404 | 0.017 | −0.301* |
| SHARE.MAN | 0.220*** | 0.110 | 0.096*** | 2.226*** | 2.226*** | −0.255 | −0.014 | −0.243* |
| SHARE.FIN | 0.223 | −2.806*** | 0.151** | 4.280*** | 4.280*** | 1.913*** | 0.111 | −1.333*** |
| SHARE.NMS | 0.168** | 1.343*** | 0.106*** | 2.742*** | 2.742*** | −0.451 | 0.018 | −0.113 |
| SHARE.CONST | 0.274* | 1.293** | 0.071 | 1.955** | 1.955** | 1.137** | −0.019 | −0.531* |
| SHARE.WH | 0.066 | 0.671 | −0.035 | 2.547*** | 2.547*** | −0.832** | −0.054 | −0.114 |
| SHARE.HOTEL | 0.170* | −0.321 | 0.086* | 2.572*** | 2.572*** | 0.351 | 0.007 | −0.300 |
| SHARE.OTHER | 0.270*** | −0.334 | 0.172*** | 1.583*** | 1.583*** | −0.493* | −0.018 | 0.022 |
| W.LOG.GDP | 0.00004 | 0.005 | −0.013*** | 0.022 | 0.022 | −0.035* | −0.011*** | 0.012 |
| W.HERFINDAL | −0.283 | −0.690 | −0.134 | −1.224 | −1.224 | 0.743 | −0.089 | 0.143 |
| W.SHARE.AGRI | −0.140 | 0.662* | 0.188*** | −2.000*** | −2.000*** | 2.528*** | 0.213*** | 1.282*** |
| W.SHARE.MIN | 0.153 | −0.132 | 0.147** | 1.267* | 1.267* | 0.047 | 0.357*** | −0.534** |
| W.SHARE.MAN | −0.025 | −0.444 | 0.150*** | 0.184 | 0.184 | 0.283 | 0.228*** | −0.059 |
| W.SHARE.FIN | 0.542** | −3.671*** | 0.514*** | 1.943 | 1.943 | 5.672*** | 0.849*** | −4.701*** |
| W.SHARE.NMS | 0.164 | −0.163 | 0.117** | 0.905 | 0.905 | 0.005 | 0.140** | 1.064*** |
| W.SHARE.CONST | −0.158 | 0.401 | 0.153 | −5.342*** | −5.342*** | 2.129** | 0.693*** | 2.754*** |
| W.SHARE.WH | −0.234* | 1.508*** | −0.080 | −0.530 | −0.530 | −0.594 | 0.195*** | 1.556*** |
| W.SHARE.HOTEL | 0.273* | −1.484** | 0.143* | −0.223 | −0.223 | −0.115 | 0.372*** | −0.710** |
| W.SHARE.OTHER | −0.124 | 0.762 | 0.311*** | −0.763 | −0.763 | −0.219 | 0.148** | −0.100 |
| INV.RATE.1991 | 0.467*** | 0.112 | 0.030** | 0.443*** | 0.443*** | −0.216** | 0.014 | 0.085 |
| HOUSE.INCOME.on.GDP | −0.011 | 0.158*** | −0.014*** | 0.007 | 0.007 | −0.088** | −0.002 | 0.004 |
| GOV.EXP.on.GDP.1991 | −0.108 | −2.168*** | 0.754*** | −2.573*** | −2.573*** | 1.235*** | 0.060 | −1.431*** |
| TAX.on.GDP | 0.0001 | 0.005*** | 0.001** | −0.014*** | −0.014*** | −0.002 | −0.0002 | 0.006*** |
| MARKET.CAPIT.on.GDP | −0.0001 | −0.0001 | 0.0001*** | 0.007*** | 0.007*** | −0.002*** | −0.0001** | −0.00005 |
| DELTA.LOG.COMP.EMP | 0.478*** | −0.481 | −0.149*** | −1.968*** | −1.968*** | −1.894*** | 0.093* | 0.223 |
| EMS | 0.010 | −0.103*** | 0.00003 | −0.061 | −0.061 | 0.593*** | 0.005 | −0.034** |
| W.INV.RATE.1991 | 0.089 | −0.034 | 0.019 | 0.756** | 0.756** | 0.010 | 0.466*** | −0.176 |
| W.HOUSE.INCOME.on.GDP | −0.074** | −0.030 | −0.026** | 0.140 | 0.140 | −0.368*** | −0.010 | 0.203*** |
| Constant | 0.121* | 0.459* | −0.013 | −1.154*** | −1.154*** | 0.506** | −0.005 | 0.346** |
| Weak IV *F* | 38.423 | 8.540 | 91.929 | 37.535 | 63.209 | 96.985 | 41.469 | 20.627 |
| Observations | 248 | 248 | 248 | 248 | 248 | 248 | 248 | 248 |
| Adjusted $R^2$ | 0.793 | 0.716 | 0.878 | 0.900 | 0.900 | 0.921 | 0.922 | 0.877 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

Table 9: Results of the first-stage regression with 217 regions

| | *Dependent variable:* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | INV.RATE | HOUSE.EXP.on.GDP | GOV.EXP.on.GDP | DOM.CREDIT.on.GDP | INFLATION | EMU | W.INV.RATE | W.HOUSE.EXP.on.GDP |
| LOG.GDP | −0.005** | 0.017* | −0.001 | 0.034*** | 0.034*** | 0.0002 | 0.0003 | 0.009* |
| HERFINDAL | −0.270** | 0.193 | 0.010 | −0.486 | −0.486 | 0.915** | −0.011 | 0.001 |
| SHARE.AGRI | 0.167* | 1.457*** | 0.061 | 0.266 | 0.266 | 0.273 | −0.058 | −0.227 |
| SHARE.MIN | 0.185* | −0.112 | −0.030 | 0.753* | 0.753* | −0.913*** | 0.051 | −0.086 |
| SHARE.MAN | 0.127* | 0.053 | 0.045 | 1.289*** | 1.289*** | −0.682*** | 0.009 | −0.361** |
| SHARE.FIN | 0.189 | −1.498** | −0.001 | 1.670** | 1.670** | 0.947 | 0.026 | −1.465*** |
| SHARE.NMS | 0.094 | 1.057*** | 0.070* | 1.968*** | 1.968*** | −0.787*** | 0.040 | −0.289* |
| SHARE.CONST | 0.186 | 0.572 | −0.036 | 1.303** | 1.303** | 0.945* | 0.006 | −0.634** |
| SHARE.WH | −0.037 | 0.421 | −0.138*** | 1.651*** | 1.651*** | −1.453*** | 0.023 | −0.078 |
| SHARE.HOTEL | 0.118 | −0.178 | 0.016 | 1.164*** | 1.164*** | 0.059 | 0.014 | −0.312* |
| SHARE.OTHER | 0.178** | −0.468 | 0.102** | 1.210*** | 1.210*** | −1.005*** | −0.005 | −0.283* |
| W.LOG.GDP | 0.001 | 0.046* | −0.003 | 0.069** | 0.069** | −0.009 | −0.006* | 0.038*** |
| W.HERFINDAL | −0.290 | −0.682 | −0.034 | −2.657** | −2.657** | 1.224 | −0.183 | −0.167 |
| W.SHARE.AGRI | −0.337*** | −0.105 | 0.132** | −3.522*** | −3.522*** | 2.279*** | 0.163** | 1.461*** |
| W.SHARE.MIN | −0.066 | 0.493 | −0.036 | −2.426*** | −2.426*** | −0.482 | 0.182* | −0.291 |
| W.SHARE.MAN | 0.023 | −1.081** | 0.027 | 0.396 | 0.396 | −0.066 | 0.182*** | −0.552*** |
| W.SHARE.FIN | 0.187 | −4.780*** | 0.441*** | −1.571 | −1.571 | 5.295*** | 0.622*** | −4.655*** |
| W.SHARE.NMS | 0.240* | −0.315 | 0.033 | 1.887*** | 1.887*** | −0.343 | 0.132* | 0.774*** |
| W.SHARE.CONST | −0.473 | 0.060 | −0.048 | −3.368*** | −3.368*** | 1.537 | 0.390** | 0.504 |
| W.SHARE.WH | −0.253 | 0.235 | −0.392*** | −0.159 | −0.159 | −2.088*** | 0.009 | 0.543* |
| W.SHARE.HOTEL | 0.182 | −1.990*** | 0.053 | −0.323 | −0.323 | −0.448 | 0.199** | −1.457*** |
| W.SHARE.OTHER | −0.120 | −0.209 | 0.079 | −0.759 | −0.759 | −0.911* | 0.121 | −0.613** |
| LOG.PART.TIME | −0.011* | 0.025 | 0.005 | 0.078*** | 0.078*** | 0.059** | 0.0004 | 0.033*** |
| W.LOG.PART.TIME | −0.002 | −0.048 | 0.005 | 0.029 | 0.029 | −0.021 | −0.014*** | −0.039** |
| INV.RATE.1991 | 0.450*** | 0.159 | 0.035*** | 0.312** | 0.312** | −0.241** | 0.013 | 0.066 |
| HOUSE.INCOME.on.GDP | 0.005 | 0.529*** | −0.013 | −0.015 | −0.015 | −0.092 | −0.016 | 0.010 |
| GOV.EXP.on.GDP.1991 | −0.337*** | −1.778*** | 0.536*** | −6.418*** | −6.418*** | 0.661 | −0.081 | −1.638*** |
| TAX.on.GDP | −0.0002 | 0.003 | 0.001*** | −0.005** | −0.005** | 0.002 | −0.0002 | 0.003*** |
| MARKET.CAPIT.on.GDP | 0.00001 | 0.00000 | 0.00001 | 0.005*** | 0.005*** | −0.003*** | −0.00003 | 0.00004 |
| DELTA.LOG.COMP.EMP | 0.528*** | 0.677 | 0.151** | −2.195*** | −2.195*** | −1.331*** | 0.126* | 0.830*** |
| EMS | −0.002 | −0.024 | −0.006 | −0.376*** | −0.376*** | 0.501*** | −0.001 | 0.0004 |
| W.INV.RATE.1991 | 0.089 | 0.074 | 0.003 | 0.135 | 0.135 | −0.152 | 0.455*** | 0.072 |
| W.HOUSE.INCOME.on.GDP | −0.043 | −0.129 | 0.031 | −0.274 | −0.274 | 0.073 | 0.006 | 0.409*** |
| Constant | 0.149** | 0.246 | 0.081** | 0.688** | 0.688** | 0.922*** | 0.015 | 0.522*** |
| Weak IV *F* | 39.848 | 7.44 | 51.210 | 35.954 | 25.315 | 58.731 | 27.106 | 17.203 |
| Observations | 217 | 217 | 217 | 217 | 217 | 217 | 217 | 217 |
| Adjusted $R^2$ | 0.847 | 0.753 | 0.841 | 0.939 | 0.939 | 0.933 | 0.946 | 0.925 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

## D The Estimate with SD

Table 10: **The estimated coefficients and the average direct, indirect, and total effects via TSML**.

| | *Dependent variable: SD* | | | | |
|---|---|---|---|---|---|
| | coeff. | W coeff. | ADE | AIE | ATE |
| SHARE.AGRI | 0.010 | 0.113*** | 0.013 | 0.136*** | 0.149** |
| SHARE.MIN | −0.024 | 0.001 | −0.024 | −0.004 | −0.028 |
| SHARE.MAN | −0.058*** | −0.035 | −0.059*** | −0.054* | −0.113*** |
| SHARE.FIN | −0.143*** | 0.044 | −0.143*** | 0.022 | −0.121 |
| SHARE.NMS | −0.064 | −0.090** | −0.067 | −0.12** | −0.187*** |
| SHARE.CONST | −0.036 | 0.032 | −0.036 | 0.031 | −0.004 |
| SHARE.WS | −0.030 | −0.112** | −0.030 | −0.139** | −0.168*** |
| SHARE.HOTEL | −0.108*** | −0.069 | −0.108*** | −0.104* | −0.213*** |
| SHARE.OTHER | −0.079∗ ∗ ∗ | 0.037 | −0.079*** | 0.027 | −0.052 |
| LOG.GDP | −0.002*** | 0.001 | −0.002*** | 0.001 | −0.001 |
| HERFINDAL | 0.081*** | 0.001 | 0.081*** | 0.018 | 0.099 |
| INV.RATE | 0.015 | −0.034 | 0.015 | −0.038 | −0.024 |
| HOUSE.EXP.on.GDP | −0.029 | 0.031 | −0.029 | 0.031 | 0.002 |
| GOV.EXP.on.GDP | −0.042 | – | −0.042 | −0.009 | −0.05 |
| DOM.CREDIT.on.GDP | 0.007** | – | 0.007** | 0.002 | 0.009** |
| INFLATION | −0.012 | – | −0.012 | −0.002 | −0.014 |
| EMU.DUMMY | −0.003 | – | −0.003 | −0.001 | −0.004 |
| Constant | 0.1074*** | – | – | – | – |
| $\lambda$ | 0.178** | – | – | – | – |
| $H_0 : \theta_1 = 0$ | 50.36*** | | | | |
| Hausman test | 13.55* | | | | |
| Sargan test | 2.237 | | | | |
| $\bar{R}^2$ | 0.608 | | | | |
| AIC_c | −1844.97 | | | | |
| N.Obs | 248 | | | | |

*Note:* *p<0.1; **p<0.05; ***p<0.01