Competition-complementarity relationships between Greek Regional Economies*

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Abstract. This article examines the nature of interregional competition and complementarity in Greece. The methodological framework deviates from the Dendrinos-Sonis model as applied in previous studies with the same scope. In fact we show that for different choices of the numeraire region one may get different outcomes for the interregional dynamics. Our methodology is close to the one adopted in Marquez and Hewings (2003) and Marquez *et al*. (2005) that is closely connected to the recently developed econometric methods for testing Granger-causality in cointegrated systems. We apply it to NUTS I and NUTS II level regions.

JEL classification: R11, R12

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1 Introduction

The goal of this study is to determine the types and the degree of spatial economic relationships among the Greek regions. We analyze competition-complementarity relationships for NUTS-I and NUTS-II level regions trying to answer via statistical modeling the following questions: Do Greek regions play against each other in attracting economic opportunities, and if so, should they? Do they compete for economic development, or do some pairs of them complement each other in terms of development? Is development in one region adversely affecting economic growth in a neighboring region? Might tax money used to promote growth in one area also spur growth in another place?

There has been a series of recent articles that aim to uncover regional competition-complementarity dynamics the vast majority of which are based in the theoretical framework proposed by Dendrinos and Sonis (1988, 1990). Hewings et al. (1996) investigated regional dynamics for an aggregate set of U.S. regions and produced forecasts for the progress of regional convergence into the next decades. Magalhaes et al. (1999) compared regional linkages for a set of Northeastern Brazilian states as derived from the Dendrinos-Sonis (D-S) model, to the ones observed for the states of Midwest in U.S. Nazara et al. (2001) provides a very nice exposition of the method and applies it to six major Indonesian regions. Dall'erba and Percoco (2003) applied the same method to a set of Italian regions, Dall'erba (2004) examined relationships between Spanish and Portuguese regions and Bonet (2003) worked similarly for a set of Colombian regions.

The methodology in this article deviates from the aforementioned ones in issues related to the D-S model and its application; our point of view is closer to the one presented in Marquez and Hewings (2003) and Marquez et al. (2005). A drawback of the D-S model is that it cannot be applied directly to a large number of regions due to the almost sure presence of multicollinearity that is expected to distort estimations. The major disadvantage though, is that as applied till now it may lead to results that contradict, depending on the choice of the numeraire region. Indeed, Nazara et al. (2001) point out in a footnote the possible inconsistency of the model which we demonstrate at the fourth section of our article. Different choices for the numeraire may lead to different outcomes for the regional competition-complementarity scheme. Our point of view is that there should not be any numeraire in the model; then the examination of regional competition-complementarity dynamics falls in the class of econometric problems related to Granger causality for cointegrated variables.

The plan of the paper is as follows. The next section describes very briefly regional economic conditions on Greece and the dataset of the study. Next we discuss the D-S model and in the fourth section we apply it for different choices of the numeraire region where we observe different results depending on the choice. The fifth and sixth sections examine the national effect on regional dynamics and interregional competition complementarity along the lines of Marquez and Hewings (2003) and Marquez et al. (2005). We end the article with some concluding remarks.

2 Greek Regional Economic Conditions: A Brief Exposition

Our analysis focuses on Greece during the period 1979-1999 using data from EUROSTAT's REGIO database. Greece covers an area of 132,000 km^2, has a population of 11,000,000 and is divided into 51 prefectures (NUTS III regions). The geographical units of our analysis are initially the 4 NUTS I regions and in the sequel the 13 NUTS II regions. Figure 1 depicts the 13 NUTS II level regions; East Makedonia-Thraki (GR11), Central Makedonia (GR12), West Makedonia (GR13) and Thessalia (GR14) form the NUTS I region Northern Greece (GR1), Ipeiros (GR21), Ionia Islands (GR22), West Greece (GR23) and Central Greece (GR24) form the NUTS I region Central Greece (GR2), Attiki (GR3) is both a NUTS I and NUTS II region and North Aegean (GR41), South Aegean (GR42) and Crete (GR43) form the NUTS I region Southern Greece and the islands (GR4). The main characteristic of the regional pattern in Greece is the existence of a great concentration of population, economic activities and infrastructure in the Greater Athens area and in the main urban center of Northern Greece, Thesaloniki. Thus, economic and urban activity is largely developed along this axis. This model of development changed during the 1980s as a result of the emergence of new sectors of specialization that favored regions of Northern Greece and to a lesser extent, the islands and some peripheral regions. The IMP and CSF programs during the 1980s and 1990s improved this situation further.

Studies of regional convergence in Greece have been conducted by Siriopoulos and Asteriou (1998) and Petrakos and Saratsis (2000). Both studies ran β-convergence regressions over the periods 1971-1996 and 1981-1991 respectively, basing their analysis on per capita output. While Siriopoulos and Asteriou (1998) concluded that there had been no tendency for regional income differences to disappear, Petrakos and Saratsis (2000) argued for a decrease in Greek regional inequalities (i.e. convergence) in the 1980s. This disparity might be attributed to the data employed and to the different level of spatial disaggregation, NUTS II and NUTS III respectively. Recently, Christopoulos and Tsionas (2004) studied the effect of technological gaps and capital deepening on the productivity growth of Greek prefectures over the period 1971-1995. Their results indicate that Greek prefectures tended to converge over time, contrary to conventional wisdom.

Figure 1. Greek regions

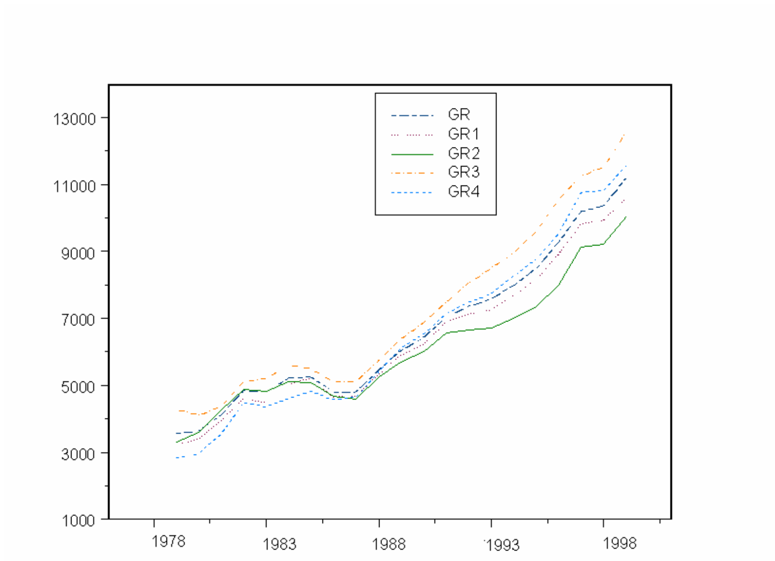

Figure 2. Per Capita GDP in Euros. GR: Greece, GR1-4: NUTS I level regions.

3 The Dendrinos-Sonis model

In the DS model the relative regional shares of the socioeconomic stock under study at a given time period are expressed as a function of the relative shares of all the regions during the previous time period. With respect to a particular stock, then, the competitive position of a region this year is a result of the competitor regions' competitive positions in the previous year.

Let Γ_{ST} be an economy defined over space and time, S be a finite number of regions in the economy and T be the time horizon. Further, let $Y_{st} = (Y_{1t}, Y_{2t}, ..., Y_{ST})$, where $(0 \leq Y_{st} \leq 1)$ represent a spatio-temporal distribution of regional economic activity and $(s = 1,...,S; t = 1,...,T)$. Following Dendrinos and Sonis (1990), we consider a set of arbitrary positive real-valued functions, $F_{jt} = (F_{1t}, F_{2t}, ..., F_{St})$ such that each F_{jt} is defined at each time period t by a subset of Y_{st}. The general discrete nonlinear process can then be defined as

$$Y_{st+1} = \frac{F_{st}}{\sum_j F_{jt}} \qquad \forall j = 1,2,...,S. \tag{1}$$

If we let region 1 be the numeraire region, we can define

$$F_{ojt} = \frac{F_{jt}}{F_{1t}} \qquad \forall j = 1,2,...,S. \tag{2}$$

The process defined in (1) can be restated using F_{ojt} explicitly to represent the temporal "comparative advantages" enjoyed by location s relative to the numeraire location

$$Y_{1t+1} = \frac{1}{1 + \sum_j F_{ojt}} \qquad \forall j = 2,...,S$$

$$Y_{st+1} = \frac{F_{ost}}{1 + \sum_j F_{ojt}} \qquad \forall j = 2,...,S$$

where $\sum_j Y_{st} = 1 \quad \forall s = 1,2,...,S,$ and $\frac{Y_{st+1}}{Y_{1t+1}} = F_{ost} \quad \forall s = 2,3,...,S.$

A log linear specification of the function F_{ojt} suggested by Dendrinos and Sonis (1988) is adopted in all DS-model applications encountered in the literature so far. It is given by

$$F_{ost} = A_s \prod_k Y_{sk} a_{sk} \qquad \text{for} \qquad F_{st} > 0; s = 2,...,S; k = 1,...,s, \qquad \text{where}$$

$A_s > 0$ represents the locational advantages of state $s \in S$, and

$$a_{sk} = \frac{\partial \ln F_{ost}}{\partial \ln Y_{kt}} \quad \text{for } s\text{=2,3,…,}S\text{; } k\text{=1,2,…,}S$$

are the regional growth elasticities, with $-\infty < a_{sk} < \infty$. Using the log-linear form we can write the process as

$$\ln Y_{st+1} - \ln Y_{1t+1} = \ln A_s + \sum_{k=1}^{s} a_{sk} \ln Y_{kt} \;, \quad \text{for } s\text{=2,…,}S\text{; } t\text{=1,…,}T.$$

Regional interaction at this level is assumed to involve a competition whereby each region attempts to increase its share of socio-economic stock, which is attained by improving its comparative advantages. However this behavior will depend on the rest of the states' behavior that is reflected in the sign and magnitude of the elasticities (a_{sk}). A negative sign for a_{sk} indicates the existence of a competitive relation between regions *s* and *k*, i.e., if the socio-economic stock share of region s increases, the share of region *k* will decrease and vice-versa. A positive coefficient indicates a complementarity relationship between *s* and *k*. To our knowledge, in all applications encountered in the literature so far, the elasticities are estimated via the Seemingly Unrelated Regressions estimator.

4 Sensitivity Analysis for the Numeraire Region

Table 1 presents the results of the estimation of the NUTS I-region D-S model for GDP per capita. The table contains estimations for five seemingly unrelated regressions systems: the first four correspond to all possible choices for the numeraire region whereas in the last system there is no numeraire. The no-numeraire system could be equivalently written as a Vector Autoregressive model of order one (VAR(1)). The last observation bridges the gap between previous D-S model applications as reported in the introduction and the error correction modeling (ECM) approach presented in Marquez and Hewings (2003) and Marquez et al. (2005) and brings the methodological framework close to Granger-causality tests for cointegrated systems; see Toda and Phillips (1993), Bruneau and Jondeau (1999), Yamamoto and Kurozumi (2003), Chigira and Yamamoto (2003), Dufour *et al*. (2003).

Reading down the columns of table 1 indicates that for Attiki as numeraire, a positive shock to Attiki would cause a decrease in the relative GDP of all other regions whereas for Southern Greece as numeraire a positive shock to the GDP of Attiki would cause an increase in the relative GDP of all other regions. The inconsistency of the D-S model as it was applied till now is more clearly (symbolically) depicted at the right part of the table.

Table 1. Application of the D-S model to NUTS I regions for all possible numeraires. Left part: SUR coefficients. Right part: Symbolic representation of interregional dynamics (++Complementarity significant at the 0.05 level, +Complementarity significant at the 0.1 level, -Competition significant at the 0.1 level, --Competition significant at the 0.05 level,)

D-S 4-REGION MODEL: NORTHERN GREECE NUMERAIRE									
GDP per capita									
	North	Central	Attiki	South-Islands		North	Central	Attiki	South-Islands
Central	-0.46	0.624	0.086	-0.252	Central		++		-
Attiki	-.777	0.015	0.542	0.227	Attica	-		++	
South-Islands	0.204	-0.429	-.303	0.534	South-Islands		--	--	++
D-S 4-REGION MODEL: CENTRAL GREECE NUMERAIRE									
GDP per capita									
	North	Central	Attica	South-Islands		North	Central	Attiki	South-Islands
North	0.46	-0.624	-0.08	0.252	North		--		+
Attiki	-.316	-0.609	0.455	0.479	Attica		--	++	++
South-Islands	0.665	-1.05	-.389	0.785	South-Islands	+	--	--	++
D-S 4-REGION MODEL: ATTIKI NUMERAIRE									
GDP per capita									
	North	Central	Attiki	South-Islands		North	Central	Attiki	South-Islands
North	0.777	-.015	-.542	-.227	North	+		--	
Central	0.317	0.609	-.455	-.479	Central		++	--	--
South-Islands	0.981	-.444	-.845	0.307	South-Islands	++	--	--	+
D-S 4-REGION MODEL: SOUTHERN GREECE NUMERAIRE									
GDP per capita									
	North	Central	Attiki	South-Islands		North	Central	Attiki	South-Islands
North	-.204	0.429	0.303	-0.533	North		++	++	--
Central	-.665	1.053	0.389	-.785	Central	-	++	++	--
Attiki	-.981	0.444	0.845	-0.306	Attica	--	++	++	-
D-S 4-REGION MODEL: NO NUMERAIRE									
GDP per capita									
	North	Central	Attiki	South-Islands		North	Central	Attiki	South-Islands
North	-.565	0.663	0.458	0.446	North				
Central	-1.03	1.286	0.544	0.194	Central		++	+	
Attiki	-1.34	0.677	0.999	0.673	Attica		+	++	++
South-Islands	-.361	0.234	0.155	0.979	South-Islands				++

5 The National Effect

To estimate the influence of the national aggregate (economy-wide effect) over each of the four NUTS I regions, we use a specification similar to the one referred to as regional curve by Marquez et al. (2005). More precisely the formulation is

$$y_{it} = \beta_{0i} + \beta_{1i} y_{nt} + \varepsilon_{it}, \quad i=1,\ldots,4 \quad (\text{or } 1,\ldots,13) \quad t=1979,\ldots,1999. \qquad (3)$$

where y_{it} denotes the gdp for region i and time period t, y_{nt} the national gdp at time t, β_{0i} is the share of gdp growth unexplained by the evolution of the national level for region i, whereas β_{1i} indicates whether the corresponding regional observation increases or diminishes when the national gdp increases. From (3) one has to estimate a system of seemingly unrelated regressions. The corresponding estimations from our dataset, presented at tables 2 and 3, indicate positive relations with the national per capita gdp per for all NUTS I and NUTS II regions. The reader should notice that intercepts and slopes corresponding to Attiki (GR3) are very close to zero and very close to one respectively, indicating an almost perfect correlation.

Table 2. SUR Coefficients (standard errors in parentheses) for relation (3) corresponding to the NUTS I regions.

β_{01}	β_{02}	β_{03}	β_{04}
-0.204 (0.114)	1.035 (0.184)	-0.074 (0.201)	-1.926 (0.23)
β_{11}	β_{12}	β_{13}	β_{14}
1.018 (0.013)	0.874 (0.021)	1.018 (0.023)	1.216 (0.026)

Table 3. SUR Coefficients (standard errors in parentheses) for relation (3) corresponding to the NUTS II regions.

$\beta_{0,11}$	$\beta_{0,12}$	$\beta_{0,13}$	$\beta_{0,14}$	$\beta_{0,21}$	$\beta_{0,22}$	$\beta_{0,23}$	$\beta_{0,24}$	$\beta_{0,25}$	$\beta_{0,3}$	$\beta_{0,41}$	$\beta_{0,42}$	$\beta_{0,43}$
0.165 (0.5)	-0.417 (0.086)	-0.074 (0.384)	0.105 (0.17)	0.675 (0.323)	-0.78 (0.23)	0.637 (0.224)	1.566 (0.465)	1.84 (0.26)	-0.07 (0.2)	-2.37 (0.39)	-1.85 (0.038)	-1.68 (0.34)
$\beta_{1,11}$	$\beta_{1,12}$	$\beta_{1,13}$	$\beta_{1,14}$	$\beta_{1,21}$	$\beta_{1,22}$	$\beta_{1,23}$	$\beta_{1,24}$	$\beta_{1,25}$	$\beta_{1,3}$	$\beta_{1,41}$	$\beta_{1,42}$	$\beta_{1,43}$
0.969 (0.057)	1.047 (0.01)	1 (0.04)	0.978 (0.02)	0.885 (0.037)	1.076 (0.026)	0.908 (0.026)	0.839 (0.05)	0.78 (0.03)	1.02 (0.02)	1.239 (0.45)	1.22 (0.038)	1.19 (0.04)

6 Regional patterns of competition and complementarity: Error Correction Modeling

The fifth SUR system estimated in the fourth section is equivalent to a VAR(1) model. One should expect economic variables considered in studies of the kind we deal with to be integrated, and for systems of such variables some cointegrating relationships to hold. That is exactly the methodological framework Marquez and Hewings (2003) and Marquez et al. (2005) propose for the examination of competition and complementarity dynamics.

As the functional structure of the equations making up the empirical dynamic model is based on the cointegration approach an ECM model is formulated to examine whether there is a short-run adjustment towards long-run equilibrium. Specifically, 'standard' equations are proposed in the form of ECM, in which a long-term equilibrium relationship is set up between the explanatory and the endogenous variables, at the same time as allowing the existence of short-term deviations with respect to this equilibrium through the inclusion of dynamic terms. The general ECM(1) model structure is given by the expression:

$$\Delta y_t = \Pi y_{t-1} + \Phi \Delta y_{t-1} + \varepsilon_t \tag{4}$$

where Δ represents the first difference operator, y_t denotes the vector containing regional gdp observations at time t, Π and Φ are rectangular matrices containing unknown coefficients and ε_t is the innovations vector for which we assume the usual properties. Thus, the first difference of the log of region's i gdp at time t (or short-term deviations from the equilibrium) is explained by the first difference of the lagged values of the dependent variable, by the first difference of the variables that cointegrate with y_{it} and by an error correction term.

Next, we display the ECM modeling results as obtained for the NUTS I level regional system. Per capita gdp observations are clearly nonstationary as observed by figure 2; the appropriate Dickey-Fuller tests (not shown) indicate the presence of a unit root for all the (four) variables under study. We proceed via applying Johansen's cointegration trace test, to detect the presence and the number of cointegrating (long - run) relationships. Table 4 indicates that there are 3 equilibrium relationships for the 4 regions of our study; table 5 contains the estimated cointegrating relationships, standardized with respect to GR1 and table 6 depicts the estimated short-term equations.

Table 4. Johansen's cointegration rank test for the 4 NUTS regions.

H0:Rank=r	H1:Rank>r	Eigenvalue	Trace	Critical Value
0	0	0.8696	84.1	39.71
1	1	0.6903	43.36	24.08
2	2	0.55	19.92	12.21
3	3	0.1789	3.94	4.14

Table 5. Results of the estimation of the cointegrating relationships

$y_{1t} = 0.43 y_{2t} + 0.0316 y_{2t} + 0.539 y_{3t}$
$y_{1t} = 0.21 y_{2t} + 0.0565 y_{2t} + 0.216 y_{3t}$
$y_{1t} = -40 y_{2t} + 0.523 y_{2t} + 39.56 y_{3t}$

Table 6. Results of the ECM estimation.

$\Delta y_{1t} = \underset{(0.71)}{-1.5}\, y_{1t-1} + \underset{(0.257)}{0.62}\, y_{2t-1} + \underset{(0.256)}{0.459}\, y_{3t-1} + \underset{(0.315)}{0.429}\, y_{4t-1}$
$\Delta y_{2t} = \underset{(0.71)}{-1.26}\, y_{1t-1} + \underset{(0.255)}{0.466}\, y_{2t-1} + \underset{(0.253)}{0.539}\, y_{3t-1} + \underset{(0.311)}{0.256}\, y_{4t-1}$
$\Delta y_{3t} = \underset{(0.598)}{-1.446}\, y_{1t-1} + \underset{(0.216)}{0.756}\, y_{2t-1} - \underset{(0.215)}{0.0025}\, y_{3t-1} + \underset{(0.263)}{0.7}\, y_{4t-1}$
$\Delta y_{4t} = \underset{(0.826)}{-0.45}\, y_{1t-1} + \underset{(0.298)}{0.304}\, y_{2t-1} + \underset{(0.296)}{0.153}\, y_{3t-1} + \underset{(0.364)}{0.004}\, y_{4t-1}$

6 Concluding Remarks

The paper draws on some diverse issues related to the topic of regional competition to provide the motivation for the application of a new approach. The contribution is in the field of dynamic regional competition where there have been a few studies to explore the nature of the relationships between adjacent regions over time. The results offer a potentially interesting implication for the design of spatially targeted strategies. In a subsequent version of the article we plan:

- To explore sectoral effects in the interregional dynamics that may be masked by the current setting.
- To link the ECM setting with the recent advances in Granger causality tests for cointegrated variables.

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