The intra-regional business cycles synchronization in Greece

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Abstract

At this part of the project, we assess the determinants of the bilateral business cycles synchronization among the Greek regions using NUTSII annual data for the period 2005-2018. 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 typical drivers of regional synchronization, as were suggested by the related literature, do not seem to play a significant role in the case of Greece (i.e. industrial structure, level of exports and public spending). It is found that investments, disposal income and unemployment rate are the statistically significant determinants that impact the bilateral business cycle synchronization. Regarding unemployment rate synchronisation, the statistically significant explanatory variables of it are the status of the region (e.g., island, tourism-focused), as well as, disposal income and public spending. One policy suggestion is that in order for Greece to achieve synchronization in the regional business cycles it should promote policies that target to align the unemployment levels and investment activity among the 13 regions.

Keywords: Business Cycle, Synchronization, Dynamic correlation, regional analysis

JEL Classifications: E32, F44.

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, given that the latter is 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 most 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) was the first study to assess regional business cycle synchronization focusing on 73 NUTSII EU regions, 47 US regions, 10 Canadian provinces and 47 Japanese prefectures, showing an increased level of convergence over time among regions. Subsequently, studies, Rodríguez-Pose and Fratesi (2007), using NUTSII data for EU countries, examined how 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 did over several decades; (ii) Ile de France is the region acting as the main channel for the transmission of business cycle shocks in Europe; followed by Inner London and Lombardi; and (iii) they identified a nonlinear relationship between sectoral composition and regional synchronization, which was amplified in the wake of the Great Recession. Camacho *et al*. (2017) results are at par with those by Gadea *et al*. (2017). Their findings, focus on 17 NUTSII regions for Spain, and 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.

Although it is rather more common for studies to use NUTSII data for the examination of regional business cycles synchronization, there are studies that focus on 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) showing, on one hand, that synchronization has increased over time and, on the other hand there seems to exist a national border effect.

The present study develops further the inquiry on Greek regional business cycles synchronization and its main drivers. There is only one other published work, Panteladis and Tsiapa (2014), on the regional business cycles synchronization for Greece. 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.

Our work extends the current literature in several ways. First, we use a robust of time-varying synchronization measure, using a multivariate GARCH model in the same fashion with Degiannakis *et al*. (2014, 2016). Second, we consider, beyond trade intensity, industry similarity, distance to be prominent drivers of synchronization, and other important determinants, 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,

not been considered till now by the related literature.

The rest of the paper is organized as follows. Section 2 describes the data that are 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

Our 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 among the business cycles of the 13 regions bilaterally, see Table 1.

[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 GVA, using the Hodrick-Prescott filter. Next, we use this cyclical component to estimate the time-varying business cycle synchronization between region *i* and *j*.

We define as $\boldsymbol{y}_t = (y_{i,t}, \quad y_{j,t})'$ the bivariate vector where $y_{i,t}$ and $y_{j,t}$, $i = 1, \dots, 13$, are the business cycle of region i and j 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 regions *i* and *j* is the dynamic correlation coefficient which is estimated as:

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

where $\sigma_{i,t}^2$ and $\sigma_{j,t}^2$ are the diagonal elements of $\boldsymbol{H}_t$, and $\sigma_{i,j,t}$ 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:

$$\begin{gathered} \begin{pmatrix} y_{i,t} \\ y_{j,t} \end{pmatrix} = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} + \begin{pmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \end{pmatrix} \\ (\varepsilon_{1,t} \quad \varepsilon_{2,t} \quad \cdot \quad \cdot \quad \cdot \quad \varepsilon_{15,t})' = \boldsymbol{H}_t^{1/2} (z_{1,t} \quad z_{2,t} \quad \cdot \quad \cdot \quad \cdot \quad z_{15,t})' \\ (z_{i,t} \quad z_{j,t})' \sim N(\boldsymbol{0}, \boldsymbol{I}) \\ \boldsymbol{H}_t = \begin{pmatrix} \sigma_{i,t}^2 & \sigma_{i,j,t} \\ \sigma_{i,j,t} & \sigma_{j,t}^2 \end{pmatrix} = (1-\lambda) \begin{pmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \end{pmatrix} (\varepsilon_{i,t} \quad \varepsilon_{j,t})' + \lambda \boldsymbol{H}_{t-1}. \end{gathered} \tag{4}$$

The *BCS* between the regional cycles is shown in Figure 1.

[FIGURE 1 HERE]

Figure 1 presents the mean, minimum and maximum business cycle synchronization as well as unemployment synchronization for all the 13 prefectures of Greece for each year. For the relevant visualization at a regional level, Figure 2 and 3 are used, which show the bilateral business cycle synchronization as well as unemployment synchronization for each of the 13 Greek regions, respectively.

[FIGURE 2 HERE]

[FIGURE 3 HERE]

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*) and public spending (*PUB_SPEND*), which are either dummy variables or monetary values expressed as a percentage of the regional GVA.

The *IND_DISS* that has been constructed by the authors. More specifically, we used the Krugman's industrial dissimilarity index (Krugman, 1991), which captures the level of industrial specialization between two regions. The index has been constructed as:

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

where, $S_{k,i,t}$ denotes the share of industry (*IND*) *k* in region's *i* GVA, in year *t* and $S_{k,j,t}$ is the share of industry (*IND*) *k* in year *t* for the region's *j* 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 research project. 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 bilaterally. To do so, a panel regression model of the following form is estimated:

$$BCS_{i,j,t} = \beta_0 + \alpha BCS_{i,j,t-1} + \sum_{j=1}^{M} \boldsymbol{\beta_j} \boldsymbol{X}_{i,t}^{(j)} + u_{i,t} + \varepsilon_{i,t}, \quad (6)$$

where, $BCS_{i,j,t}$ denotes the level of business cycle synchronization in year *t*, $\boldsymbol{X}_{i,t}^{(j)}$ is the vector of explanatory variables (M=11), $u_{i,t}$ is the between-region error and $\varepsilon_{i,t}$ is the within-region error. The α is the coefficient of the lagged dependent variable and $\boldsymbol{\beta_j}$ denotes the vector of coefficients of the explanatory variables that need to be estimated.

The panel regression includes random effects[5], which means that the variation across regions is 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

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

model. It is also noted that the standard errors of the panel regression are robust. We shall mention 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*) and public spending (*PUB_SPEND*).

5. Empirical analysis

In the present section we examine 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.

The results are shown in Tables 2 and 3 for the bilateral *BCS* and UNS, respectively.

[TABLES 2 HERE]

[TABLES 3 HERE]

In Table 2 we observe that *INV*, *DISP_INC* and *UNEMP* are the statistically significant determinants that impact the bilateral *BCS*. It is observed that the effects of *INV* and *UNEMP* are negative. In particular, when the difference in investments (or unemployment) between two regions increases, then their level of *BCS* tends to become lower. We also observe that in order for Greece to achieve synchronization in the regional business cycles it should promote policies that target to align the unemployment levels and investment activity among the 13 regions. The positive effect of *DISP_INC* is rather unanticipated, as it suggests that higher difference in the change of the disposable income between two regions leads to greater synchronization. This may be explained by the catch-up effect and the marginal propensity to consume or the hidden black economy. It is well known that the marginal propensity to consume is higher in low income countries and regions. Also, in terms of black economy activity[6], 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.

Turning to Table 3 we can notice that the bilateral *UNS* is determined by the status of a region as an island region (*ISL*), as well as, by *TOUR*, *DISP_INC* and *PUB_SPEND*. As far

[6] According to IOBE the black-undeclared economy in Greece accounts to 27% of the total GDP.

as, ISL is concerned, we maintain that island regions tend to be experience more synchronized unemployment rates. Similarly, narrower gaps of *DISP_INC* and *PUB_SPEND* between two regions, tend to generate higher synchronization in their unemployment rates. This is rather anticipated as similarities in disposable income and public spending could yield similar reactions in regional GVA. Contrary to our expectations, TOUR shows a positive effect, suggesting that there is higher level of synchronization between a tourist and a non-tourist region, as opposed to two tourist regions or two non-tourist regions. This may very well be explained by the fact, that tourism creates direct and indirect economic effects across all domestic regions: First, most of the employed seasonally labour force in the tourist regions are coming from non-tourist regions, which at out of tourist season periods return consume at the non-tourist regions. Second most of the inputs, agricultural and non-agricultural products consumed by the tourist regions are produced in non-tourist regions. Third, a range of services, such as transportation, etc. are registered in non-tourist regions. To sum up the tourist regions activity create a multidimensional derived demand and economic activity for non-tourist regions.

6. Conclusion

The purpose of the present paper was to develop further the inquiry on regional business cycles synchronization and its main drivers, focusing on Greece. The present work extends the current literature in several ways: by using a robust measure of time-varying synchronization measure, using a multivariate GARCH model and by considering, not only the most frequently identified drivers of synchronization (trade intensity, industry similarity, distance), also important other determinants that have not been considered by the related literature (regional characteristics in terms of tourist destinations, island vs non-island regions, regional savings and disposable income, as well as public spending on regions).

The used data are expressed in annual frequency over the period 2005-2018 for the 13 Greek regions. The set of examined drivers of business cycle synchronization and unemployment rate 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 drivers of business cycle synchronization, it was first extracted the cyclical component of the regional GVA. The cyclical component is extracted using the Hodrick-Prescott filter. Subsequently, we used this cyclical component to estimate the time-varying business cycle synchronization between region *i* and *j*. The methodology adopted was a panel regression model. The panel regression included random effects, which means that the variation across regions was 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.

The panel regression results, based on the model specification, where *BCS* is the dependent variable, show that *INV*, *DISP_INC* and *UNEMP* are the statistically significant determinants that impact the bilateral *BCS*. Regarding the bilateral *UNS*, it is determined by the status of a region as an island region (*ISL*), as well as, by *TOUR*, *DISP_INC* and *PUB_SPEND*. Typical drivers of regional synchronization, as were suggested by the related literature, do not seem to play a significant role in the case of Greece. In particular, the industrial structure and the level of exports are not among the significant determinants of synchronization. Even more, contrary to our expectations, TOUR shows a positive effect, suggesting that there is higher level of synchronization between a tourist and a non-tourist region, as opposed to two tourist regions or two non-tourist regions. This may very well be explained by the fact, that tourism creates direct and indirect economic effects across all domestic 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
Regional unemployment rate	UN_i	Unemployment rate of each Greek region *i*	Greek Statistical Authority
Distance	DIS	Distance between Athens 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
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 bilateral Business Cycle Synchronization of the 13 regions of Greece, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
LAG1_BCS	0.833	0.040	20.96	0.000	0.755	0.911	***
TOUR	0.003	0.008	0.38	0.701	-0.012	0.018	
ISL	0.011	0.009	1.20	0.230	-0.007	0.029	
DIS	0.000	0.000	0.44	0.663	0.000	0.000	
IND_DISS	-0.024	0.023	-1.06	0.288	-0.069	0.021	
IMP	0.000	0.000	0.37	0.708	0.000	0.000	
EXP	0.017	0.014	1.28	0.199	-0.009	0.044	
INV	-0.180	0.033	-5.43	0.000	-0.245	-0.115	***
SAV	0.011	0.023	0.49	0.625	-0.033	0.055	
DISP_INC	0.118	0.063	1.87	0.061	-0.005	0.241	*
PUB_SPEND	0.001	0.002	0.72	0.470	-0.002	0.005	
UNEMP	-0.401	0.106	-3.79	0.000	-0.608	-0.193	***
Constant	0.152	0.037	4.07	0.000	0.079	0.225	***

Mean dependent var	0.872	SD dependent var	0.213
Overall r-squared	0.955	Number of obs	1091
Chi-square	2322.051	Prob > chi2	0.000
R-squared within	0.036	R-squared between	0.996

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

Table 3: Determinants of bilateral Unemployment Synchronization of the 13 regions of Greece, 2005-2018.

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
LAG1_UNS	0.595	0.050	11.79	0.000	0.496	0.694	***
TOUR	0.005	0.002	1.92	0.055	0.000	0.009	*
ISL	-0.032	0.005	-6.16	0.000	-0.042	-0.022	***
DIS	0.000	0.000	1.43	0.154	0.000	0.000	
IND_DISS	-0.007	0.007	-1.08	0.281	-0.021	0.006	
IMP	-0.000	0.000	-0.93	0.352	-0.000	0.000	
EXP	-0.007	0.005	-1.32	0.186	-0.017	0.003	
INV	-0.007	0.010	-0.67	0.502	-0.027	0.013	
SAV	0.008	0.012	0.68	0.495	-0.015	0.031	
DISP_INC	-0.032	0.009	-3.61	0.000	-0.050	-0.015	***
PUB_SPEND	-0.003	0.001	-3.52	0.000	-0.005	-0.001	***
Constant	0.394	0.049	8.08	0.000	0.298	0.489	***

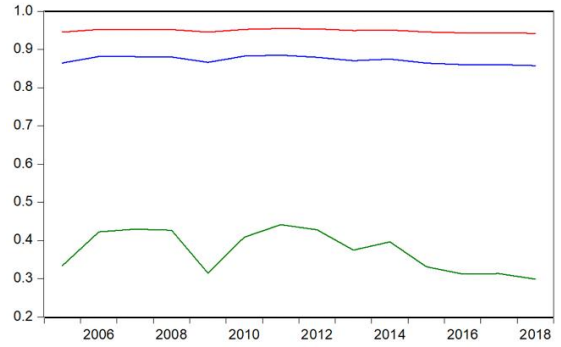
Mean dependent var	0.941	SD dependent var	0.044
Overall r-squared	0.843	Number of obs	1091
Chi-square	1628.649	Prob > chi2	0.000
R-squared within	0.053	R-squared between	0.927

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

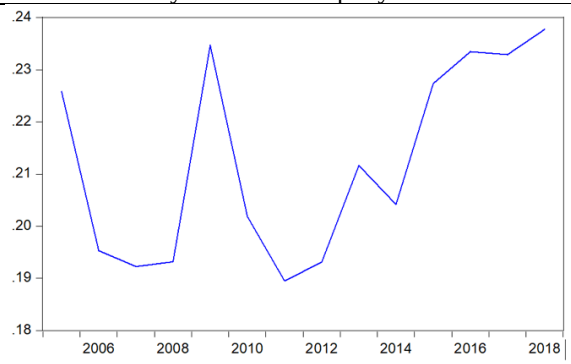
FIGURES

Figure 1: Bilateral Business Cycle and Unemployment Synchronization for the 13 prefectures of Greece, 2005-2018.

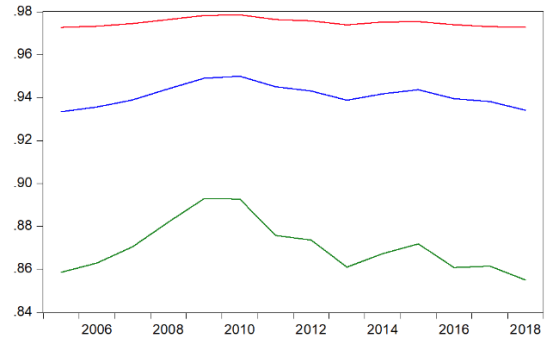
Average, minimum, maximum bilateral business cycle synchronization per year



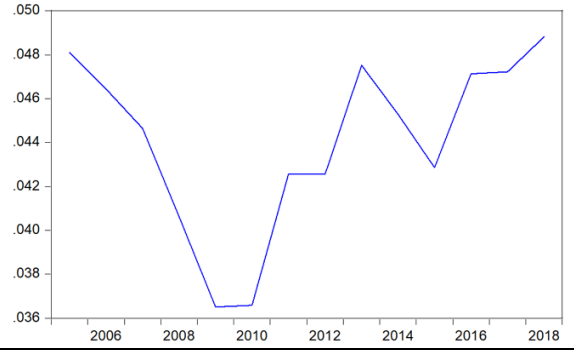
Standard deviation of all bilateral business cycle synchronization per year



Average, minimum, maximum bilateral unemployment synchronization per year

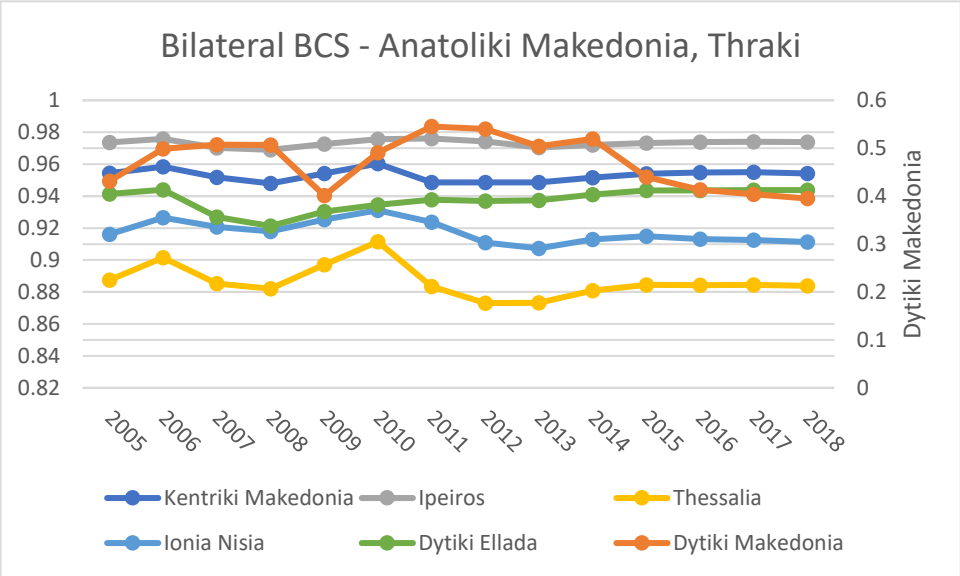


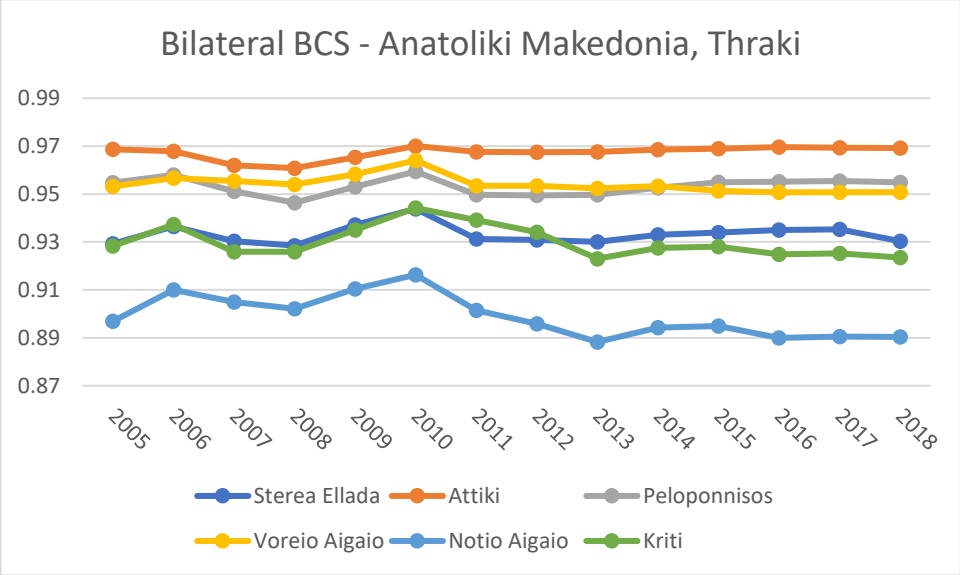
Standard deviation of all bilateral unemployment synchronization per year

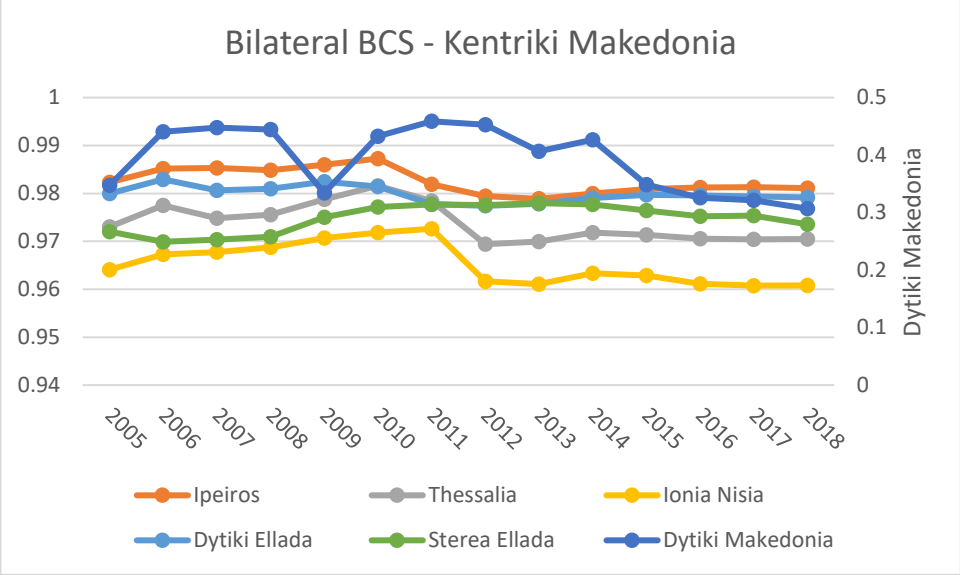


Note: In the top (bottom) left panel the figure depicts the mean (blue line), minimum (green line) and maximum (red line) business cycle (unemployment) synchronization of all bilateral business cycles (unemployment rates) among the 13 prefectures of Greece for each year during the sample period 2005-2018.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

Figure 2: Bilateral Business Cycle Synchronization for the 13 prefectures of Greece, 2005-2018.






Bilateral BCS - Kentriki Makedonia
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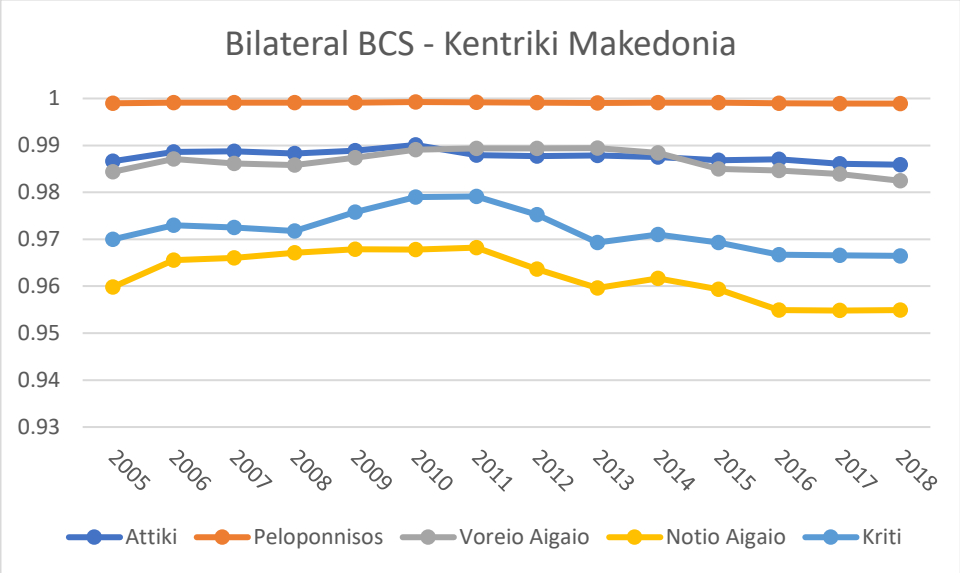
Thessalia
Ionia Nisia
Dytiki Ellada
Sterea Ellada
Dytiki Makedonia


Bilateral BCS - Kentriki Makedonia
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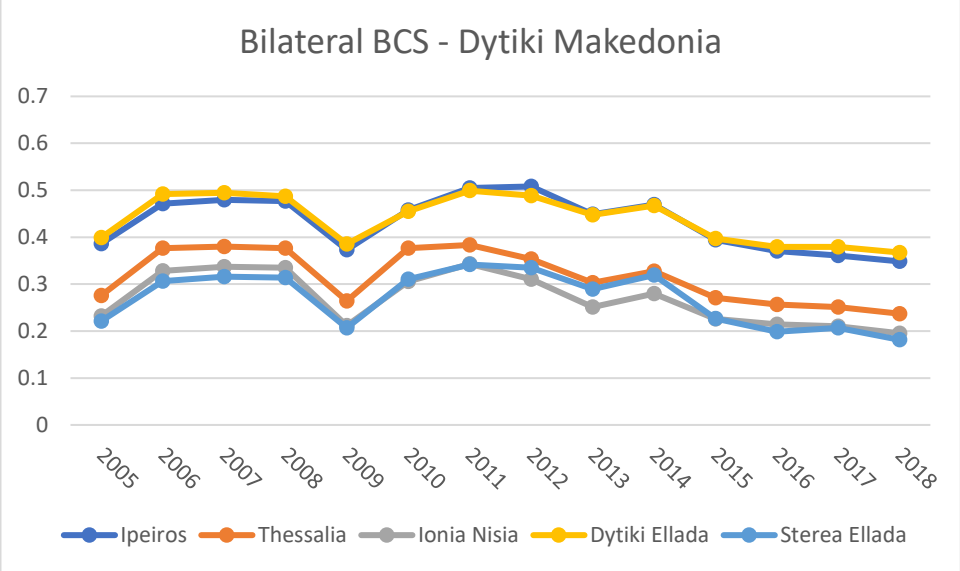
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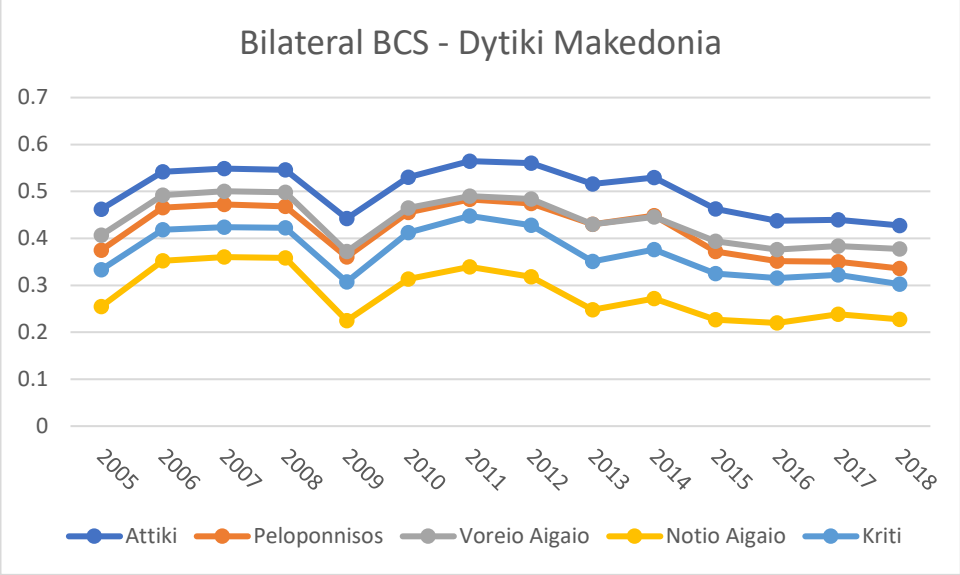
Bilateral BCS - Dytiki Makedonia
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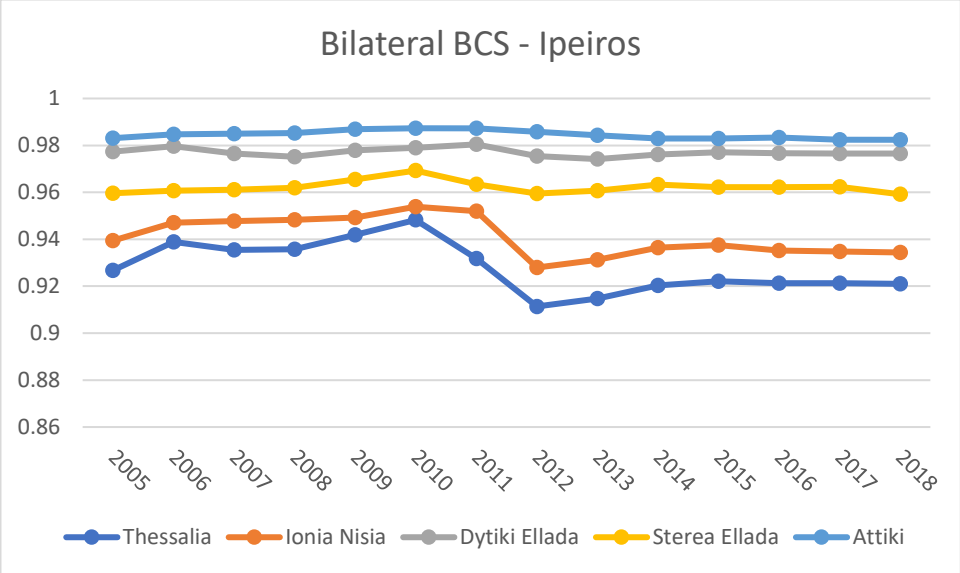
Bilateral BCS - Ipeiros
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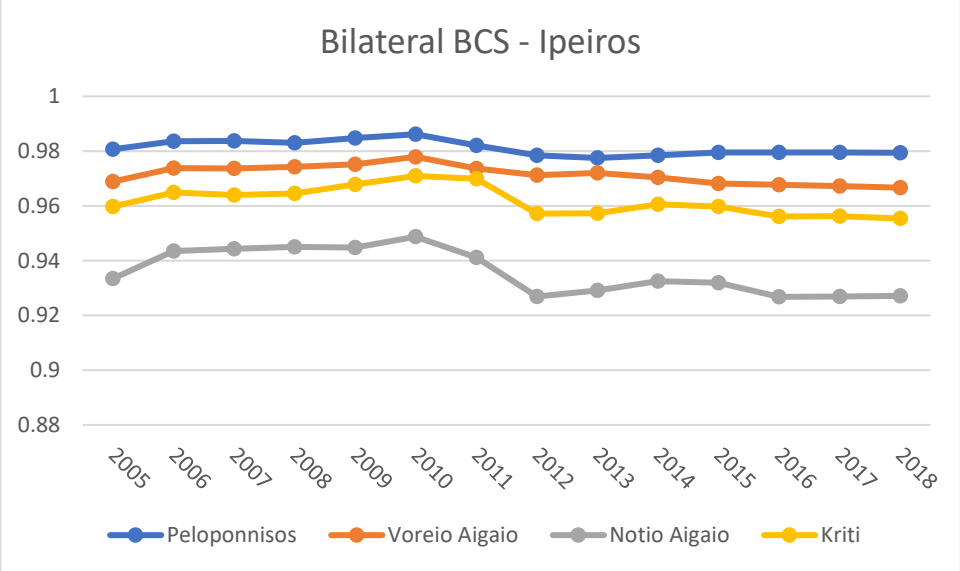
Bilateral BCS - Ipeiros
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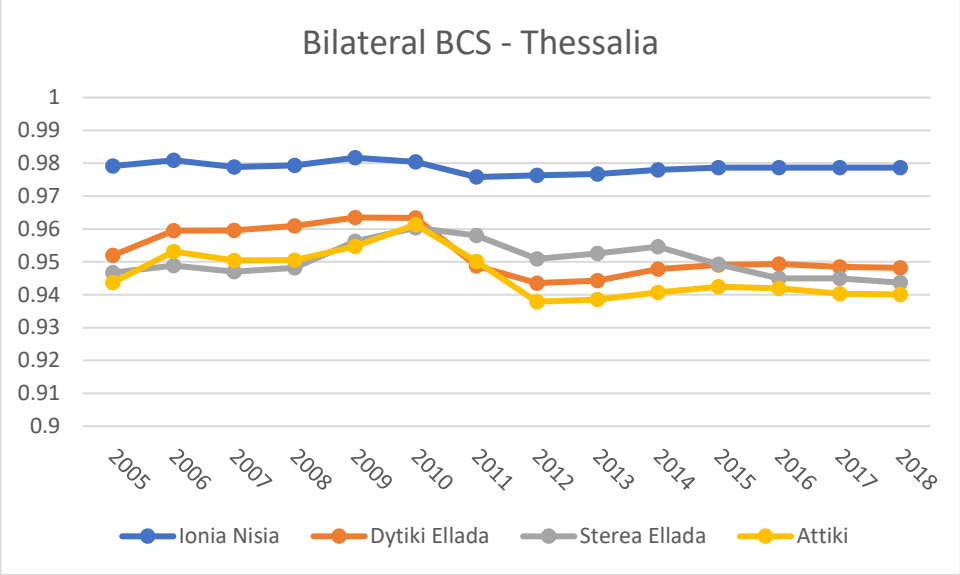
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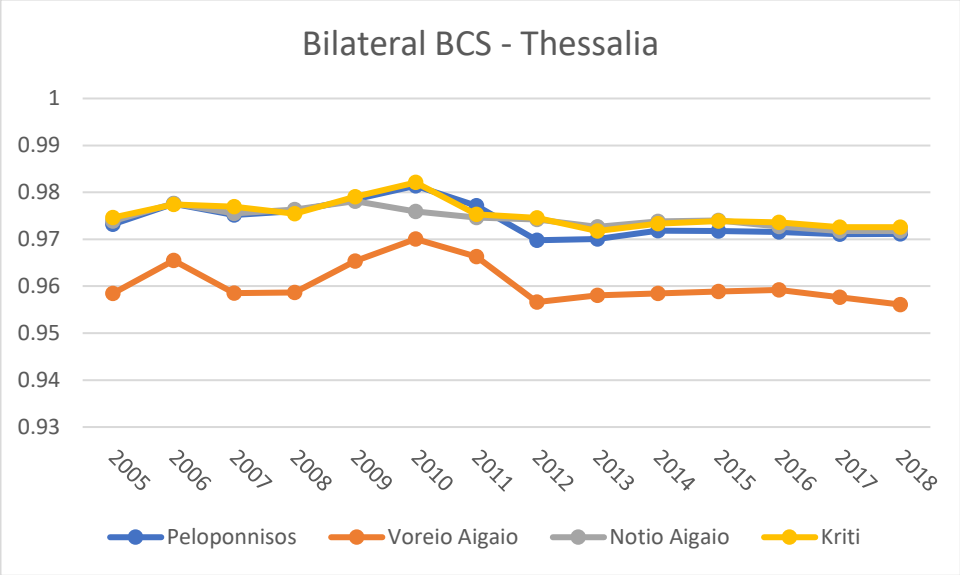
Bilateral BCS - Thessalia
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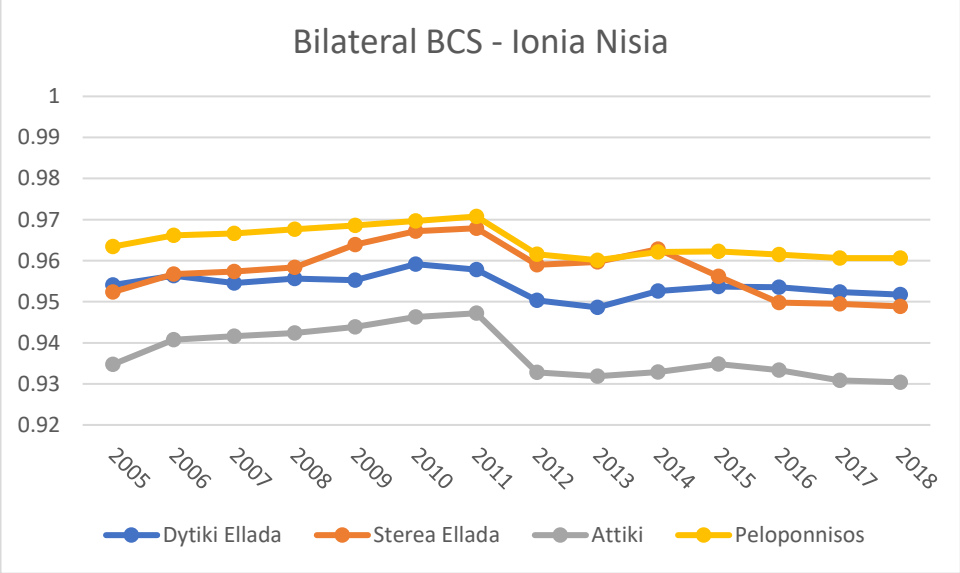
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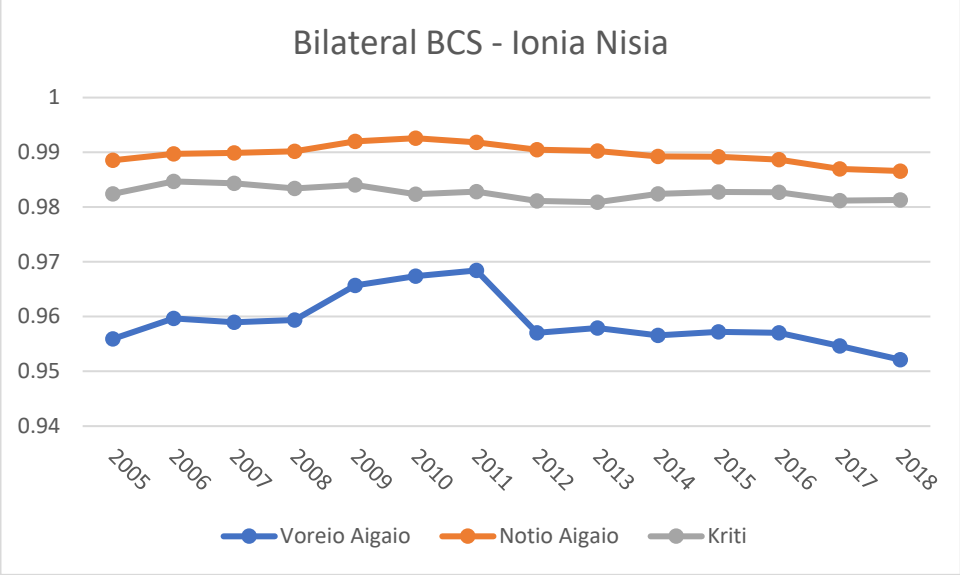
Bilateral BCS - Ionia Nisia
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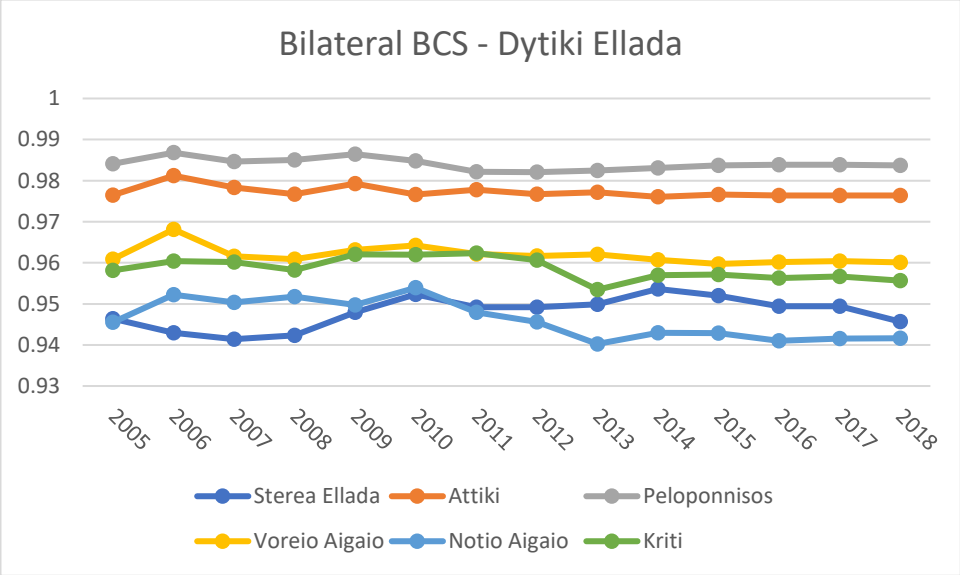
Bilateral BCS - Dytiki Ellada
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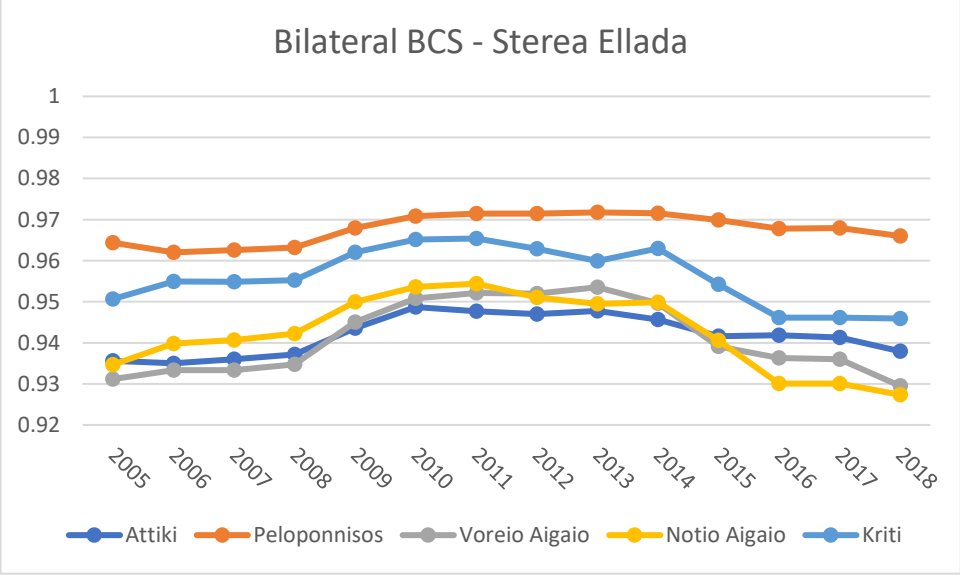
Bilateral BCS - Sterea Ellada
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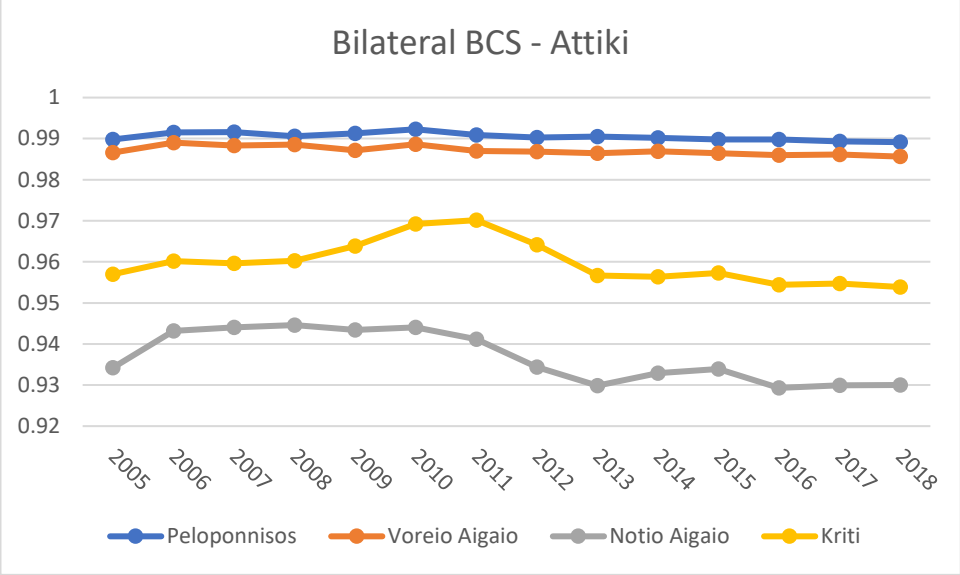
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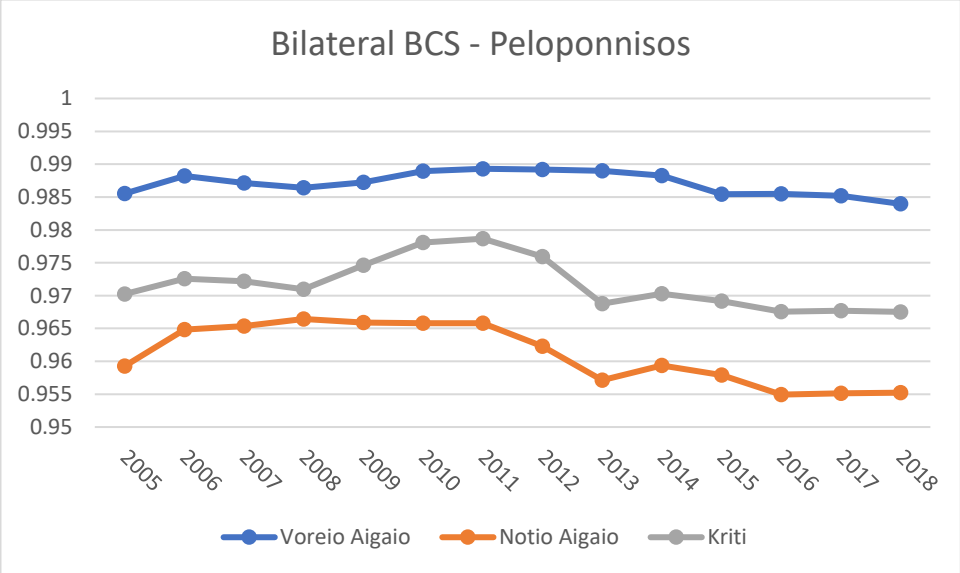
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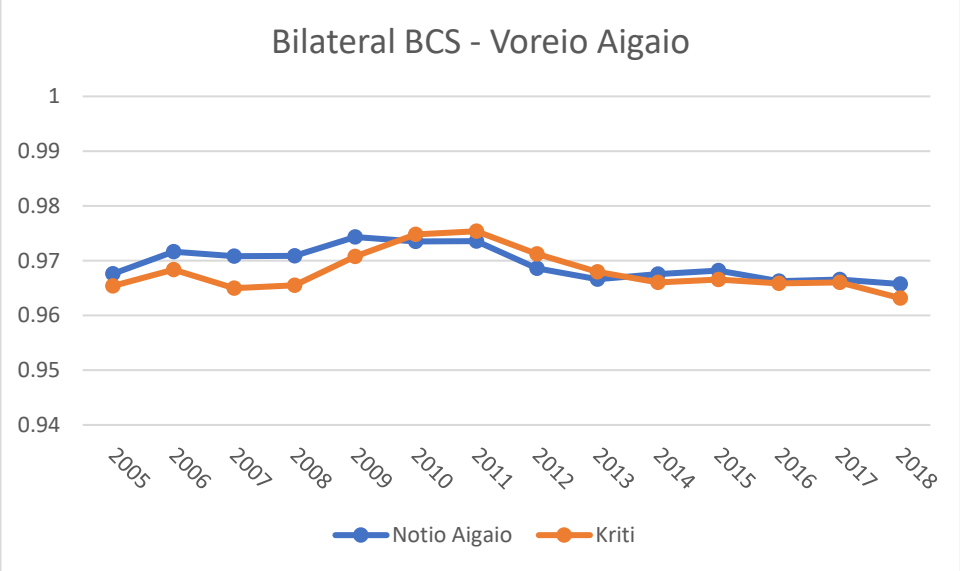
Bilateral BCS - Voreio Aigaio
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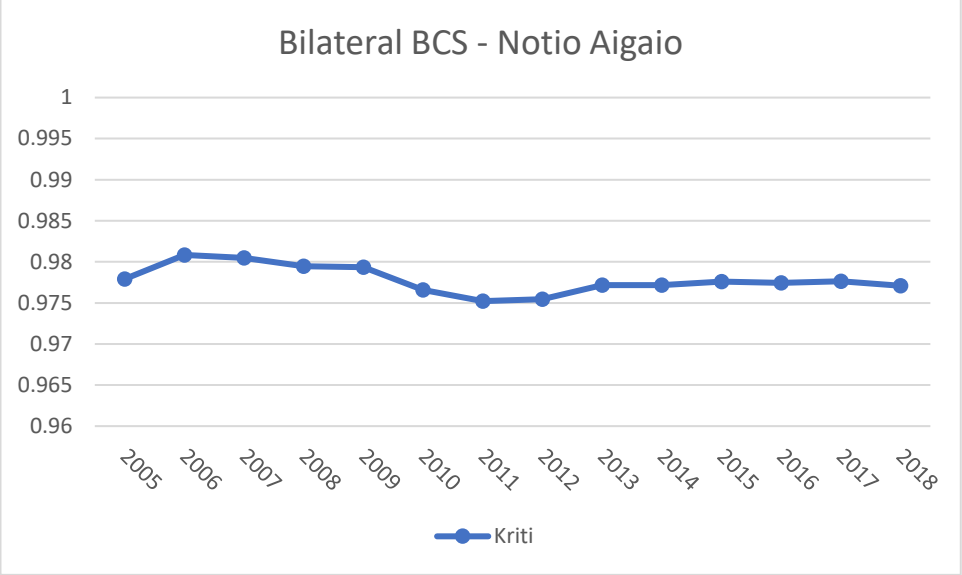
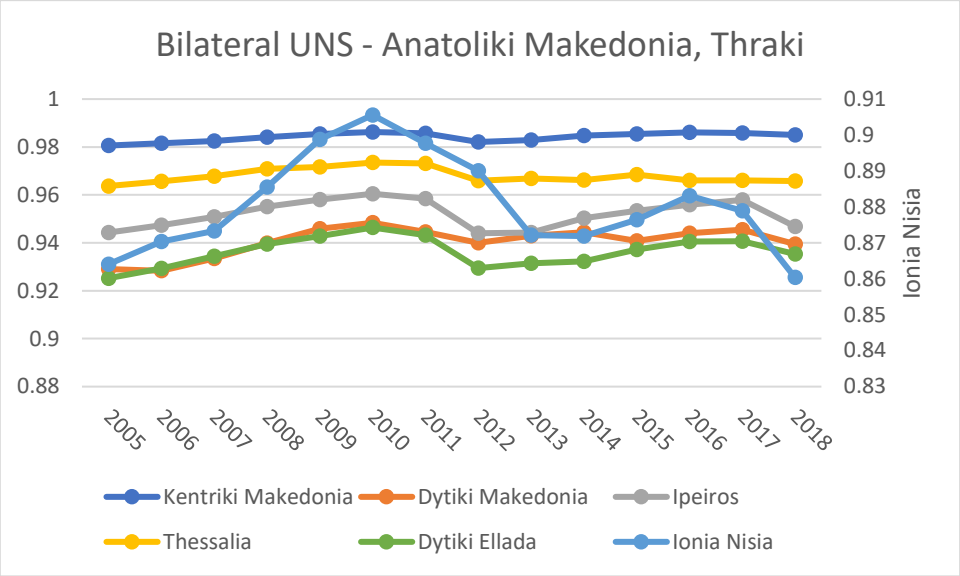
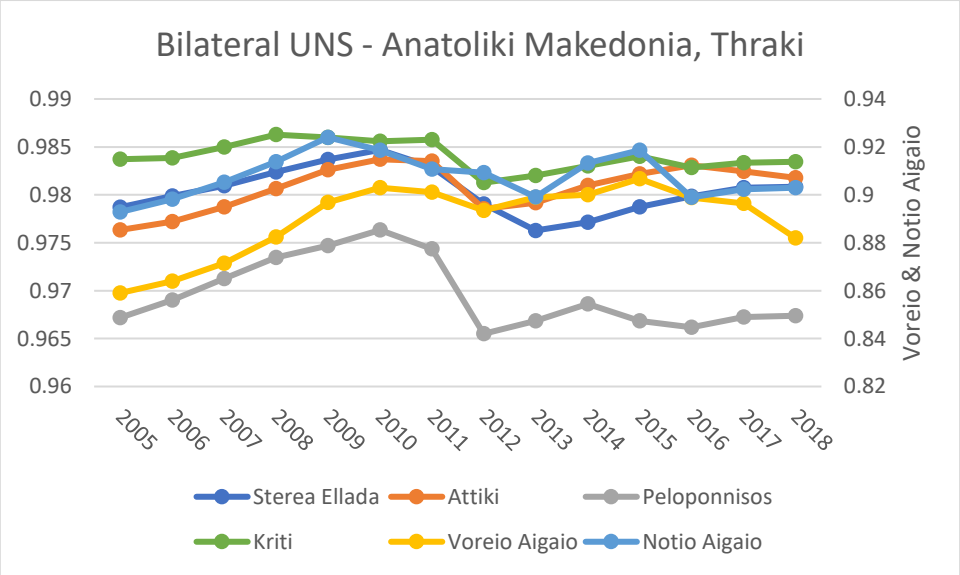
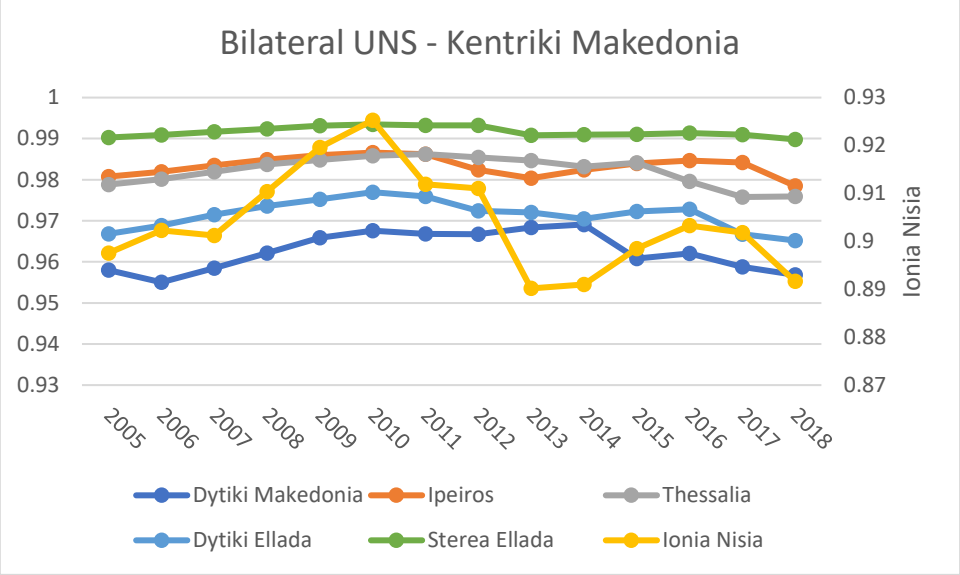


Note: The figure depicts the business cycle synchronization of all bilateral business cycles of each of the 13 prefectures of Greece for each year during the sample period 2005-2018.

Figure 3: Bilateral Unemployment Synchronization for the 13 prefectures of Greece, 2005-2018.



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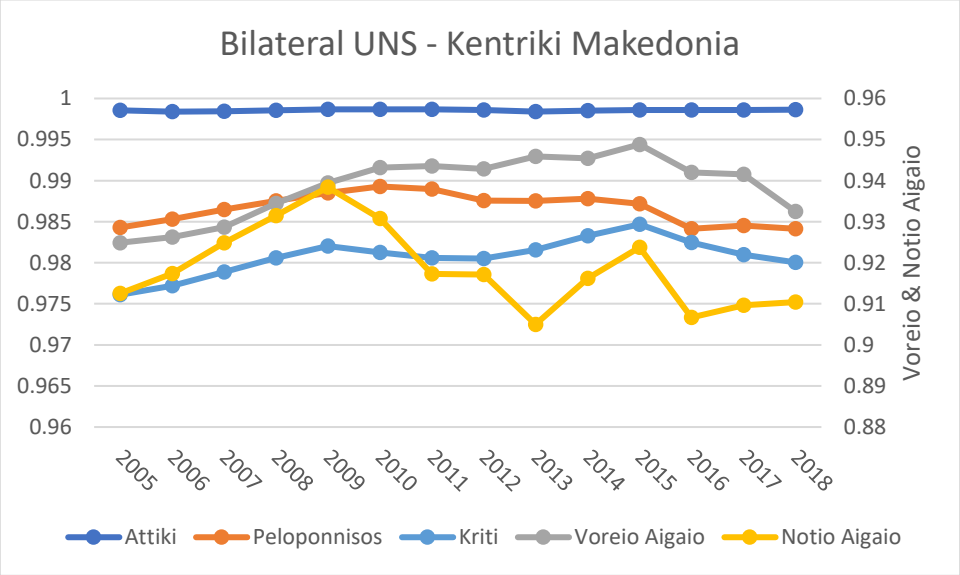
Ipeiros
Thessalia
Dytiki Ellada
Sterea Ellada
Ionia Nisia


Bilateral UNS - Kentriki Makedonia
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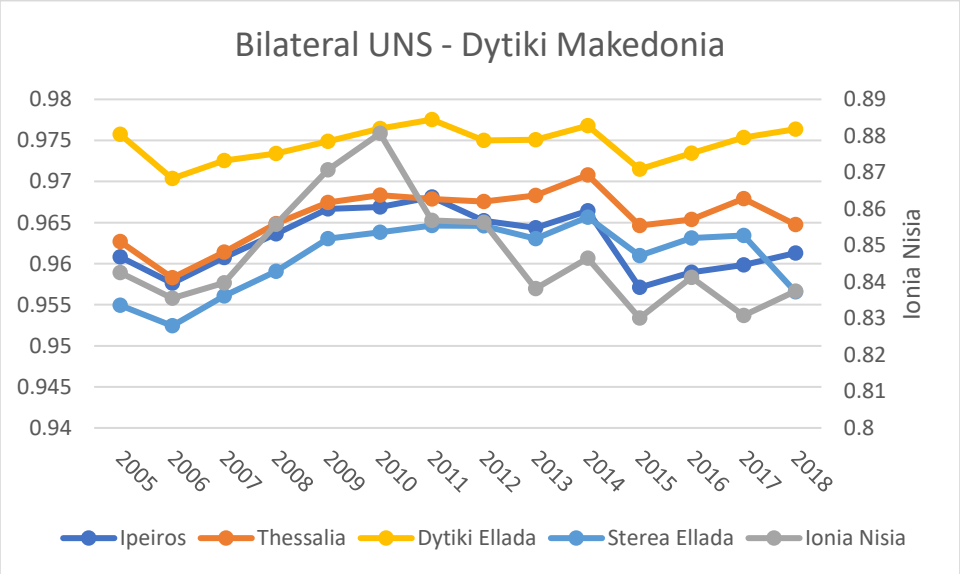
Kriti
Voreio Aigaio
Notio Aigaio


Bilateral UNS - Dytiki Makedonia
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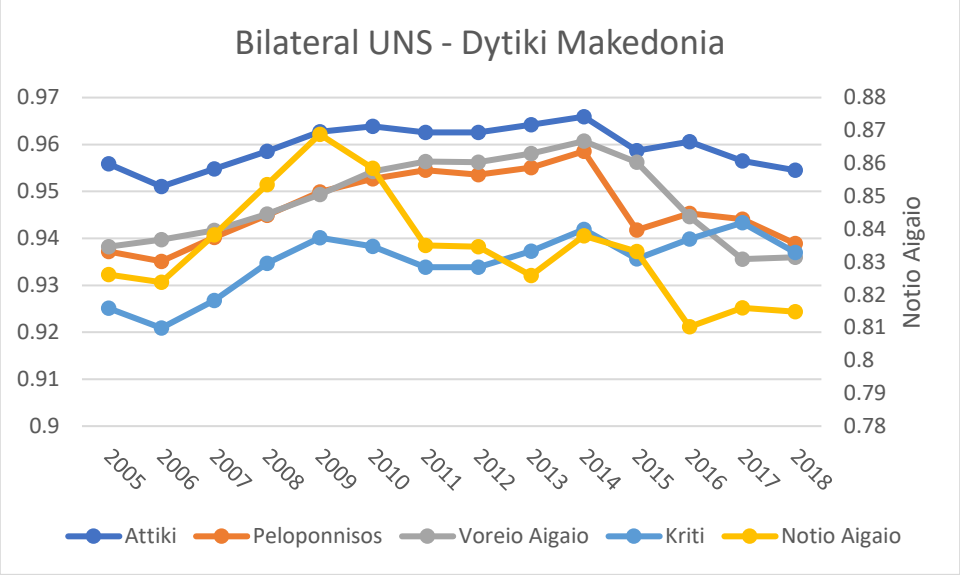
Sterea Ellada
Ionia Nisia


Bilateral UNS - Dytiki Makedonia
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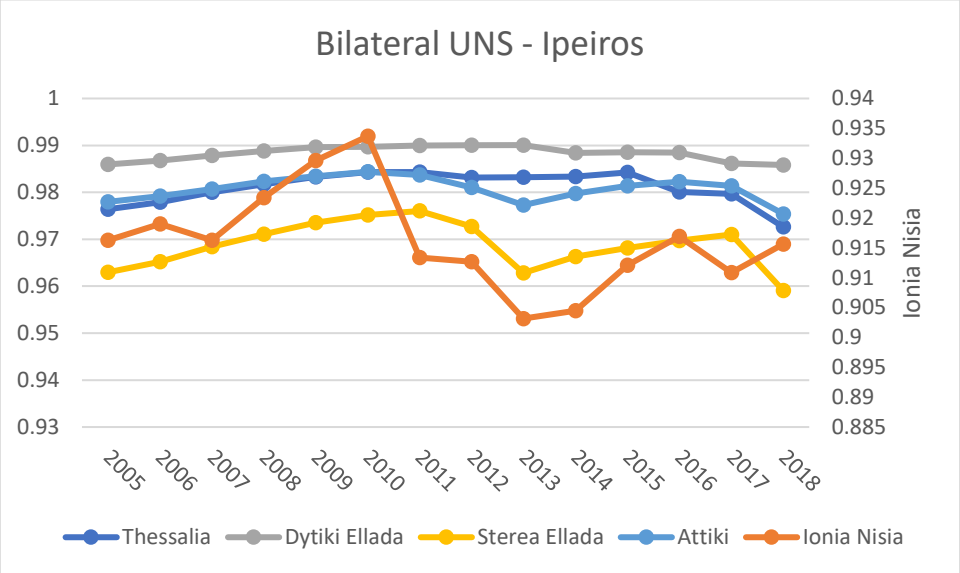
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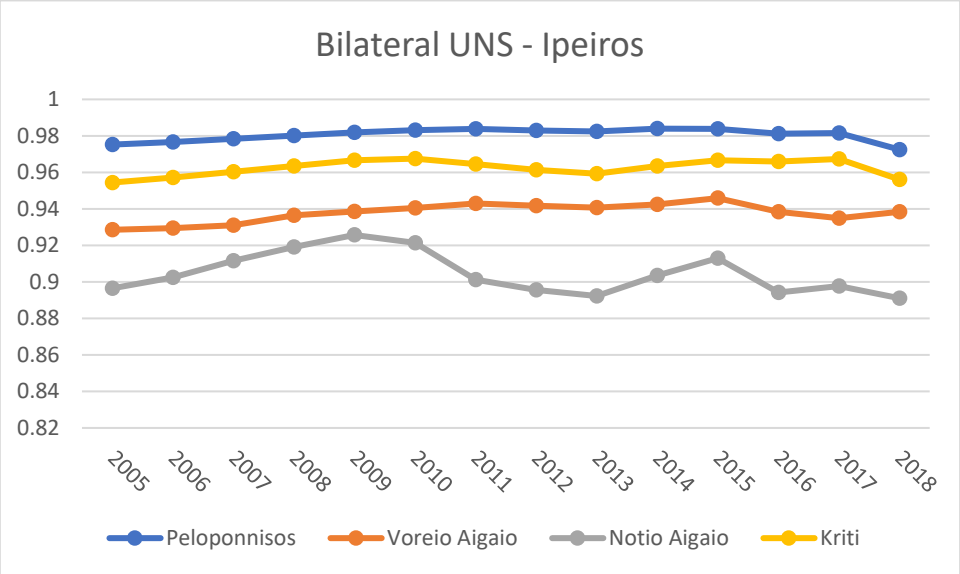
Bilateral UNS - Ipeiros
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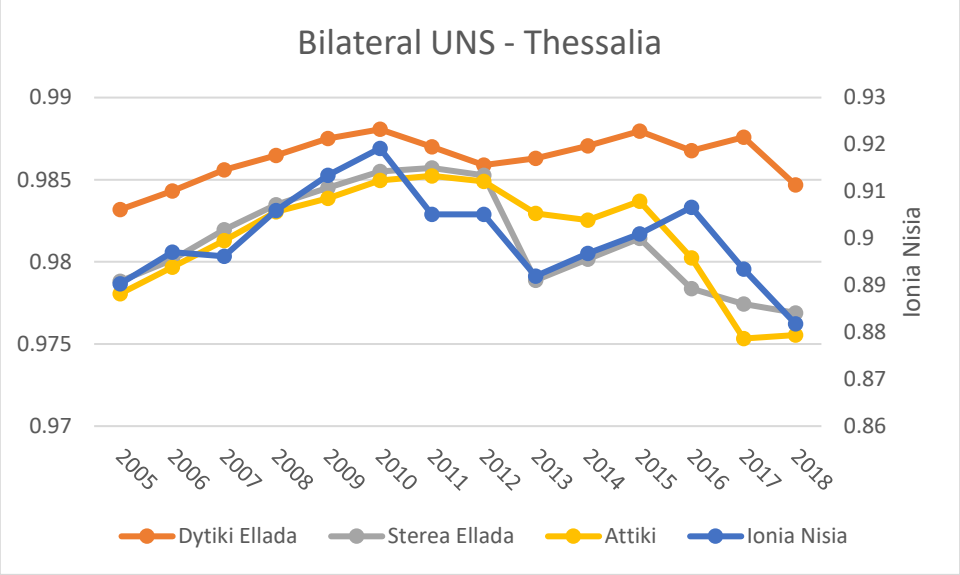
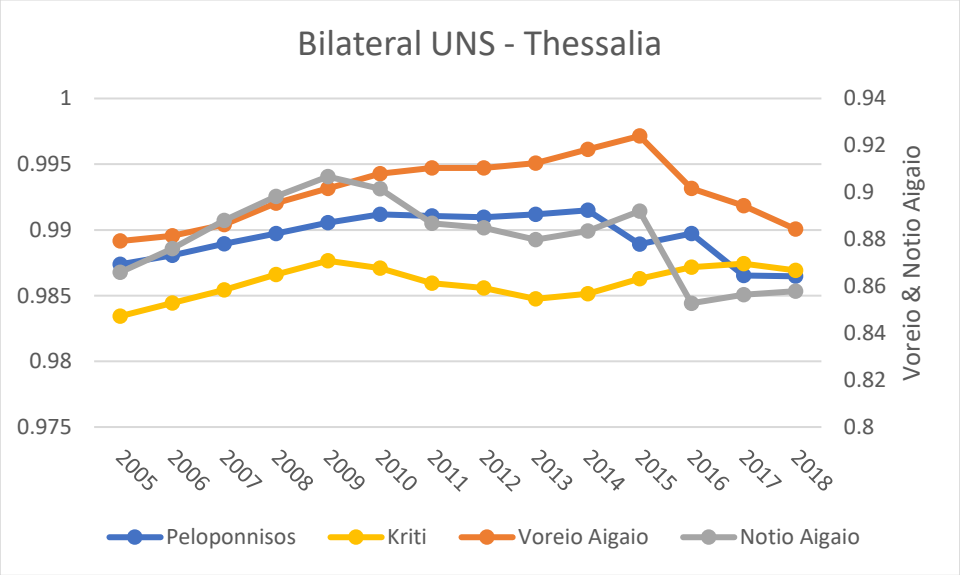
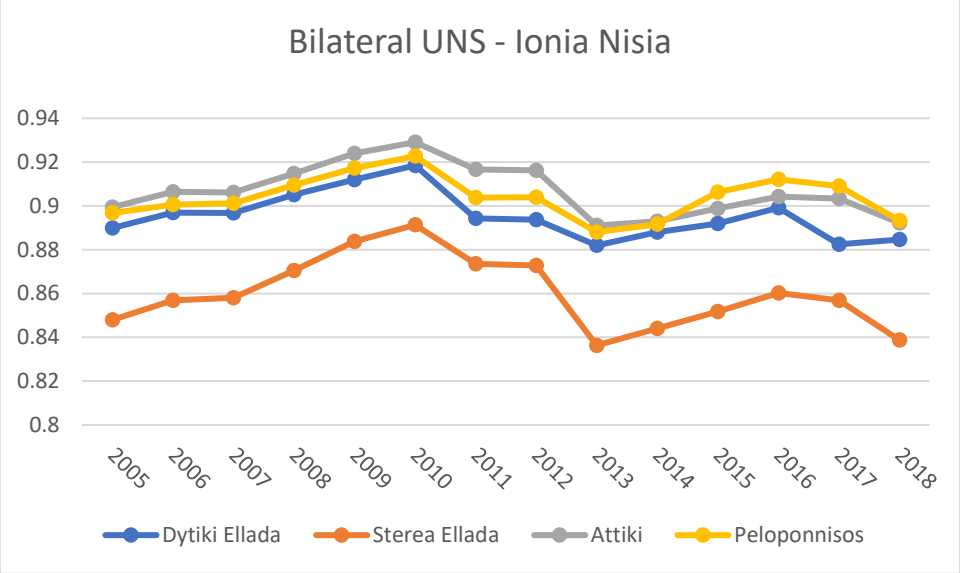
Notio Aigaio
Kriti


Bilateral UNS - Thessalia
0.99
0.985
0.98
0.975
0.97
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
Ionia Nisia
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Dytiki Ellada
Sterea Ellada
Attiki
Ionia Nisia


Bilateral UNS - Thessalia
1
0.995
0.99
0.985
0.98
0.975
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
Voreio & Notio Aigaio
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Peloponnisos
Kriti
Voreio Aigaio
Notio Aigaio


Bilateral UNS - Ionia Nisia
0.94
0.92
0.9
0.88
0.86
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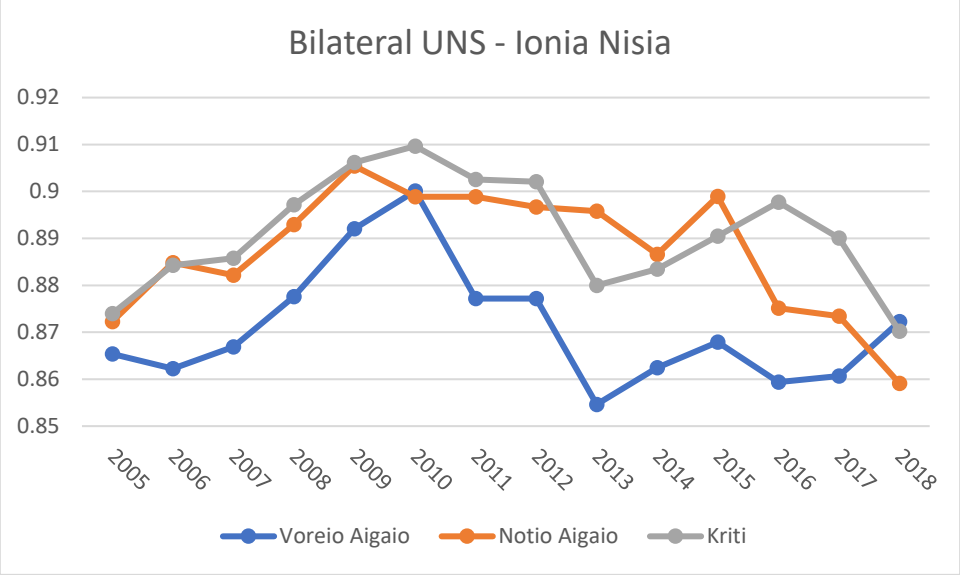
0.82
0.8
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Dytiki Ellada
Sterea Ellada
Attiki
Peloponnisos


Bilateral UNS - Ionia Nisia
0.92
0.91
0.9
0.89
0.88
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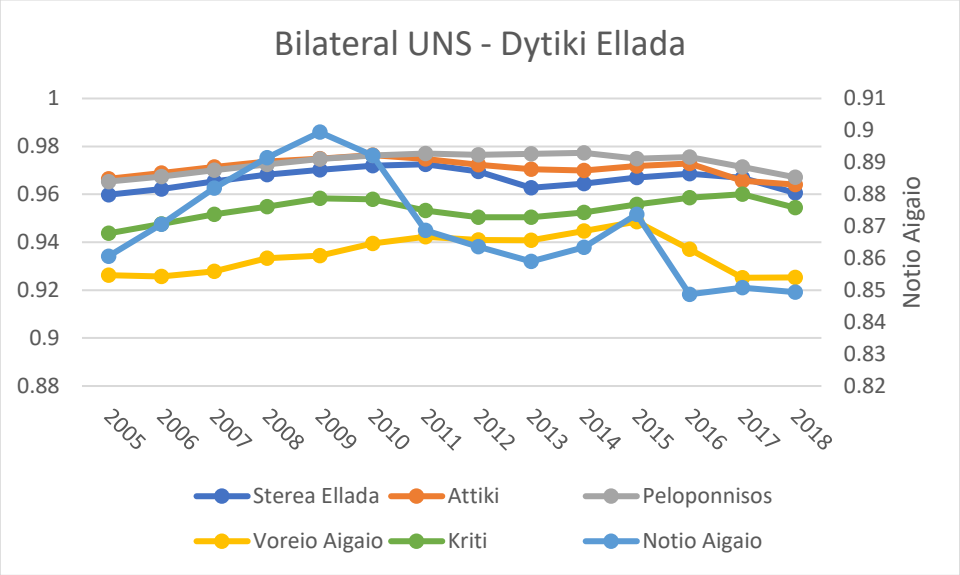
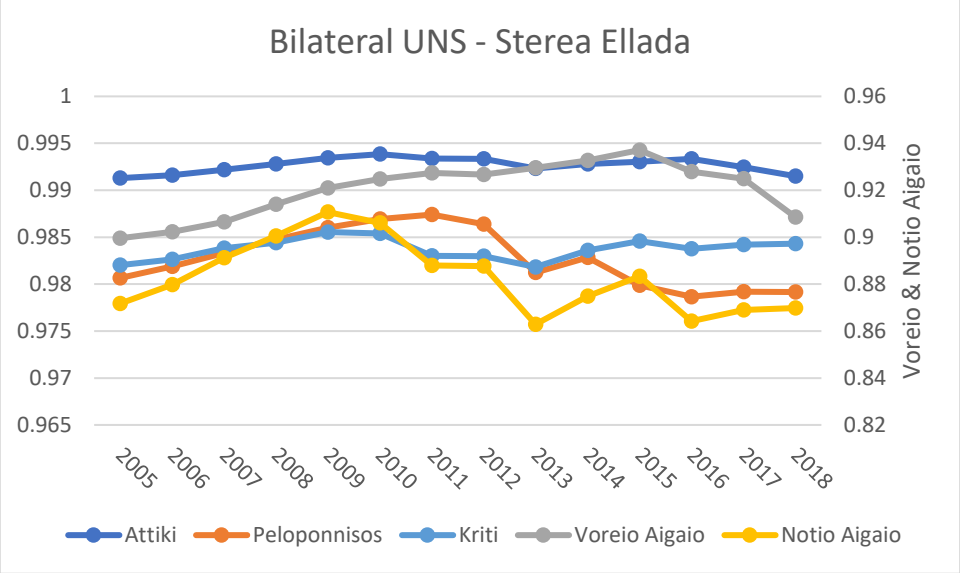
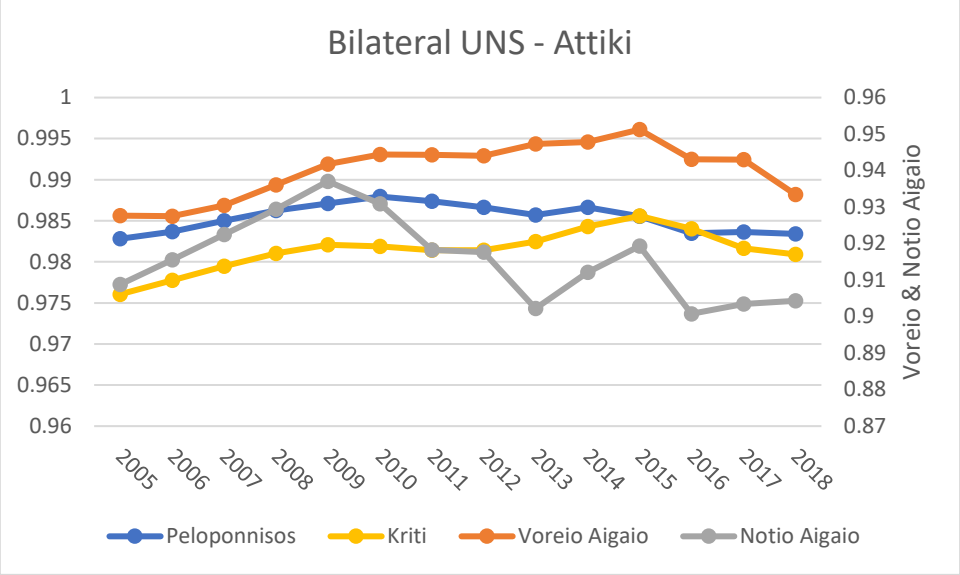
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Voreio Aigaio
Notio Aigaio
Kriti


Bilateral UNS - Dytiki Ellada
1
0.98
0.96
0.94
0.92
0.9
0.88
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
Notio Aigaio
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Sterea Ellada
Attiki
Peloponnisos
Voreio Aigaio
Kriti
Notio Aigaio


Bilateral UNS - Sterea Ellada
1
0.995
0.99
0.985
0.98
0.975
0.97
0.965
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
Voreio & Notio Aigaio
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Attiki
Peloponnisos
Kriti
Voreio Aigaio
Notio Aigaio


Bilateral UNS - Attiki
1
0.995
0.99
0.985
0.98
0.975
0.97
0.965
0.96
0.96
0.95
0.94
0.93
0.92
0.91
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0.89
0.88
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Voreio & Notio Aigaio
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Peloponnisos
Kriti
Voreio Aigaio
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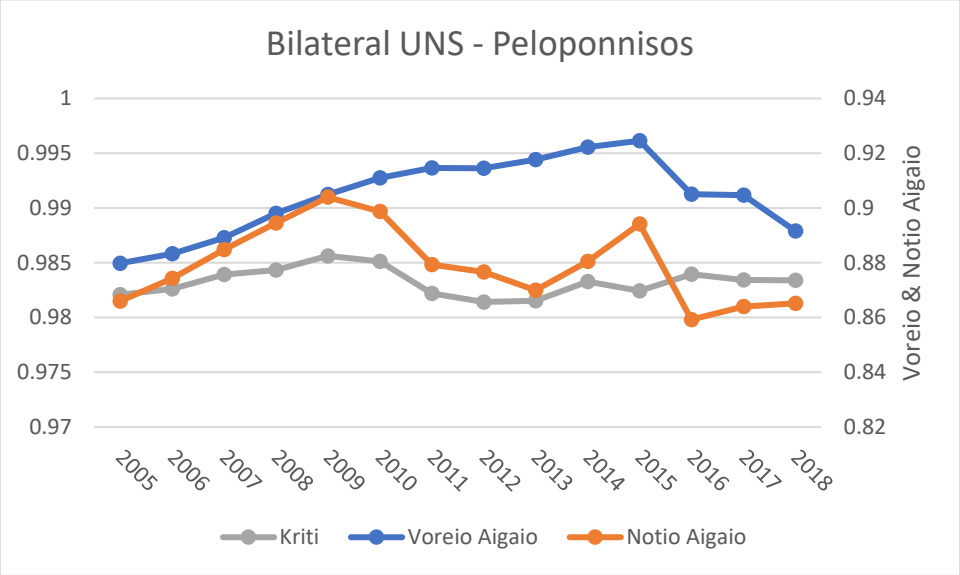
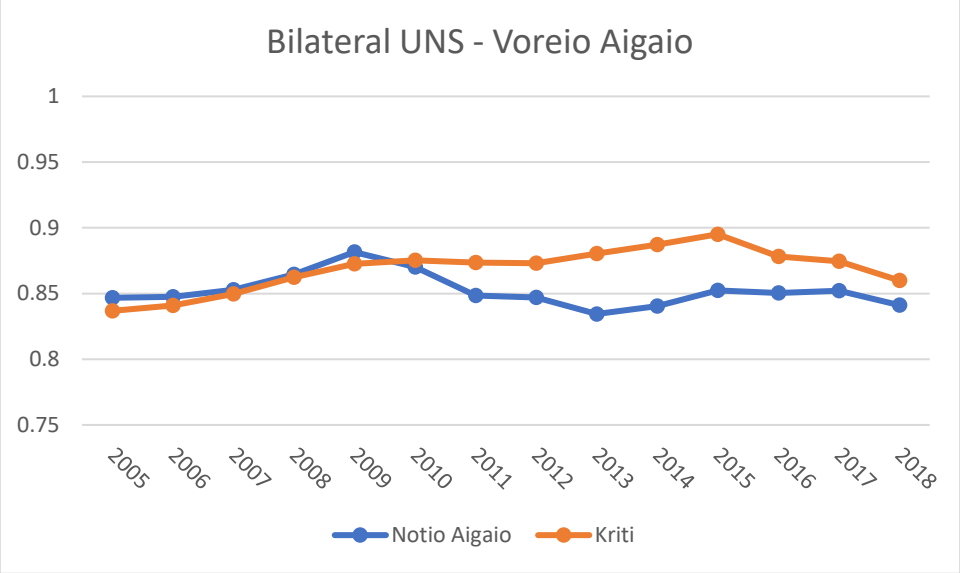
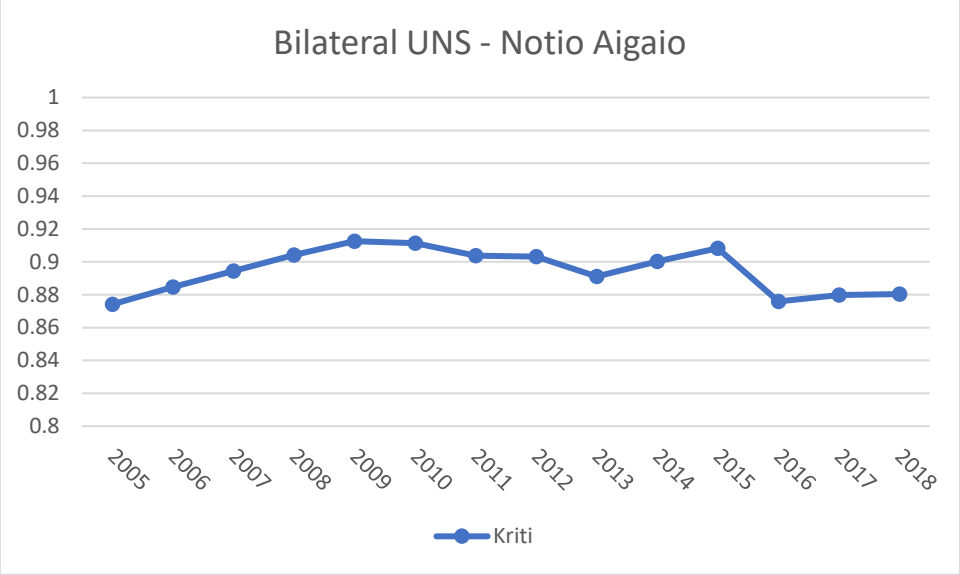

Bilateral UNS - Peloponnisos
1
0.995
0.99
0.985
0.98
0.975
0.97
0.94
0.92
0.9
0.88
0.86
0.84
0.82
Voreio & Notio Aigaio
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Kriti
Voreio Aigaio
Notio Aigaio


Bilateral UNS - Voreio Aigaio
1
0.95
0.9
0.85
0.8
0.75
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Notio Aigaio
Kriti



Note: The figure depicts the unemployment rate synchronization of all bilateral business cycles of each of the 13 prefectures of Greece for each year during the sample period 2005-2018.