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DETERMINANTS OF REGIONAL BUSINESS CYCLE SYNCHRONIZATION IN GREECE

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ABSTRACT

We assess the determinants of regional business cycles synchronization in Greece vis-à-vis the national reference business cycle, using NUTSII annual data. The computation of the time-varying synchronization is based on the dynamic estimate of a conditional variance-covariance model and subsequently a panel regression model is used to evaluate its determinants. The findings show that island regions, industrial structure, imports, savings and disposable income are the key determinants, based on the GVA business cycle synchronization vis-à-vis the national reference cycle. We also assess the determinants of employment synchronization (vis-à-vis the national employment level) and we find that regions with higher disposable income and public spending tend to drive the level of synchronization. Turning to the inter-regional synchronization we provide evidence that investments, disposable income and employment drive the GVA business cycle synchronization, whereas the employment synchronization is determined by the level of imports, disposable income and public spending, as well as, by the status of regions as island economies. We further show that the Greek economic crisis during the period 2010-2018 has dimished or eliminated the effects of the aforementioned drivers, suggesting that during the said period, sychronisation was mainly driven by the wider economic conditions. These findings lead to important policy implications, which are thoroughly discussed.

Keywords: Business Cycle, Employment, Synchronization, Dynamic Correlation.
JEL Classifications: E32, F44.

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1. Introduction

Since the seminal work on Optimum Currency Areas (OCA) by Mundell (1961) to be followed by McKinnon (1963) and Kenen (1969), a vast literature has emerged on business cycles synchronization, a pre-requisite for the well-functioning of a common currency area. The earlier studies on the topic were developed even before the inception of the euro currency, with the notable works by Eichengreen (1990), De Grauwe and Vanhaverbeke (1993) and Fatas (1997), who assessed whether Europe could form an OCA. More recent studies attempted to answer the question of synchronized business cycles[1], not only, among member-states of the European Monetary Union (EMU) or the European Union (EU)[2], but also at country level beyond EMU or EU[3].

Another strand of research assesses the main drivers of business cycles synchronization, with the bilateral trade intensity, dis(similarily) of industrial structure, financial integration, fiscal stance, political ideologies, globalization, and distance between countries being among the identified factors[4].

Beyond the wealth of evidence in favor or against the synchronization of EMU or EU member-countries' business cycles, extensive research has focused on the synchronization at regional level. Sala-i-Martin (1996), the first study to assess regional business cycle synchronization, focus on 73 NUTSII EU regions, 47 US regions, 10 Canadian provinces and 47 Japanese prefectures and shows an increased level of convergence over time among regions. Subsequent studies, Rodríguez-Pose and Fratesi (2007), using NUTSII data for EU countries, examined whether the regional business cycles are synchronized with the national cycle, providing evidence of pro-cyclical regional disparities, as regions are more dependent on transfers or public investment and employment. More recently, Gadea *et al*. (2017) investigated

[1] For instance, the reader is directed to the works by De Haan *et al*. (2002), Altavilla (2004), Camacho *et al*. (2008), Koopman and Azevedo (2008), Papageorgiou *et al*. (2010), Aguiar-Conraria and Soares (2011), Soares (2011), Artis *et al*. (2011), Mink *et al*. (2011), Crespo-Cuaresma *et al*. (2013), Lee (2012), Degiannakis *et al*. (2014) and Camacho *et al*. (2019).

[2] For instance, the reader is directed to the works by De Haan *et al*. (2002), Altavilla (2004), Camacho *et al*. (2008), Koopman and Azevedo (2008), Papageorgiou *et al*. (2010), Aguiar-Conraria and Soares (2011), Soares (2011), Artis *et al*. (2011), Mink *et al*. (2011), Crespo-Cuaresma *et al*. (2013), Lee (2012), Degiannakis *et al*. (2014) and Camacho *et al*. (2019).

[3] For example, Kose *et al*. (2008) studies the global business cycles, Bergman *et al*. (2011) looks at the Scandinavian region, Jiménez-Rodríguez *et al*. (2013) focus on the Central and Eastern European countries, whereas the studies by Magrini *et al*. (2015), Lange (2017) and Leiva-Leon (2017) study the American continent with their focus being in Canada and the US.

[4] See, Kalemli-Ozcan *et al*. (2001), Kose *et al*. (2003), Imbs (2004), Imbs (2006), Inklaar *et al*. (2008), Cerqueira and Martins (2009), Cerqueira and Martins (2011), Montinari and Stracca (2016), Degiannakis *et al*. (2016), Bunyan *et al*. (2020).

the evolution of regional economic interlinkages in Europe at NUTSII level, using GDP data for 213 NUTSII regions in 18 EU countries. Their findings show that (i) in just two years, the Great Recession synchronized Europe twice as much as the European Union integration process achieved over several decades; (ii) the region Ile de France is acting as the main channel for the transmission of business cycle shocks in Europe to be followed by Inner London and Lombardi; and (iii) a nonlinear relationship between sectoral composition and regional synchronization, which was amplified in the wake of the Great Recession. The results of Camacho *et al*. (2017) work, which focus on 17 NUTSII regions for Spain, alike those of Gadea *et al*. (2017) show substantial increase in the regional business cycles synchronization in the post-Great Recession period. More recent work by Gomez-Losko *et al*. (2019), using annual real GDP data for NUTSII regions corresponding to 16 European countries, reports, though co-movements among regions are relatively low, an increasing trend in the level of synchronization after the Great Recession.

Though, it is more common for studies to use NUTSII data to examine regional business cycles synchronization, a number of studies that use NUTSI or NUTSIII regions (see, for instance, Acedo-Montoya and de Haan, 2008; Montoya and De Haan, 2008; Marino, 2013; Beck, 2016; Bandrés *et al*., 2017) show, on one hand, that synchronization has increased over time and, on the other hand the existence of a national border effect.

The present study develops further, the only published work on the regional business cycles synchronization for Greece (Panteladis and Tsiapa, 2014), the inquiry on national regional business cycles synchronization and its main drivers. Their study uses the Pearson correlation with 8-years rolling window on data from 1980 to 2008 both at the NUTSII and NUTSIII level. The study approximates a time-varying correlation measure and shows that the business cycles of the NUTSIII regions are more synchronized with the NUTSII level rather than the national business cycle. The industrial dissimilarity, similarity in manufacturing specialization, similarity in input-output linkages and agglomeration economies appear to be the drivers of synchronization or de-synchronization.

The paper extends the current literature in several important ways. First, we use a robust of time-varying synchronization measure, using a multivariate GARCH model in line with Degiannakis *et al*. (2014, 2016). Second, we consider both the GVA business cycle synchronization and the employment synchronization, for robustness purposes. Third, apart from the typical drivers of synchronization (e.g., trade and industry dissimilarity), we consider variables, such as the regional characteristics in terms of tourist destination and island vs non-

island regions, as well as regional savings, disposable income and public spending on regions, not been considered thus far by the related literature. Finally, we generate results for both the level of regional business cycle synchronization vis-à-vis the national reference cycle, as well as the inter-regional synchronization.

Our findings suggest that island regions, industrial structure, imports, savings and disposable income tend to drive the regional GVA business cycle synchronization vis-à-vis the national reference cycle. As far as the employment synchronization is concerned, we show that regions with higher disposable income and public spending tend to drive the level of synchronization. The results based on the inter-regional GVA business cycle synchronization exhibit similarities with the literature review, with differences in regional investments, disposable income and employment being important determinants business cycle synchronization. Finally, the level of inter-regional employment synchronization is impacted by the status of regions as island economies. Even more, it is also determined by differences in the regional disposable income and public spending on the regions. Importantly, we show that the Greek economic crisis during the period 2010-2018 either dimished or eliminated, to a large extend, the effects of the aforementioned drivers, signifying the economic deterioration that took place in all regions during that period.

The rest of the paper is organized as follows. Section 2 describes the data that is used in the present study, along with the data sources. Section 3 provides a detailed discussion of the data construction, whereas Section 4 describes the methodology that is employed in this research. Section 5 analyses the empirical findings, before Section 6 concludes the study and provide the policy implications.

2. Data description

The dataset, been retrieved from Eurostat, Greek Statistical Authority, Greek Exporters Association, Ministry of Finance, Association of Greek Tourism Enterprises and Bank of Greece, consists of annual frequency over the period 2005-2018 for the 13 Greek regions. The current study focuses on the drivers of business cycle synchronization between the average national reference business cycle and the business cycles of the 13 regions, see Table 1. Our sample has a total of 156 region-years with the monetary values expressed in constant prices of 2005.

[TABLE 1 HERE]

3. Data Construction

3.1 Dependent variable

To assess the drivers of business cycle synchronization, we first extract the cyclical component of the regional and national-wide GVA, using the Hodrick-Prescott filter. Next, we use this cyclical component to estimate the time-varying business cycle synchronization between region *i* and the national-wide reference cycle.

We define as $\boldsymbol{y}_t = (y_{i,t},\ \ y_{GR,t})'$ the bivariate vector for $y_{i,t}$, $i = 1, \dots, 13$, being the business cycle of region i and $y_{GR,t}$ denoting the national-wide reference cycle at year t. The generalized form of a system that enables us to compute the dynamic estimation of business cycle synchronization is:

$$\begin{aligned} &\boldsymbol{y}_t = \boldsymbol{\mu}_t + \boldsymbol{\varepsilon}_t \\ &\boldsymbol{\varepsilon}_t = \boldsymbol{H}_t^{1/2}\boldsymbol{z}_t \\ &\boldsymbol{z}_t \sim N(\boldsymbol{z}_t; \boldsymbol{0}, \boldsymbol{I}) \\ &\boldsymbol{H}_t = \sigma(\boldsymbol{I}_{t-1}), \end{aligned} \tag{1}$$

where $\boldsymbol{\mu}_t$ denotes the conditional to the available information at time $t-1$ mean of $\boldsymbol{y}_t$, $\boldsymbol{H}_t$ is the conditional covariance matrix of $\boldsymbol{\varepsilon}_t \equiv \boldsymbol{y}_t - \boldsymbol{\mu}_t$, $\boldsymbol{z}_t$ is a process with $E(\boldsymbol{z}_t) = \boldsymbol{0}$, $E(\boldsymbol{z}_t\boldsymbol{z}_t') = \boldsymbol{I}$, $N(\boldsymbol{z}_t; \boldsymbol{0}, \boldsymbol{I})$ is the bivariate standard normal density function and $\sigma(.)$ is a positive measurable function of the past information set, $\boldsymbol{I}_{t-1}$.

The business cycle synchronization between region *i* and the national-wide reference cycle is the dynamic correlation coefficient which is estimated as:

$$BCS_{i,GR,t} = \frac{\sigma_{i,GR,t}}{\sqrt{\sigma_{i,t}^2\sigma_{GR,t}^2}}, \tag{2}$$

where $\sigma_{i,t}^2$ and $\sigma_{GR,t}^2$ are the diagonal elements of $\boldsymbol{H}_t$, and $\sigma_{i,GR,t}$ is the non-diagonal element of $\boldsymbol{H}_t$.

One of the most straight forward specifications to estimate the $\boldsymbol{H}_t = \sigma(\boldsymbol{I}_{t-1})$, which guarantees the $\boldsymbol{H}_t$ to be positive definite and does not require the estimation of any parameters of $\boldsymbol{H}_t$, is the multivariate Riskmetrics® model proposed by J.P. Morgan (1996).

The covariance matrix of the multivariate Riskmetrics model is defined as:

$$\boldsymbol{H}_t = (1-\lambda)\boldsymbol{\varepsilon}_{t-1}\boldsymbol{\varepsilon}_{t-1}' + \lambda\boldsymbol{H}_{t-1}, \tag{3}$$

where $0 < \lambda < 1$ is a scalar.

The bivariate Riskmetrics analytically has the form:

$$\begin{pmatrix} y_{i,t} \\ y_{GR,t} \end{pmatrix} = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} + \begin{pmatrix} \varepsilon_{i,t} \\ \varepsilon_{GR,t} \end{pmatrix}$$

$$(\varepsilon_{1,t} \quad \varepsilon_{2,t} \quad \cdot \quad \cdot \quad \cdot \quad \varepsilon_{15,t})' = \boldsymbol{H}_t^{1/2}(z_{1,t} \quad z_{2,t} \quad \cdot \quad \cdot \quad \cdot \quad z_{15,t})' \tag{4}$$

$$(z_{i,t} \quad z_{GR,t})' \sim N(\mathbf{0}, \boldsymbol{I})$$

$$\boldsymbol{H}_t = \begin{pmatrix} \sigma_{i,t}^2 & \sigma_{i,GR,t} \\ \sigma_{i,GR,t} & \sigma_{GR,t}^2 \end{pmatrix} = (1-\lambda)\begin{pmatrix} \varepsilon_{i,t} \\ \varepsilon_{GR,t} \end{pmatrix}(\varepsilon_{i,t} \quad \varepsilon_{GR,t})' + \lambda \boldsymbol{H}_{t-1}.$$

The *BCS* between the regional cycles and the national-wide reference cycle is shown in Figure 1.

[FIGURE 1 HERE]

Figure 1 shows the presence of a very high level of *BCS* between each region's cycle and the national-wide reference cycle with the level of synchronization varying between 0.94 and 1. However, there is a notable exception, this of Dytiki Makedonia, which presents the lowest level of synchronization with the national-wide reference cycle, with a fluctuation between 0.36 and 0.52. This finding may very well be explained by two main factors. First the isolation of the region from the rest of mainland not only due to the mountainous dominance but also due to the poor transportation infrastructure, road[5] and airport, linking the region to the rest of Greece, especially the main economic centers such as Thessaloniki, where its demand for food and manufacturing products is met mainly by neighboring and lower transportation cost suppliers in Central Macedonia, direct competitors of Dytiki Makedonia, such as Serres, Kavala, Pella, Imathia and Chalkidiki. Dytiki Makedonia's suppliers are faced with even stronger obstacles, such as transportation cost, and competition due to transportation cost and close substitution supply by the near by regions, to access the consumer of Attiki. Second, though its demographic characteristics resemble to those of the rest of Greece, most of the indices of main economic variables, such as participation of economic active labor force to its total labor force, contribution of tourism to its total GDP, recovery of employment, rank the region to the bottom among the rest of the domestic regions and consequently from the county's average. In almost all cases, the peak in the level of synchronization in observed during 2010, which is in line with our a-priori expectations as it marks the start of the Greek debt crisis. However, following the year 2010, according to Figure 1 results, it is quite interesting to a decoupling behavior, albeit the high correlation level.

[5] It is expected the Egnatia avenue to amplify the problem.

3.2. Drivers of synchronization

Our set of drivers of business cycle synchronization includes tourism (*TOUR*), island (*ISL*), distance (*DIS*), industrial dissimilarity index (*IND_DISS*), imports (*IMP*), exports (*EXP*), investments (*INV*), savings (*SAV*), disposable income (*DISP_INC*), public spending (*PUB_SPEND*) and employment (*EMP*), which are either dummy variables or monetary values expressed as a percentage of the regional GVA.

The *IND_DISS* has been constructed by the authors adopting Krugman's industrial dissimilarity index (Krugman, 1991), which captures the level of industrial specialization between each region and Greece. The index has been constructed as:

$$IND\_DISS_{i,GR,t} = \sum_{k}^{K} \left| S_{k,i,t} - S_{k,GR,t} \right|, \quad (5)$$

where, $S_{k,i,t}$ denotes the share of industry (*IND*) *k* in region's *i* GVA, in year *t* and $S_{k,GR,t}$ is the share of industry (*IND*) *k* in year *t* for the whole Greek GVA. The range of values that this index takes is between 0 and 1, with values close to 0 suggesting similar industrial structure between region *i* and Greece.

4. Methodology

In this part, we provide methodological details in regard with the panel regression applied in this paper. The main purpose of this study is the investigation of the potential drivers of regional business cycle synchronization (*BCS*) between the 13 Greek regional cycles and the national-wide reference cycle. To do so, a panel regression model for region *i* at year *t* is expressed in an analytical form as follows:

$$BCS_{i,GR,t} = \theta_0 + \theta_1 BCS_{i,GR,t-1} + \sum_{k=1}^{N} \xi_k z_i^{(k)} + \sum_{j=1}^{M} \delta_j x_{i,t}^{(j)} + \sum_{j=1}^{M} \gamma_j x_{i,t}^{(j)} d_t + u_{i,t} + \varepsilon_{i,t}, \quad (6)$$

where, $BCS_{i,GR,t}$ denotes the level of business cycle synchronization in year *t*, $z_i^{(k)}$ denotes the time-invariant explanatory variables (N = 3 variables), whereas $x_{i,t}^{(j)}$ are the time-varying explanatory variables (M = 8 variables). The $u_{i,t}$ and $\varepsilon_{i,t}$ denote the between-region and within-region errors, respectively. The θ_1 is the coefficient of the lagged dependent variable and ξ_k and δ_j denote the coefficients of the explanatory variables. Greece has experienced a significant economic recession during 2010-2018. The possible effects of such crisis are taken into consideration here with γ_j coefficients, where d_t is the crisis dummy which takes the value of

one for the period 2010-2018 and zero otherwise.[6] Thus, the impact of the debt crisis on the determinants of *BCS* is captured by the $\delta_j + \gamma_j$ coefficients.

The panel regression includes random effects[7], which means that the variation across regions are assumed to be random and uncorrelated with the explanatory variables and all the necessary tests have been applied. The GLS method has been used for the estimation of the model. It is also noted that the standard errors of the panel regression are robust. The number of observations of those panel regressions is 156 (regions x years). We shall reiterate that the set of the explanatory variables consists of the following variables: the first lag of the dependent variable, tourism (*TOUR*), island (*ISL*), distance (*DIS*), industrial dissimilarity index (*IND_DISS*), imports (*IMP*), exports (*EXP*), investments (*INV*), savings (*SAV*), disposable income (*DISP_INC*), public spending (*PUB_SPEND*) and employment (*EMP*).

5. Empirical analysis

Starting our analysis with the panel regression results based on the *BCS* as the dependent variable, the estimation results show that several of the a-priori considered drivers exercise a statistically significant impact on the level of synchronization, including *ISL*, *DIS*, *IND_DISS*, *IMP*, *SAV* and *DISP_INC*, as well as the lagged *BCS* level (see Table 2).

[TABLE 2 HERE]

More specifically, we observe that *ISL*, *IND_DISS*, *IMP* and *DISP_INC* have a negative sign, whereas the reverse holds true for *DIS* and *SAV*.

Focusing on the variables that tend to diminish the level of *BCS*, *ISL* suggests that the island regions tend to exhibit a lower synchronization vis-à-vis the national reference cycle. This is rather expected given that during our sample period, island regions tend to have relatively higher and a less dependent *GVA* on the domestic economy and as such they are less impacted by the national-wide economic conditions.

[6] We have estimated eq.6 including the crisis dummy as an additional explanatory variable and the results show that the variable is significant, suggesting that the Greek debt crisis has impacted the level of synchronization between the regional business cycles and the Greek-reference cycle. The results are available upon request by the authors. Given this result, we assess whether the debt crisis also influenced the determinants of the BCS, hence the development of the interaction terms.

[7] The inclusion of random and not fixed effects is indicated by the Hausman test.

The *IND_DISS* coefficient suggests that regions which score a high index of industrial dissimilarity vis-à-vis the national-wide industrial structure are more prone to idiosyncratic shocks and hence less synchronized, which is rather expected.

As far as *IMP* is concerned, the negative sign (along with the insignificant effect of *EMP*) may suggest that either a particular region is exhibiting higher growth rates and hence it has an increased ability to import more goods and services, or that its demand structure substitutes domestic supply with imports, which may have a negative effect on its EMP. In either case, the effect on *BCS* is in line with the a-priori expected negative sign.

The negative impact of *DISP_INC* on the *BCS* clearly states that higher level of regional disposable income (as a % of regional total income) tends to lead to stronger demand and hence greater economic activity. In other words, regions which register high *DISP_INC* are expected to perform better compared to the country-wide economic conditions, and hence deviate from the country-wide business cycle.

Thus far we have not taken into consideration into our econometric model the domestic severe economic crisis which may very well have led regions to a greater or less synchronization defined by the variable *BCS*. It is clear from Table 2 that the impact of *IMP* and *IND_DISS* are becoming insignificant when the *IMP_D* and *IND_DISS_D* are also considered, showing that the importing activity of the regions and their industrial structure cease to affect the level of *BCS*. In addition, the effect of *DISP_INC* during the crisis period becomes significantly lower in magnitude relative to the pre-crisis period. This effect may very well be attributed to the paradox of thrift where different economic structure of regions may lead to different consumer anticipating behaviors during crisis.

Turning our attention to the determinants that exercise a positive impact on *BCS*, *SAV* exhibits a positive effect on *BCS*, which is rather expected as the mainstream growth models would inform us, given that increased savings leads to higher capital stock, allowing regions to improve their economic output. However, we observe that *SAV* seem to exercise a much lesser impact in promoting *BCS* during the crisis period. This may very well be due to the paradox of savings where personal savings are a net drag on the economy during a recession. An important feature of the Global Crisis of 2008-2009 was a sharp increase in precautionary savings (Mody et al. 2012), which renewed interest in the *paradox of thrift* (Chamley, 2012; Eggertsson and Krugman, 2012; Guerrieri and Lorenzoni, 2017; Fornaro and Romei, 2019). Similar developments we observe in the Greek regions during the crisis where in nine (9)

regions the savings increased and only in four (4) regions savings decreased, while in the pre-crisis period, 2005-2008, a strong rise of savings, ranging between 9 to 13 per cent, is registered across all, exclunding one (Evritania), domestic regions[8]. Worth mentioning that 2 out of the 4 regions where savings drop include the two largest cities, i.e. Athens and Thessaloniki which in pre-crisis and during crisis period register savings well above the national average.

Finally, *DIS* exhibits a rather unanticipated effect, showing that longer distance between Attiki and the capital city of each region leads to greater synchronization level. A plausible explanation could be related to the fact that *DIS* is influenced by the distance that island regions have from Athens. To test this hypothesis, we re-estimate eq.6, although we exclude from our sample the island regions. Indeed, as Table 3[9] shows, *DIS* becomes insignificant suggesting that distant inland regions do not actually exhibit higher synchronization vis-à-vis the regions that are closer to Attiki. The impact that we observe in Table 2 is driven rather by the distance of the island regions from Attiki. Even more, we examine whether the impact of *DIS* is nonlinear by adding its squared term in the estimated eq.6. The results, Table 4, show that a possible nonlinear relationship is not significant. Hence, we can conclude that the unanticipated effect observed in Table 2 is indeed driven by the island regions.

[TABLES 3 & 4 HERE]

Having analysed the baseline results, we face an important limitation, which could distort our findings. This limitation is related to the narrow fluctuations of the *BCS*, which are always close to 1, except for Dytiki Makedonia, for the reasons already discussed. It could be said that our findings may be driven by outlier of Dytiki Makedonia in our sample whose economy, among other factors, depend on the exploration of lignite and the operation of the largest national public unit of production of electricity.

The identified limitation, opt us to the estimation of eq.6, where the employment synchronization (*EMPS*) is used as the dependent variable. The level of synchronization between the regional and national employment rates is estimated in the same fashion as in the business cycle synchronization. This choice is motivated by Barrios *et al.* (2003), Belke and

[8] The percentage changes are calculated based on the savings raw data, which is available upon request.
[9] Note that the exclusion of island regions from the sample also changes some of the remaining results. For brevity, we do not analyse these results in the main text, given that the focus on Table 3 is on *DIS*. In any case, it is interesting to note that both *EMPL* and *PUB_SPEND* are important determinants of *BCS*, during non-crisis period, whereas their effect is rather marginal or insignificant during the Greek debt crisis period.

Heine (2006), Marino (2013), Dixon and Shepherd (2013), Duran and Ferreira-Lopez (2017) and Lange (2017) who also use employment data as an alternative proxy of economic growth.

The level of *EMPS* for the 13 Greek regions is quoted in Figure 2, where it becomes clear, comparing the *EMPS* with *BCS*, the significant larger fluctuation of the former relatively to the latter, with the wider range to be evident in Ionia Nisia, followed by Notio Aigaio. By contrast, the higher correlation levels are observed in Attiki, Sterea Ellada and Kentriki Macedonia. The high correlation among those three regions may very well be explained by two facts: First the region of Attiki and Central Makedonia accommodate the two largest in population and economic activity Greek cities. Second the region of Sterea Ellada became gradually the extensive region of Attiki in terms of economic activity due to proximity to the region of Attiki and the high quality transportation infrastructure. The results justify the differences in the characteristics of the economic activity among the two groups of regions, mainland versus islands.

[FIGURE 2 HERE]

Table 5 demonstrates the results related to the *EMPS*. We note that apart from the lagged dependent variable, the *DISP_INC* and *PUB_SPEND* variables also exhibit a significant effect on *EMPS*.

[TABLE 5 HERE]

6. Further analysis

Thus far we have identified and analysed the determinants of *BCS* and *EMPS* between each Greek region and the national-wide business cycle or employment rate. In the present section we dive deeper into the drivers of synchronization by focusing, motivated by Bunyan *et al*. (2020), Gächter *et al*. (2017) and Darvas *et al*. (2005), on the bilateral relationship among all pairs of the 13 Greek regions. The opted approach overcomes the issue of computing a country-wide business cycle, which may not be representative in cases of large deviation among the regional business cycles. To do so, we use the same dataset as in Section 5, yet the determinants are in their differential form, as follows:

$$X_{i,m,t} = \left| X_{i,t} - X_{m,t} \right|, \qquad (7)$$

where, $X_{i,m,t}$ is the absolute difference between the value of each explanatory variable of regions i and m. Figure 3 presents the mean, minimum and maximum business cycle synchronization, as well as, employment synchronization among the 13 prefectures of Greece

for each year. We should also reiterate that the estimated results are performed on both dependent variables, i.e. the bilateral *BCS* and the bilateral *EMPS*. Thus, in this section the level of synchronization is estimated using eqs.1-4, yet we perform the estimations for each region-pair. Hence, eq.2 is now shown as:

$$BCS_{i,m,t} = \frac{\sigma_{i,m,t}}{\sqrt{\sigma_{i,t}^2 \sigma_{m,t}^2}}. \quad (8)$$

The results are shown in Tables 6 and 7 for the bilateral *BCS* and *EMPS*, respectively.

[FIGURE 3 HERE]

[TABLES 6 and 7 HERE]

In Table 6 we observe that the determinants which exercise a statistically significant effect on the bilateral *BCS* are not necessarily those discussed in Section 5 (see Table 2). More specifically, although *DISP_INC* is shown to be marginally significant for the bilateral *BCS*, as was in the case of Table 2, the sign of the coefficient is the opposite. This is rather unexpected as it suggests that diversion among the level of disposable income (as % of total income) is expected to promote bilateral *BCS*. This could be explained by the catch-up effect and the marginal propensity to consume or the shadow economy. It is well known that the marginal propensity to consume is higher in low income countries and regions. Also, in terms of shadow economy activity[10], there is a high probability, that the low disposable income regions, mainly agricultural dependent economic activity regions, where the public service and private companies registered labour portion is low, the margin for un-registered labour activity is high.

Furthermore, we note that other major determinants of bilateral *BCS* are the *INV* and *EMPL*. The negative effects of *INV* is expected as the higher the difference in investments between two regions increases lead to lower level of *BCS*, because regions' increased level of investments (% GVA) is expected to lead to a higher economic trajectory. By contrast, the greater the divergence in the employment rates between two regions the higher their bilateral *BCS*. This can be explained by the job spatial mobility still not very high in Greece but with an upward trend owned to a large extend to immigrants. In any case we note that, when the crisis dummie are considered, the effect of *INV* becomes marginal at best because of the negative chain impact on gross output triggered by the drop in disposable income compbined with the rise of savings.

[10] According to IOBE the black-undeclared economy in Greece accounts to 24,5% of the total GDP (IOBE, 2020).

Turning to Table 7 we can notice that the bilateral *EMPS* is determined by the status of a region as an island region (*ISL*), as well as, by *IMP*, *DISP_INC* and *PUB_SPEND*. As far as, *ISL* is concerned, we maintain that island regions tend to be experience less synchronized in their employment rates with inland regions.

Furthermore, narrower differences of *DISP_INC* and *PUB_SPEND* between two regions, tend to generate higher synchronization in their employment rates. This is rather anticipated because similarities in the size disposable income and public spending could have similar effects on regional employment. Interestingly enough, we observe that their effect remains unchanged even during the debt crisis period, given that the interaction terms of these two variables are insignificant.

7. Policy Implications

According to the panel regression results, island, distance, industrial dissimilarity index, imports, savings and disposable income exercise a significant impact on the regional GVA business cycle synchronization vis-à-vis the national reference cycle. The policy implications of the specific results can be summarized as follows:

Island regions tend to exhibit a lower synchronization vis-à-vis the national reference cycle. This is expected because, even during domestic crisis, the islands dependence, due mainly to tourism, on exports of services immune them from domestic economic cycles. To this extend state investments in tourism infrastructure (i.e., marinas) as well as state investments in marketing of the tourist product especially for those regions other than islands will extend the period of the tourist product and will bring forth other regions of the country as tourist destinations focusing on their specific endowments (i.e. religious tourism, historical tourism, spa tourism, etc.).

Turning to the results based on the inter-regional GVA business cycle synchronization, we highlight that this is driven by investments and employment. Furthermore, we report that the level of inter-regional employment synchronization is significantly affected by island economics, imports, disposable income and public spending To this direction the policy implications of the results can be summarized as follows:

An important policy implication of the results at the inter-regional level is the need for joint entrepreneurship collaboration to exploit economies of scale (e.g., the case of the Greek wine producers who are facing increased costs due to their low size, as well as, small and

fragmented ownership) which could be overcome with the effective operation of co-operatives. State policy can also encourage the cooperation activity among regions through infrastructure and joint intra regional projects.

A policy instrument that can be adopted is the marketing of local products to exploit island regions. Trade integration, particularly through intermediate input trade can exert influence on business cycle co-movements.

The role of investment as a tool for inter-regional cycle synchronization highlight the importance of the continuation of the current state policy of encouraging investment at regions through public budget and European funds. Another policy tool that can utilized is related to the exploitation of Enterprise Greece which is the official investment and trade promotion agency of the Greek State to attract regional Foreign Direct Investments (FDIs). Finally, an important tool that can be explored by the state is the reinforcement of the role of cooperative banks to increase regional investment. All the suggested policy implications will increase regional disposable income.

A key policy for regional business cycle synchronization is to re-invent cooperatives to allow them to expand and diversify their business operations. There is a need for cooperatives, especially those in the agricultural sector, to form producer associations to exploit size of scales to market their products which could support local disposable income and reduce unemployment.

8. Conclusion

The purpose of the present paper is to develop further the analysis on regional business cycles synchronization and its main drivers, focusing on Greece. The present work extends the current literature in several ways. First by adopting a robust measure of time-varying synchronization measure, using a multivariate dynamic variance – covariance model. Secondly we extend the list of determinants beyond the commonly used variables, such as trade, distance and industry dissimilarity. More specifically, we also assess the impact of determinants on business cycle synchronization, such as, regional characteristics in terms of tourist destinations, island vs non-island regions, regional savings and disposable income, as well as public spending on regions, that have not been yet considered by the related literature. Even more, our study considers both the GVA business cycle and employment synchronization vis-à-vis the national reference business cycle and national-wide employment. Finally, we also examine the

determinants of inter-regional synchronization to assess whether additional useful insights can be generated.

To do so, we have considered annual data over the period 2005-2018 for the 13 Greek regions. The set of drivers of business cycle synchronization includes tourism (*TOUR*), island (*ISL*), distance (*DIS*), industrial dissimilarity index (*IND_DISS*), imports (*IMP*), exports (*EXP*), investments (*INV*), savings (*SAV*), disposable income (*DISP_INC*) and public spending (*PUB_SPEND*). All variables are either dummy variables or monetary values that are expressed as a percentage of the regional GVA (Gross Value Added). To assess the effect of the said drivers a panel regression model including random effects is estimated.

The panel regression results suggest that island regions, as well as industrial structure, imports, savings and disposable income exercise a significant impact on the regional GVA business cycle synchronization vis-à-vis the national reference cycle. More specifically, we show that island regions deviate from the national reference cycle, suggesting that such regions tend to have materially higher GVA. Apart from the island regions, we further show that the business cycles of regions with higher dissimilarily in the industrial structure, imports, savings and disposable income also deviate from the national reference cycle.

Having analysed the baseline results based on GVA business cycles, we re-estimate our panel regression model using the employment synchronization (*UNS*), as the dependent variable. The level of synchronization between the regional and national employment rates is estimated in the same fashion as in the business cycle synchronization. The results show that regions with higher differences in disposable income and public spending tend to drive the level of synchronization.

Turning to the results based on the inter-regional GVA business cycle synchronization, we highlight that this is driven by regional investments, disposable income and employment. Furthermore, we report that the level of inter-regional employment synchronization is significantly affected by the status of regions as island economies. Finally, the inter-regional employment synchronization is also determined by the regional imports, disposable income and public spending.

Finally, it is shown that during the Greek economic crisis period (2010-2018), the impact of the aforementioned drivers in synchronization has been diminished. This can be justified by the fact that wider economic conditions during that period affected synchronization across all regions, irrespectively individual characteristics.

Our results indicate interesting directions for future research. It could indeed be important for both academics and policy makers to extend this research study with the inclusion of additional European regions by grouping them based on their characteristics (e.g., mediterranean regions). This could shield the major European institutions (e.g., European Commission) with a policy tool that generates optimal decision making processes on budget allocation across all countries and regions.

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TABLES

Table 1: List of variables used in the study.

Variable's name	Acronym	Description	Source
Regional Gross Value Added	GVA_i	Gross Value Added of each Greek region *i*, in million euros	Greek Statistical Authority & Eurostat
Greek Gross Value Added	GVA_{GR}	Gross Value Added of Greece, in million euros	Greek Statistical Authority & Eurostat
Regional employment rate	EMP_i	Employment rate of each Greek region *i*	Greek Statistical Authority
Greek employment rate	EMP_{GR}	Employment rate of Greece	Greek Statistical Authority
Distance	DIS	Distance between Athens (Attiki) and the capital city of each region, in Km	Authors' own calculation
Island region	ISL	Dummy variable that takes the value of 1 if the region is primality an island region and 0 otherwise	Authors' own calculation
Tourism region	TOUR	Dummy variable that takes the value of 1 if the region attracts a significant number of tourists and 0 otherwise	Authors' own calculation based on data from the Association of Greek Tourism Enterprises
Size of regional industrial sectors	$IND_{k,i}$	Industrial GVA for each region (Industries included: Agriculutral, Mining, Construction, Trade, Communication, Financials, Real Estate, Professional Services, Public Administration, Recreation), in million euros	Greek Statistical Authority & Eurostat
Size of Greek industrial sectors	$IND_{k,GR}$	Industrial GVA of Greece (Industries included: Agriculutral, Mining, Construction, Trade, Communication, Financials, Real Estate, Professional Services, Public Administration, Recreation), in million euros	Greek Statistical Authority & Eurostat
Industrial dissimilarity index	IND_DISS	Krugman's industrial dissimilarity index. It takes values between 0 and 1.	Authors' own calculation
Regional imports	IMP	Regional imports, as a % of regional GVA	Greek Statistical Authority & Greek Exporters Association
Regional exports	EXP	Regional exports, as a % of regional GVA	Greek Statistical Authority & Greek Exporters Association
Regional investments	INV	Regional investments, as a % of regional GVA	Greek Statistical Authority
Regional savings	SAV	Regional savings, as a % of regional GVA	Bank of Greece
Regional disposable income	DISP_INC	Regional disposable income as a % of regional total income	Eurostat
Public spending in each region	PUB_SPEND	Public spending in each region, as a % of regional GVA	Ministry of Finance

Table 2: Determinants of Business Cycle Synchronization between the Greek reference cycle and the 13 regions of Greece, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Constant	-.042	.096	-0.43	.664	-.231	.147	
LAG1_BCS	.853	.053	15.97	0	.748	.958	***
TOUR	-.008	.009	-0.95	.342	-.025	.009	
ISL	-.037	.016	-2.31	.021	-.068	-.006	**
DIS	.011	.005	2.18	.029	.001	.02	**
IND_DISS	-.168	.061	-2.73	.006	-.288	-.048	***
IMP	-.369	.161	-2.29	.022	-.685	-.054	**
EXP	.43	.321	1.34	.18	-.199	1.06	
INV	-.105	.064	-1.63	.103	-.231	.021	
SAV	.206	.077	2.68	.007	.056	.356	***
DISP_INC	-.552	.149	-3.70	0	-.844	-.259	***
PUB_SPEND	-6.715	5.973	-1.12	.261	-18.422	4.992	
EMP	2.102	1.487	1.41	.158	-.813	5.017	
Interaction terms							
EMP_D	-1.75	1.329	-1.32	.188	-4.355	.854	
IND_DISS_D	.159	.071	2.23	.026	.019	.298	**
IMP_D	.369	.161	2.29	.022	.053	.685	**
EXP_D	-.467	.31	-1.50	.133	-1.075	.142	
INV_D	-.21	.147	-1.43	.152	-.498	.078	
SAV_D	-.142	.072	-1.96	.05	-.284	0	**
DISP_INC_D	.386	.164	2.36	.018	.065	.707	**
PUB_SPEND_D	6.712	5.978	1.12	.262	-5.005	18.429	
Mean dependent var		0.938	SD dependent var			0.141	
Overall r-squared		0.904	Number of obs			156	
R-squared within		0.002	R-squared between			0.994	

**** p<.01, ** p<.05, * p<.1*

Table 3: Determinants of Business Cycle Synchronization between the Greek reference cycle and the 13 regions of Greece – EXCLUDING ISLAND REGIONS, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Constant	.719	.333	2.16	.031	.067	1.372	**
LAG1_BCS	.615	.204	3.02	.003	.216	1.014	***
TOUR	.001	.019	0.05	.960	-.037	.039	
DIS	.014	.012	1.20	.232	-.009	.038	
IND_DISS	-.015	.078	-0.19	.851	-.168	.139	
IMP	-.241	.475	-0.51	.612	-1.171	.690	
EXP	-.326	.643	-0.51	.612	-1.585	.933	
INV	-.481	.285	-1.69	.092	-1.04	.078	*
SAV	.085	.140	0.61	.544	-.189	.359	
DISP_INC	-.160	.345	-0.46	.644	-.837	.517	
PUB_SPEND	-17.452	6.756	-2.58	.010	-30.693	-4.211	***
EMP	4.574	1.841	2.48	.013	.966	8.183	**
Interaction terms							
EMP_D	-3.944	1.722	-2.29	.022	-7.32	-.568	**
IND_DISS_D	-.086	.104	-0.82	.410	-.290	.118	
IMP_D	.240	.475	0.51	.613	-.690	1.171	
EXP_D	.323	.622	0.52	.603	-.896	1.543	
INV_D	-.248	.215	-1.16	.248	-.669	.173	
SAV_D	-.033	.141	-0.23	.816	-.310	.244	
DISP_INC_D	-.06	.296	-0.20	.838	-.641	.520	
PUB_SPEND_D	17.463	6.767	2.58	.010	4.199	30.727	***
Mean dependent var		0.923	SD dependent var			0.168	
Overall r-squared		0.873	Number of obs			107	
R-squared within		0.000	R-squared between			0.977	

**** p<.01, ** p<.05, * p<.1*

Table 4: Determinants of Business Cycle Synchronization between the national reference cycle and the 13 regions of Greece – NONLINEAR DISTANCE EFFECT, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Constant	-.048	.105	-0.46	.644	-.254	.157	
LAG1_BCS	.845	.061	13.81	0	.725	.964	***
TOUR	-.005	.012	-0.44	.664	-.028	.018	
ISL	-.04	.018	-2.16	.031	-.076	-.004	**
DIS	.021	.016	1.32	.187	-.01	.051	
DIS^2	-.002	.003	-0.60	.547	-.006	.003	
IND_DISS	-.166	.061	-2.72	.006	-.286	-.047	***
IMP	-.369	.16	-2.31	.021	-.682	-.055	**
EXP	.418	.319	1.31	.189	-.206	1.043	
INV	-.115	.071	-1.62	.106	-.254	.024	
SAV	.215	.076	2.82	.005	.066	.365	***
DISP_INC	-.547	.154	-3.55	0	-.849	-.245	***
PUB_SPEND	-6.672	5.871	-1.14	.256	-18.178	4.834	
EMP	2.092	1.463	1.43	.153	-.776	4.96	
Interaction terms							
EMP_D	-1.741	1.305	-1.33	.182	-4.298	.817	
IND_DISS_D	.156	.073	2.13	.033	.012	.3	**
IMP_D	.369	.16	2.30	.021	.055	.682	**
EXP_D	-.459	.309	-1.49	.137	-1.065	.146	
INV_D	-.21	.147	-1.43	.152	-.498	.078	
SAV_D	-.142	.073	-1.95	.051	-.284	.001	*
DISP_INC_D	.385	.167	2.31	.021	.059	.712	**
PUB_SPEND_D	6.669	5.877	1.13	.256	-4.85	18.189	
Mean dependent var		0.938	SD dependent var			0.141	
Overall r-squared		0.904	Number of obs			156	
R-squared within		0.002	R-squared between			0.994	

**** p<.01, ** p<.05, * p<.1*

Table 5: Determinants of Employment Synchronization between the national reference cycle and the 13 regions of Greece, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Constant	.372	.178	2.09	.037	.023	.722	**
LAG1_EMPS	.629	.154	4.09	.000	.328	.931	***
TOUR	-.013	.012	-1.02	.306	-.037	.012	
ISL	-.041	.034	-1.22	.221	-.108	.025	
DIS	-.002	.004	-0.41	.683	-.009	.006	
IND_DISS	-.077	.068	-1.13	.257	-.211	.056	
IMP	.153	.112	1.37	.172	-.066	.372	
EXP	-.109	.264	-0.41	.680	-.626	.408	
INV	.097	.099	0.98	.328	-.097	.291	
SAV	-.017	.049	-0.34	.736	-.113	.080	
DISP_INC	.178	.081	2.20	.028	.020	.336	**
PUB_SPEND	-.673	.297	-2.27	.023	-1.255	-.091	**
Interaction terms							
IND_DISS_D	-.022	.050	-0.44	.662	-.120	.076	
IMP_D	-.153	.112	-1.37	.171	-.373	.066	
EXP_D	.111	.270	0.41	.680	-.417	.640	
INV_D	.042	.110	0.38	.701	-.173	.257	
SAV_D	.072	.051	1.40	.160	-.029	.173	
DISP_INC_D	-.228	.109	-2.08	.037	-.443	-.014	**
PUB_SPEND_D	.663	.301	2.21	.027	.074	1.252	**
Mean dependent var		0.910	SD dependent var			0.114	
Overall r-squared		0.885	Number of obs			156	
R-squared within		0.008	R-squared between			0.976	

**** p<.01, ** p<.05, * p<.1*

Table 6: Determinants of bilateral Business Cycle Synchronization of the 13 regions of Greece, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Constant	-.247	.107	-2.30	.022	-.457	-.036	**
LAG1_BCS	.826	.042	19.68	.000	.743	.908	***
TOUR	.003	.008	0.37	.713	-.013	.020	
ISL	.013	.01	1.28	.202	-.007	.033	
DIS	.000	.000	0.54	.589	.000	.000	
IND_DISS	-.048	.046	-1.05	.292	-.138	.042	
IMP	.026	.026	1.01	.311	-.024	.077	
EXP	.101	.084	1.20	.230	-.064	.266	
INV	-.261	.043	-6.11	.000	-.345	-.177	***
SAV	-.003	.032	-0.08	.936	-.066	.061	
DISP_INC	.118	.064	1.84	.066	-.008	.243	*
PUB_SPEND	.001	.001	0.82	.411	-.001	.004	
EMP	.409	.125	3.27	.001	.164	.654	***
Interaction terms							
EMP_D	-.013	.01	-1.30	.195	-.034	.007	
IND_DISS_D	.027	.037	0.73	.467	-.046	.099	
IMP_D	-.026	.026	-1.01	.312	-.076	.024	
EXP_D	-.071	.075	-0.94	.349	-.218	.077	
INV_D	.237	.037	6.35	0	.164	.31	***
SAV_D	.009	.026	0.33	.744	-.043	.06	
DISP_INC_D	-.024	.064	-0.38	.705	-.15	.101	
PUB_SPEND_D	-	-	-	-	-	-	
Mean dependent var		0.872	SD dependent var			0.213	
Overall r-squared		0.956	Number of obs			1091	
R-squared within		0.055	R-squared between			0.995	

**** p<.01, ** p<.05, * p<.1*

Note: There is no estimated coefficient for *PUB_SPEND_D* as it is highly correlated with *PUB_SPEND*. $PUB\_SPEND_{i,m,t} = \left|PUB\_SPEND_{i,t} - PUB\_SPEND_{m,t}\right|$ in the pre-crisis period is almost zero for most region-pairs, suggesting that there were receiving similar support from the central government. Different levels of public spending is observed in the post-2009 period. Hence, the *PUB_SPEND* is essentially the same variable with *PUB_SPEND_D*, which takes a zero (0) value in pre-crisis period and *PUB_SPEND* during the crisis period. Thus, we exclude *PUB_SPEND_D* from the estimation.

Table 7: Determinants of bilateral Employment Synchronization of the 13 regions of Greece, 2005-2018.

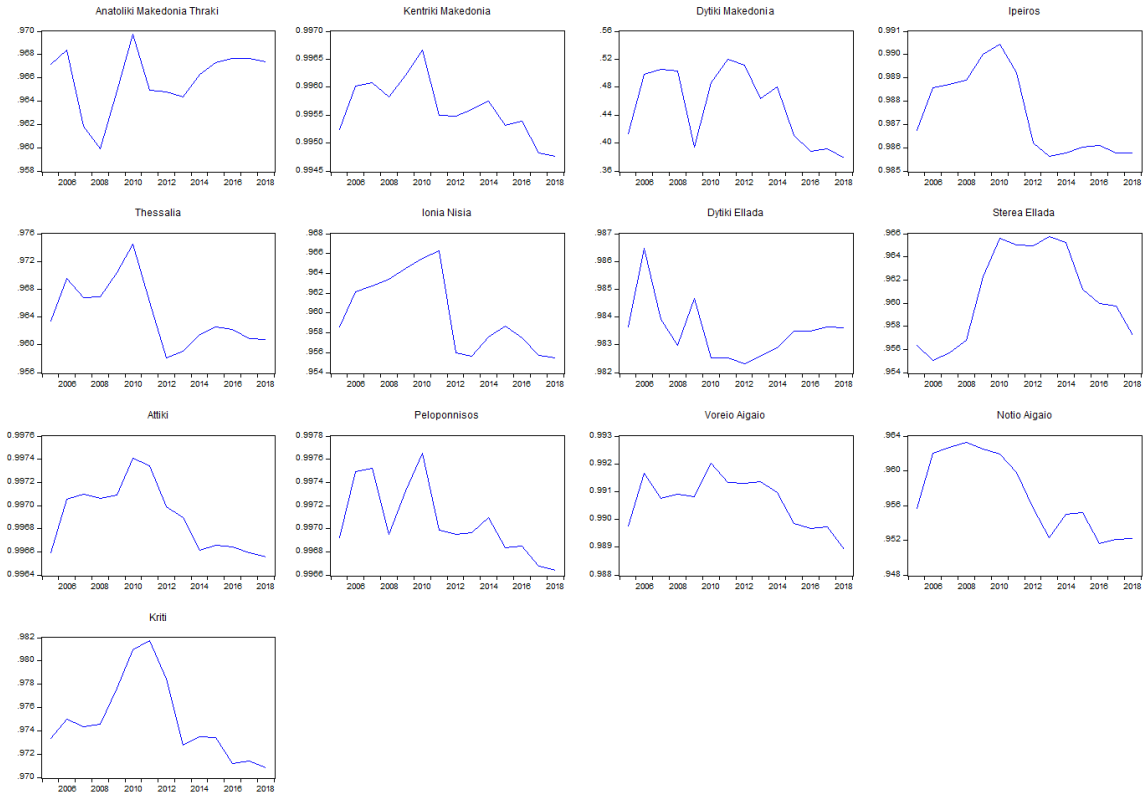
	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Constant	.376	.048	7.87	.000	.283	.470	***
LAG1_EMPS	.612	.049	12.38	.000	.515	.709	***
TOUR	.004	.002	1.57	.117	-.001	.008	
ISL	-.030	.005	-5.95	.000	-.040	-.020	***
DIS	.000	.000	1.46	.144	.000	.000	
IND_DISS	-.012	.008	-1.41	.159	-.029	.005	
IMP	.021	.008	2.66	.008	.005	.036	***
EXP	.002	.028	0.06	.956	-.054	.057	
INV	-.010	.010	-0.97	.333	-.031	.010	
SAV	.007	.012	0.61	.539	-.016	.031	
DISP_INC	-.033	.010	-3.36	.001	-.052	-.014	***
PUB_SPEND	-.002	.001	-2.90	.004	-.004	-.001	***
Interaction terms							
IND_DISS_D	.007	.006	1.26	.207	-.004	.018	
IMP_D	-.021	.008	-2.66	.008	-.036	-.005	***
EXP_D	-.006	.024	-0.26	.791	-.054	.041	
INV_D	-.002	.014	-0.14	.887	-.029	.025	
SAV_D	-.003	.009	-0.39	.695	-.020	.013	
DISP_INC_D	.009	.018	0.49	.622	-.027	.045	
PUB_SPEND_D	-	-	-	-	-	-	
Mean dependent var		0.941	SD dependent var			0.044	
Overall r-squared		0.849	Number of obs			1091	
R-squared within		0.052	R-squared between			0.936	

*** $p<.01$, ** $p<.05$, * $p<.1$

Note: There is no estimated coefficient for *PUB_SPEND_D* as it is highly correlated with *PUB_SPEND*. $PUB\_SPEND_{i,m,t} = \left|PUB\_SPEND_{i,t} - PUB\_SPEND_{m,t}\right|$ in the pre-crisis period is almost zero for most region-pairs, suggesting that there were receiving similar support from the central government. Different levels of public spending is observed in the post-2009 period. Hence, the *PUB_SPEND* is essentially the same variable with *PUB_SPEND_D*, which takes a zero (0) value in pre-crisis period and *PUB_SPEND* during the crisis period. Thus, we exclude *PUB_SPEND_D* from the estimation.

FIGURES

Figure 1: Business Cycle Synchronization between the national reference cycle and the 13 prefectures of Greece, 2005-2018.



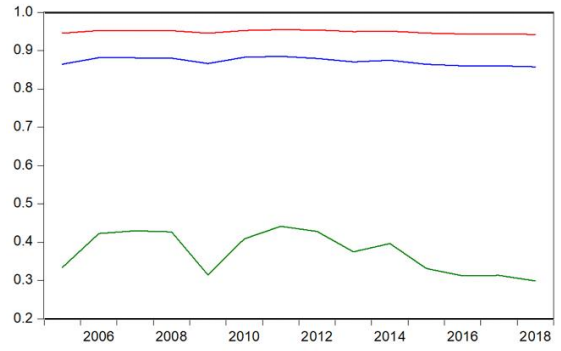
Note: The figure shows the time-varying business cycle synchronization as it was estimated by eqs.1-4.

Figure 2: Employment Synchronization between the national reference cycle and the 13 prefectures of Greece, 2005-2018.

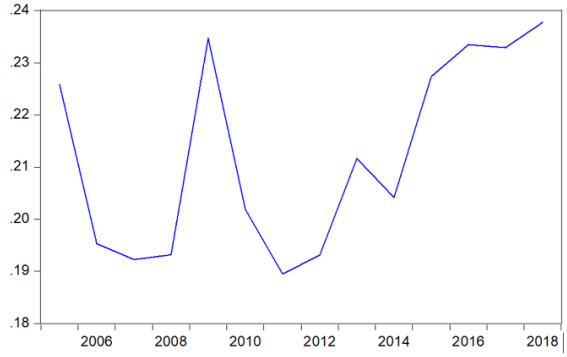
Note: The figure shows the time-varying employment synchronization as it was estimated by eqs.1-4.

Figure 3: Bilateral Business Cycle and Employment Synchronization for the 13 prefectures of Greece, 2005-2018.

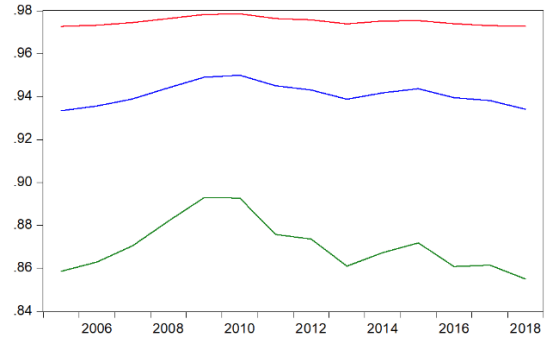
Average, minimum, maximum bilateral business cycle synchronization per year



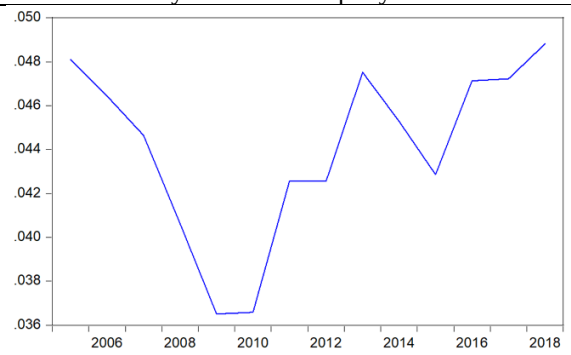
Standard deviation of all bilateral business cycle synchronization per year



Average, minimum, maximum bilateral employment synchronization per year



Standard deviation of all bilateral employment synchronization per year



Note: In the top (bottom) left panel the figure depicts the mean (blue line), minimum (green line) and maximum (red line) business cycle (employment) synchronization of all bilateral business cycles (employment rates) among the 13 prefectures of Greece for each year during the sample period 2005-2018. In the top (bottom) right panel the figure depicts the standard deviations of all bilateral business cycle (employment rates) synchronization among the 13 prefectures of Greece for each year during the sample period 2005-2018.

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