IJER © Serials Publications
11(2), July-Dec. 2014: 333-354
ISSN: 0972-9380

Fixed Capital Formation in Regional Level: The Case of Greece

Christos Karpetis* **& Spyros Zikos****

Abstract: *In this paper the level of net capital stock will be determined in nominal terms in the case of the thirteen regions of Greece. The appropriate ARIMA(p,d,q) models for the series of regional gross investment are determined, using annual data over the period from 1974 to 2006. These models are used in order to produce, via a calibration method, the regional gross investment series for the period prior to 1974. The regional net capital stock series are finally determined using four different depreciation patterns and for a depreciation period of 18 and 25 years.*

Key Words: *Net Capital, Calibration, Depreciation,*

J.E.L. Codes: *C22, C63, E22*

I. INTRODUCTION

The determination of the time series of net investment, both in national and regional level, is very important since this series is used widely in order to either investigate the significance of the convergence hypothesis or estimate the form of an economy's production function.

The researcher is facing three main problems in his effort to determine the level of net investment series. The first of these is the lack of statistical data concerning the time series of gross investment; the second is the selection of the depreciation pattern of physical capital and the third has to do with the assumption about the service life of the physical capital.

The lack of statistical data in regional level, mainly, concerns the period that precedes the examined one and becomes more severe as the span of physical's capital service life becomes bigger. This problem could be avoided in case we derive the time series of capital stock from a previously estimated production function [Dadkhah & Zahedi (1986)] or by apportioning the national capital stock among the regions

* Assistant Professor, Department of Balkan, Slavic & Oriental Studies, University of Macedonia, Thessaloniki, Greece, *E-mail: ckarpet@uom.gr*

** Professor, Department of Economics, University of Macedonia, Thessaloniki, Greece

[Garafalo & Yamarik (2002)]. These methodologies can not be used, however, in the context of our analysis in order to determine the series of net investments of the Greek regions, due to the lack of reliable statistical data about the level of regional production. Instead, we will follow a two-step procedure. In the first step we will estimate the *ARIMA*(p,d,q) model that underlies the evolution of regional gross investment for the period that data are available, that is 1974 ~ 2006, for each one of the thirteen Greek regions. Assuming that the estimated ARIMA(p,d,q) model also describes the evolution of the series in the period prior to 1974, we will use our findings in order to perform a calibration analysis and estimate the series of regional gross investment for the period before 1974.

The affection of the series of net investment by the depreciation pattern of physical capital has been investigated in the past by a number of researchers [Domar (1953), Linhart (1970), Coen (1975)] and is associated with a number of secondary problems like the determination of capital's service life [Redfern (1955), Nevin (1963), Dean & Irwin (1964)] and the value of depreciation rate [Boskin *et al.* (1987)].

As far as the case of Greece is concerned, the measurement of capital stock both in national or regional level is very difficult due to the lack of statistical data. In national level, annual estimations of gross and net capital stock are available from the O.E.C.D. [(1987), (1994)], while Skountzos & Mattheou (1991) provide estimates of annual national gross capital stock covering the period 1950 ~ 1991. Moreover, Georganta *et al.* (1994) provides annual statistical data that concerns estimates of sectorally disaggregated manufacturing capital stock for the period 1980 ~ 1991. In regional level, annual estimates of net capital stock of thirteen Greek regions are provided by Melacroinos & Spence (2000) covering the period 1980 ~ 1993.

The goal of our paper is to determine the net investment series in the case of thirteen administrative regions of Greece, namely (1) Eastern Macedonia and Thrace (E.M.T.), (2) Central Macedonia (C.M.), (3) Western Macedonia (W.M.), (4) Thessaly (TH.), (5) Epirus (EP.), (6) Ionian Islands (I.I.), (7) Western Greece (W.G.), (8) Central Greece (C.G.), (9) Attica (ATT.), (10) Peloponnese (PEL.), (11) Northern Aegean Islands (N.A.I.), (12) Southern Aegean Islands (S.A.I.) and (13) Crete (CR.). The series of regional net investments will be determined using four different depreciation patterns, that is (i) Straight Line, (ii) Double Declining Balance, (iii) One – Hoss Shay and (iv) Sum of the Years Digits, and assuming that firstly, the depreciation rate is determined exogenously and secondly, that capital's service life is either 18 or 25 years.

Our paper comprises four sections. The second section describes the followed methodology and the econometric tools that are used in order (*i*) to estimate the functional form of the equation that describes the evolution of regional gross investments between 1974 and 2006, (*ii*) to determine the statistical data of the gross investment time series of thirteen Greek regions for the period 1949 ~ 1973 and (*iii*) to derive the net investment series for the period 1974 ~ 2006 under four different depreciation patterns and for two different time spans concerning the service life of capital stock. In the third and fourth section the statistical findings and the conclusions of our analysis are presented respectively.

II. METHODOLOGY

The determination of regional net investments series is a procedure in the context of which the following steps are taken place:

First step. Using the available statistical data we estimate the appropriate ARIMA(p,d,q) model that describes the evolution of regional gross investments series:

$$\Delta^d I_{j,t} = \sum_{i=1}^{p} \varphi_i \, \Delta^d I_{j,t-i} + \sum_{i=1}^{q} \theta_i \, u_{j,t-i} + e_{j,t} \tag{1}$$

where φ_i & θ_i: constant coefficients, p & q: the order of model's Autoregressive and Moving Average component, $j = 1, \ldots, 13$, $I_{j,t}$: the gross investments series of region j, d: the order of integration of $I_{j,t}$ series, $e_{j,t} \sim i.i.d.\, N\left(0, \sigma^2_{e_j}\right)$: a white noise term and $t = 1$ (1974), …. , $T = 33$ (2006).

The statistical estimation of model (1) for each region j premises the determination of parameters p, d & q, which are taking integer and non negative values, that is $p, d, q \in \mathbb{N}_+$. In the case of economic time series these parameters are expected to take integer values in the closed interval [0,2], while in our analysis they are assumed to take integer values in the closed interval [0,3].

Parameter d is associated with the stationarity of the examined series and its magnitude could be appointed after the performance of a unit root test on sequence $\left\{I_{j,t}\right\}_{t=1}^{T}$, $j = 1, \ldots, 13$. In our analysis the series' stationarity will be investigated at a 5% significance level[1] (a = 5%) via a *KPSS* test, in the context of which a constant and trend are included in the test equation. *Bartlet kernel* is the used spectral estimation method and bandwidth is selected using the *Newey – West* method. The sensitivity of the *KPSS* test results concerning the selection of the spectral estimation method is investigated by performing this unit root test in $\left\{\Delta^d I_{j,t}\right\}_{t=1}^{T}$, d = 0, 1, 2 & 3, using the following spectral estimation methods[2] (*i*) *Bartlet*, (*ii*) *Parzen*, (*iii*) *Quadratic Spectral* (*Q.S.*), (*iv*) *Autoregressive – OLS detrended* (*AR – OLS*), (*v*) *Auto-regressive Spectral* (*AR Spectral*) & (*vi*) *Autoregressive – GLS detrended* (*AR – GLS*).

To verify the *KPSS* results concerning the determination of parameter d, the series stationarity is also investigated via an *Augmented Dickey – Fuller* (*ADF*) *test*. The test equation used is of the following general form:

$$\Delta Y_{j,t} = a_0 + a_1\, t + \gamma\, Y_{j,t-1} + \sum_{i=1}^{k} c_i \Delta Y_{j,t-i} + \varepsilon_{j,t} \tag{2}$$

where $Y_{j,t} = \Delta^d I_{j,t}$, $d = 0, \ldots, 3$, $t = 1, 2, \ldots, T\ (= 33)$, $k = 0, 1, \ldots, \sqrt{T} \approx 6$ and $\varepsilon_{j,t} \sim i.i.d.\left(0, \sigma^2_{\varepsilon_j}\right)$.

The presented in equation (2) lag length parameter k is chosen using the *Schwarz* information criterion and its chosen magnitude ensures that $\mu_{j,t}$ is a white noise process[3]. Given that the *ADF* test results may be affected by the method used in order to determine the value of parameter k, we estimate equation (2) using the *OLS* method and selecting the lag length parameter k using alternatively one of the following information criteria (*i*) *Schwarz* (*S.I.C.*), (*ii*) *Akaike* (*A.I.C.*) & (*iii*) *Hannan–Quinn* (*H.Q.*).

If the sequence $\left\{I_{j,t}\right\}_{t=1}^{T}$, $j = 1, \ldots, 13$, is proved to have $\tilde{d}$ unit roots, that is $d = \tilde{d} \in [0,3]$, our analysis proceeds with the definition of the parameters p & q of model (1). In the context of this model fifteen different ARIMA ($p, \tilde{d}, q$) models are derived for $p, q \in [0,3]$. Since our initial objective is to specify the model that best describes the evolution of $I_{j,t}$ series, the model that is chosen among the fifteen estimated ones is that for which for $p = \tilde{p},\ d = \tilde{d}\ \&\ q = \tilde{q} \in [0,3]$, the adjusted coefficient of determination $\left(\bar{R}^2\right)$ is maximized and the residuals series $\left\{\hat{e}_{j,t}\right\}$ of equation (1) is proved to be a white noise process.

Second step. The $ARIMA\left(\tilde{p}, \tilde{d}, \tilde{q}\right)$ model that has been specified in the first step of the followed procedure is used in the second step in order to specify the values of $\left\{I_{j,t}\right\}$ series at a period of time that statistical data are not available (1949 ~ 1973) and is extended 25 periods of time (years) prior to the first period that data are available (1974).

More specifically in the second step we perform a calibration analysis using for each one of the j greek region the following model:

$$\Delta^{\tilde{d}} I_{j,t} = \sum_{i=1}^{\tilde{p}} \hat{\varphi}_i \, \Delta^{\tilde{d}} I_{j,t-i} + \sum_{i=1}^{\tilde{q}} \hat{\theta}_i \, u_{j,t-i} + \tilde{e}_{j,t} \tag{3}$$

where t = 1 (1949), …. , 25 (1973), $\hat{\varphi}_i$ & $\hat{\theta}_i$: the resulting from equation (1) estimated coefficients and $\tilde{e}_{j,t} \sim i.i.d.\ N(0,1)$.

The use of equation (3) in order to derive the calibrated values of $\left\{I_{j,t}\right\}_{t=1949}^{1973}$, j = 1, …. , 13 sequences is subjected to two major difficulties. Firstly, it is assumed that we have sufficient initial conditions, that is the knowledge of $I_{j,t}$ magnitude at t = 1 (1949), 2 (1950), 3 (1951) etc., the number of which is determined by the magnitude of parameters $\tilde{p}$, $\tilde{d}$ & $\tilde{q}$. If, for example, we had that $\tilde{p} = 1$, $\tilde{d} = 1$ & $\tilde{q} = 0$, then equation (3) would suggest an AR(2) model with respect to $I_{j,t}$ and we would have to use two initial conditions, say $I_{j,1949} = \overline{I}_{j,1949}$ & $I_{j,1950} = \overline{I}_{j,1950}$, in order to derive the sequence $\left\{I_{j,t}\right\}_{t=1949}^{1973}$, j = 1, …. , 13.

Given the absence of available data concerning the beginning of our sample period, the initial conditions will be artificial and will be constructed using the following equation:

$$\overline{I}_{j,1949+h} = I_{j,1974+h}\left(1+\overline{g}_j\right)^{-25} \tag{4}$$

where: h = 0, 1, 2, …. and $\overline{g}_j$: the mean growth rate of $I_{j,t}$ during the period t = 1 (1974) to t = 33 (2006), that is:

$$\overline{g}_j = \frac{1}{T-1} \sum_{t=2}^{T=33} \left(\frac{I_{j,t} - I_{j,t-1}}{I_{j,t-1}} \right) \tag{5}$$

According to equation (4) the first, second etc. initial condition that is used in the context of the calibration analysis, is the discounted value of the first, second etc. available observation of the $\{I_{j,t}\}$ series.

The second difficulty concerning our calibration analysis is that we take different series $\{I_{j,t}\}$ for different sequences of the error term $\tilde{e}_{j,t}$ in equation (3). In order to avoid this problem we repeat the calibration analysis for 1000 different samples of

$\tilde{e}_{j,t}$, and each observation of the final sequence $\left\{I_{j,t}\right\}_{t=1949}^{1973}$, $j = 1, \ldots 13$, is defined as the mean value of the 1000 replications of the corresponding series.

Third step. After the specification of series $\left\{I_{j,t}\right\}_{t=1949}^{2006}$, $j = 1, \ldots, 13$, at the second step of our analysis, we will use these series in the third and final step to determine the sequence of net investments for each of the thirteen administrative regions of Greece.

It is well known that net investments are defined as the difference between gross investments and the depreciation of capital. According to this definition if $I_{j,t}$ and $D_{j,t}$ are the levels of gross investments and the depreciation of capital of region j at time t respectively, then the level of region's net capital stock ($NK_{j,t}$) is determined mathematically via the following relation:

$$NK_{j,t} = I_{j,t} - D_{j,t} \tag{6}$$

A question that arises from the above stated definition is related with the notion of the deprecation of capital. In general we could relate the notion of depreciation with the following four senses that are widely used in accounting and economic literature [Goldberg (1955)]: (i) Depreciation as a fall in price, that is, the reduction of an asset's price that comes as a result of its purchase[4]. (ii) Depreciation as physical deterioration that results after the asset's use in production. (iii) Depreciation as fall in value that comes after the use of the asset and its technological obsolescence. (iv) Depreciation as allocation of cost, that is, the distribution of an asset's cost over the period that intervenes between the acquisition and the retirement of capital. In the analysis that follows we adopt the third of the above stated senses, considering capacity depreciation of capital assets as losses in their productive capacity as they age.

The size of region's j depreciation of capital stock at time t ($D_{j,t}$) is determined in the context of the following relation:

$$D_{j,t} = \sum_{i=1}^{n} d_i I_{j,t-i} \tag{7}$$

where d_i: the percentage of capital good's initial productive capacity that is lost i periods after its acquisition and n: the upper limit of its assumed service life.

After the substitution of relation (7) in (6) the latter is altered taking the form:

$$NK_{j,t} = I_{j,t} - \sum_{i=1}^{n} d_i I_{j,t-i} \tag{8}$$

From the above relation it is quite evident that the level of net investments is affected by the size of n, that is, the assumed service life of physical capital. The effects of different values of n on the series of net investments are investigated by Redfern (1955) and Nevin (1963). In our analysis the value of n is assumed to be determined exogenously and in the context of the tax legislation of Greece.

Net capital stock of region j at time t ($NK_{j,t}$) could be equivalently defined as the sum of region's gross investments at the same period ($I_{j,t}$) and the non depreciated gross investments of the last n periods ($ND_{j,t}$), that is:

$$NK_{j,t} = I_{j,t} + ND_{j,t} = I_{j,t} + \sum_{i=1}^{n} \left(1 - d_i\right) I_{j,t-i} \tag{9}$$

Regarding the designation of the functional form of depreciation we will follow the analysis of Coen (1975) and Linhart (1970) distinguishing between the following four different methods of physical capital's depreciation:

(*i*) The *straight line depreciation* (*sld*) according to which the productive capacity of physical capital is diminished by the same amount in each one of the n periods of its service life. At the end of the depreciation period the capital asset will have been fully depreciated. Setting $d_i = 1/n$ for $i = 1, 2, \ldots, n$, the level of depreciation at period t is determined in the context of the following relation:

$$D_{j,t}^{sld} = \sum_{i=1}^{n} d_i I_{j,t-i} = \frac{1}{n} \sum_{i=1}^{n} I_{j,t-i} \tag{10}$$

The magnitude of net capital stock of region j at time t, as this is determined via (9) after the substitution of (10), is computed by the following relation:

$$NK_{j,t}^{sld} = \frac{1}{n} \sum_{i=0}^{n} \left(n - i\right) I_{j,t-i} \tag{11}$$

(*ii*) The *double declining balance* (*ddb*) *depreciation* method, in the context of which the productive capacity of physical capital is diminished by a constant rate of $2/n$. It is worth mentioning that at the end of its service life the capital asset is not depreciated fully. It continues to contribute in the production process even after the end of its assumed service life. In this pattern of depreciation the depreciation rate is defined as $d_i = \left(2/n\right)\left[\left(n-2\right)/n\right]^{i-1}$ for $i = 1, 2, \ldots, n$, and the magnitude of the depreciation of gross investments at period t is determined via the following relation:

$$D_{j,t}^{ddb} = \sum_{i=1}^{n} d_i I_{j,t-i} = \frac{2}{n} \sum_{i=1}^{n} \left(\frac{n-2}{n} \right)^{i-1} I_{j,t-i} \tag{12}$$

The net capital stock of region j at period t, as this is determined via (9) after the substitution of (12), is evaluated according to the next relation:

$$NK_{j,t}^{ddb} = \sum_{i=0}^{n-1} \left(1 - \frac{2}{n} \right)^{i} I_{j,t-i} \tag{13}$$

(*iii*) The "*sum-of-the-years-digits*" (*syd*) method in the context of which we set $d_i = (n+1-i) \Big/ \sum_{i=1}^{n} i$ for i = 1, 2, …. , n , and the level of depreciation at period t is determined using the following relation:

$$D_{j,t}^{syd} = \sum_{i=1}^{n} d_i I_{j,t-i} = \frac{2}{n(n+1)} \sum_{i=1}^{n} (n+1-i) I_{j,t-i} \tag{14}$$

The basic characteristics of this method of depreciation are first, the faster depreciation of the capital asset at the first years of its service life and secondly, the rapid decline of its productive capacity.

The magnitude of net capital stock of region j at period t, as this is determined via (6) after the substitution of relation (14), is calculated with the help of the following mathematical expression:

$$NK_{j,t}^{syd} = I_{j,t} - \frac{2}{n(n+1)} \sum_{i=1}^{n} (n+1-i) I_{j,t-i} \tag{15}$$

or equivalently and using (9)

$$NK_{j,t}^{syd} = \sum_{i=0}^{n} \left[I_{j,t-i} \prod_{\ell=0}^{i} (1-d_\ell) \right] = I_{j,t} + \sum_{i=1}^{n} \left\{ I_{j,t-i} \prod_{\ell=1}^{i} \left[\frac{n(n-1) - 2(1-\ell)}{n(n+1)} \right] \right\} \tag{16}$$

where $d_0 = 0$.

(*iv*) The "*one-hoss shay*" (*ohs*) method, in the context of which the productive capacity of the capital asset is assumed to be unchangeable throughout its service life and the depreciation of the asset is taking place at the last year of its service life. The level of depreciation at period t that is determined according to this method is given by the following expression:

$$D_{j,t}^{ohs} = \sum_{i=1}^{n} d_i I_{j,t-i} \text{ , where } d_i = \begin{cases} 0 & \text{for } i = 1,\ 2,\ \ldots ,\ n-1 \\ 1 & \text{for } i = n \end{cases} \tag{17}$$

The magnitude of net capital stock of region *j* at period *t*, as this is determined via (6) or (9) after the substitution of (17), is calculated using the next relation:

$$NK_{j,t}^{ohs} = \sum_{i=0}^{n-1} I_{j,t-i} \tag{18}$$

Relations (11), (13), (15) and (18) will be used in section III in order to determine the series of net capital stock for the 13 regions of Greece assuming that $n = 18$ and $n = 25$.

III. EMPIRICAL RESULTS.

The thirteen geographic and administrative regions of Greece ($j = 1, 2, \ldots , 13$) that will be examined in our analysis are (*i*) Eastern Macedonia and Thrace ($j = 1$), (*ii*) Central Macedonia ($j = 2$), (*iii*) Western Macedonia ($j = 3$), (*iv*) Thessaly ($j = 4$), (*v*) Epirus ($j = 5$), (*vi*) Ionian Islands ($j = 6$), (*vii*) Western Greece ($j = 7$), (*viii*) Central Greece ($j = 8$), (*ix*) Attica ($j = 9$), (*x*) Peloponnese ($j = 10$), (*xi*) Northern Aegean Islands ($j = 11$), (*xii*) Southern Aegean Islands ($j = 12$) and (*xiii*) Crete ($j = 13$). In table 1 the available data on yearly basis are presented concerning the series of gross investment in regional ($I_{j,t}$) and national (I_t) level over the period 1974 ~ 2006.

A necessary premise for the determination of the net investment series is the knowledge of the gross investment series. Assuming that the service life span of physical capital is *n* years, the determination of the level of net investments for year t_1 requires the knowledge and use of gross investment series over the period $t_1 - n$ and t_1. This is the main problem we encounter in the case of the determination of Greek regional net investment series, given the lack of statistical data for the series of gross investment.

One way to avoid the above-stated problem is to make the arbitrary assumption that the level of regional gross investment series equals the annual average of the four first years of the period that data are available [Melachroinos & Spence (2000), pp. 55 ~ 57]. This methodology is, however, somehow not only arbitrary but also theoretically incorrect[5], given the fact that the level of capital stock is affected by differences in gross asset formation.

The application of the described in section II methodology concerning the determination of the net investment series of the thirteen Greek regions, begins with the investigation of the stationarity of $\left\{ I_{j,t} \right\}_{t=1974}^{2006}$, $j = 1, \ldots , 13$, sequences. The results of the *ADF* & *KPSS* unit root tests are presented in table 2.

Table 1
Gross Regional Capital Investments in Manufacture in Current Prices and Billion of Drachmas

Year	$I_{1,t}$	$I_{2,t}$	$I_{3,t}$	$I_{4,t}$	$I_{5,t}$	$I_{6,t}$	$I_{7,t}$	$I_{8,t}$	$I_{9,t}$	$I_{10,t}$	$I_{11,t}$	$I_{12,t}$	$I_{13,t}$
1974	0.534	2.620	1.598	1.405	0.108	0.019	0.545	3.921	10.927	1.056	0.079	0.186	0.180
1975	0.638	3.430	1.183	1.863	0.367	0.010	0.781	4.119	9.149	2.627	0.052	0.122	0.216
1976	1.514	3.700	1.108	3.050	0.342	0.023	0.951	7.068	8.976	1.380	0.045	0.107	0.216
1977	1.179	3.104	2.378	3.134	0.380	0.037	0.881	7.023	9.469	1.151	0.106	0.247	0.099
1978	1.691	5.311	0.487	2.278	0.371	0.048	1.481	6.614	12.190	1.916	0.070	0.131	0.413
1979	2.285	7.177	0.658	3.078	0.501	0.065	2.001	8.938	16.473	2.589	0.095	0.177	0.558
1980	2.370	7.998	1.079	5.668	0.657	0.042	4.108	12.974	18.453	5.366	1.107	0.232	0.661
1981	3.093	14.564	2.349	5.716	1.102	0.069	6.456	23.002	22.375	1.579	0.256	0.274	0.689
1982	4.884	13.148	1.866	5.462	0.544	0.063	5.114	19.256	21.035	3.729	0.119	0.298	0.541
1983	2.385	18.415	3.155	7.417	1.794	0.090	6.689	36.212	24.065	6.281	0.159	0.313	0.647
1984	7.557	13.385	2.646	5.409	0.332	0.348	5.058	28.390	24.266	6.734	0.061	0.283	0.762
1985	5.553	15.091	2.855	8.975	0.374	0.184	8.446	25.372	43.797	3.930	0.113	0.181	1.031
1986	4.550	18.844	2.451	7.816	0.752	0.254	5.716	21.366	60.588	7.646	0.100	0.172	1.006
1987	5.397	20.179	0.130	9.017	2.113	0.240	7.557	26.603	61.349	4.025	0.055	0.278	1.201
1988	7.879	30.488	2.213	6.967	1.037	0.792	9.903	34.920	61.153	4.440	0.020	1.044	1.435
1989	8.739	38.460	0.655	10.586	2.104	0.263	12.577	48.699	69.064	7.756	0.141	0.502	1.987
1990	8.368	38.090	0.214	15.131	1.476	0.427	12.543	62.637	79.190	15.010	0.320	0.827	3.412
1991	8.951	46.153	0.463	13.331	2.440	0.636	14.129	58.207	86.067	15.413	0.202	1.278	3.333
1992	11.435	46.830	0.151	18.769	3.920	0.568	10.491	51.552	111.280	12.661	0.240	0.903	2.985
1993	9.881	43.390	0.160	16.553	7.561	0.528	9.196	51.075	113.424	12.876	0.381	0.903	2.641
1994	25.152	47.954	0.616	17.457	5.180	0.960	10.035	43.222	116.982	14.624	1.144	0.765	3.902
1995	21.286	66.283	0.579	14.904	2.272	0.605	13.677	57.767	140.171	13.311	0.656	0.863	4.839
1996	26.956	66.639	0.579	26.923	3.750	0.560	21.820	55.418	122.016	13.274	0.511	1.034	6.961
1997	36.557	70.903	0.938	28.364	2.562	0.393	26.930	70.177	154.070	16.829	0.764	2.443	6.991
1998	47.954	87.439	0.582	35.751	6.210	0.688	24.717	94.946	214.937	18.340	0.394	2.268	7.900
1999	44.488	113.918	1.173	44.545	9.185	0.579	22.554	94.221	252.848	45.561	1.042	2.370	7.978
2000	49.060	142.326	1.837	47.768	6.519	0.407	21.443	132.952	285.421	78.201	1.034	2.999	12.161
2001	44.273	126.436	0.676	68.716	9.150	0.090	18.291	141.716	309.529	18.990	0.422	4.039	10.475
2002	54.081	107.974	1.571	33.901	11.819	0.366	15.651	110.211	241.028	27.295	0.453	5.939	10.544
2003	23.215	128.480	0.994	50.932	8.909	0.175	16.419	132.110	218.688	37.649	0.384	2.015	16.081
2004	23.199	105.227	0.383	47.340	4.813	0.112	19.073	89.737	252.728	30.892	1.753	2.251	13.492
2005	24.124	75.140	0.468	33.533	3.211	1.575	14.882	57.791	175.132	155.857	0.933	1.073	13.624
2006	31.577	103.299	5.879	56.770	14.339	0.539	17.225	103.774	442.524	27.217	2.822	2.049	13.621

Note: The data refers to manufactures with personnel of more than 20 workers.

Source: National Statistical Service (E.S.Y.E.) – Annual Industrial Surveys (Various Issues). The determination of the non available data concerning the years 1978 and 1979 was carried out in a two stage procedure. In the first stage, and covering the period 1974 ~ 1977 and 1980 ~ 2004, the mean percentage share of each region's gross capital stock in national gross capital stock was determined. In the second stage these shares were used to weight the data of national gross capital stock series for the years 1978 and 1979 and determine this way the level of gross capital stock for these two years and for each one of the thirteen Greek regions.

Table 2
***A.D.F.* vs *K.P.S.S.* Unit Root Test Results and Determination of Series order of Integration**

Var.		*A.D.F.*				*K.P.S.S.*						
		A.I.C.	*S.I.C.*	*H.Q.*		*Bartlet*	*Parzen*	*Q.S.*	*A.R. – O.L.S.*	*A.R. Spec.*	*A.R. – G.L.S.*	$\tilde{d}$
$I_{1,t}$	k	6	6	6	***BW/LL***	4	4	3.73	4	7	4	
	T_γ	– 5.622	– 5.622	– 5.622	***LMS***	0.088	0.081	0.082	0.997	39.636	0.774	0
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(0)	I(0)	I(0)	*d* > 3	*d* > 3	*d* > 3	
$I_{2,t}$	k	6	6	6	***BW/LL***	4	7	3.74	3	3	3	
	T_γ	– 5.012	– 5.012	– 5.012	***LMS***	0.111	0.103	0.103	0.00001	0.00001	0.002	0
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	
$I_{3,t}$	k	0	0	0	***BW/LL***	3	7	3.56	0	0	0	
	T_γ	– 5.778	– 5.778	– 5.778	***LMS***	0.118	0.105	0.111	0.081	0.082	0.068	1
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(0)	I(0)	I(0)	I(1)	I(1)	I(1)	
$I_{4,t}$	k	5	5	5	***BW/LL***	3	8	4.24	1	1	4	
	T_γ	– 4.099	– 4.099	– 4.099	***LMS***	0.045	0.131	0.137	0.005	0.002	11.794	1
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(1)	I(0)	I(0)	I(2)	I(2)	*d* > 3	
$I_{5,t}$	k	1	1	1	***BW/LL***	3	10	5.04	1	1	1	
	T_γ	– 4.404	– 4.404	– 4.404	***LMS***	0.137	0.181	0.166	0.041	0.041	0.042	0
	I($\tilde{d}$)	I(0)	I(0)	I(0)	**I(*d*)**	I(0)	*d* > 3	*d* > 3	I(0)	I(0)	I(0)	
$I_{6,t}$	k	0	0	0	***BW/LL***	3	7	3.69	0	0	0	
	T_γ	– 5.153	– 5.153	– 5.153	***LMS***	0.113	0.104	0.108	0.135	0.135	0.135	0
	I($\tilde{d}$)	I(0)	I(0)	I(0)	**I(*d*)**	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	
$I_{7,t}$	k	0	0	0	***BW/LL***	3	5	2.68	0	0	0	
	T_γ	– 4.402	– 4.402	– 4.402	***LMS***	0.084	0.079	0.080	0.066	0.066	0.066	0
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(0)	I(0)	I(0)	I(1)	I(1)	I(1)	
$I_{8,t}$	k	4	3	4	***BW/LL***	3	5	2.71	2	1	4	
	T_γ	– 4.461	– 6.207	– 4.461	***LMS***	0.069	0.066	0.065	0.548	0.008	0.002	0
	I($\tilde{d}$)	I(1)	I(0)	I(1)	**I(*d*)**	I(0)	I(0)	I(0)	*d* > 3	I(3)	I(0)	
$I_{9,t}$	k	4	4	4	***BW/LL***	3	5	2.76	3	5	7	
	T_γ	– 7.080	– 7.080	– 7.080	***LMS***	0.061	0.071	0.059	0.018	404.486	0.023	1
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(1)	I(1)	I(1)	I(2)	*d* > 3	I(0)	
$I_{10,t}$	k	3	3	3	***BW/LL***	0	10	5.19	5	4	6	
	T_γ	–12.469	–12.469	–12.469	***LMS***	0.038	0.169	0.161	67.530	1019.95	3.671	2
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(2)	*d* > 3	*d* > 3	*d* > 3	*d* > 3	*d* > 3	
$I_{11,t}$	k	0	0	0	***BW/LL***	4	4	2.2	0	0	0	
	T_γ	– 8.753	– 8.753	– 8.753	***LMS***	0.110	0.120	0.116	0.066	0.068	0.053	1
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	
$I_{12,t}$	k	0	0	0	***BW/LL***	2	3	1.58	0	3	6	
	T_γ	– 7.120	– 7.120	– 7.120	***LMS***	0.099	0.098	0.116	0.039	11.294	66.213	0
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(0)	I(0)	I(0)	I(1)	*d* > 3	*d* > 3	
$I_{13,t}$	k	1	1	1	***BW/LL***	0	14	7.22	1	1	1	
	T_γ	– 6.582	– 6.582	– 6.582	***LMS***	0.027	8.686	76.345	0.013	0.012	0.013	1
	I($\tilde{d}$)	I(1)	I(1)	I(1)	**I(*d*)**	I(1)	*d* > 3	*d* > 3	I(1)	I(1)	I(1)	

***Note* 1:** *k*: the truncation lag length parameter in equation (2), *BW/LL*: bandwidth selection (*BW*) using the *Newey – West* method in the case of *Bartlet*, *Parzen* & *Quadratic Spectral* estimation method and lag length selection (*LL*) using the *S.I.C.* criterion in the case of *A.R. – O.L.S. detrended*, *Autoregressive Spectral* & *Autoregressive – G.L.S. detrended* spectral estimation method.

***Note* 2:** $T_\gamma = \hat{\gamma} / se(\gamma)$: the *A.D.F.* test statistic & *LMS*: the LM statistic in the context of the *K.P.S.S.* unit root test.

***Note* 3:** The I(*d*) line indicates the degree of first differences in $\{\Delta^d I_{j,t}\}$ sequence, d = 0, 1, 2, 3, for which the unit root test is taking place, as well as the result of the unit root test at a 5% significance level.

***Note* 4:** *A.D.F.* critical values for 25 observations: – 4.38 (1%), – 3.95 (5%) & – 3.24 (10%).
K.P.S.S. critical values: 0.216 (1%), 0.146 (5%) & 0.119 (10%).

The inspection of the presented in table 2 unit root results drives us into the following inferences:

(*a*) The *A.D.F.* unit root test results are not sensitive either to the criterion used in order to select the value of the lag length parameter k or to the significance level at which the unit root test is conducted.

(*b*) In the context of the *A.D.F.* test all three information criteria result to the selection of the same value concerning the lag parameter k for all the series, with the exception of the gross investment series of the eighth Greek region (Central Greece).

(*c*) The *K.P.S.S.* test results are quite sensitive to the spectral estimation that is used[6] and less sensitive to the significance level of the chosen critical values.

(*d*) Using the proposed by Kwiatkowski et al. (1997) *Bertlet* spectral estimation method and at a 5% significance level, the *K.P.S.S.* unit root test indicates (*i*) the series of Eastern Macedonia and Thrace (j = 1), Central Macedonia (j = 2), Western Macedonia (j = 3), Epirus (j = 5), Ionian Islands (j = 6), Western Greece (j = 7), Central Greece (j = 8) and Southern Aegean Islands (j = 12) as stationary processes (d = 0), (*ii*) the series of Thessaly (j = 4), Attica (j = 9), Northern Aegean Islands (j = = 11) and Crete (j = 13) as integrated processes of order 1 (d = 1) and finally (*iii*) the series of Peloponnese (j = 10) as a second order integrated process (d = 2). It has to be noted that in the case of the gross investment series of Western Macedonia (j = 3), the inspection of the series' line plot and correlogram of its first and second differences are indicative of a first order integrated process.

(*e*) The *A.D.F.* and *K.P.S.S.* test results coincide in seven out of thirteen gross investment regional series (54%).

The second step of the followed procedure after the determination of series' stationarity is the specification of the *ARIMA*(p,d,q) models that underlie their time evolution over the period 1974 ~ 2006. The models that are selected between the fifteen $ARIMA\left(p,\tilde{d},q\right)$, where $p, q = 0, \ldots, 3$, candidate models, using the maximum value of the adjusted coefficient of determination as the selection criterion, are presented in table 3.

In the context of the presented in table 3 data we reach to the conclusion that three of the specified models (23%) are of the *AR*(p) type, two of them (15%) are *IMA*(d,q) models and four models are classified as *ARMA*(p, q) (31%) and *ARIMA*(p,d,q) (31%) type models. Using these models along with the appropriate number of initial conditions, the values of which for each series are determined using relation (4), we proceed with the specification of the data of the regional gross investment series over the period 1949 ~ 1973. The time evolution of series $I_{j,t}$, $j = 1, \ldots, 13$, over the periods 1949 ~ 1973 and 1974 ~ 2006 is presented graphically in the context of diagrams 1 and 2.

Table 3
The Selected *ARIMA*(*p, d, q*) Models that Describe the Time Evolution of Series
$\left\{ I_{j,t} \right\}_{t=1974}^{2006}$, $j = 1, \ldots, 13$.

Var.	*Model*	*Adj. R^2*	$\hat{\varphi}_1$	$\hat{\varphi}_2$	$\hat{\varphi}_3$	$\hat{\theta}_1$	$\hat{\theta}_2$	$\hat{\theta}_3$
$I_{1,t}$	**ARIMA(1,0,0)**	0.8011	0.9787[a]	~	~	~	~	~
$I_{2,t}$	**ARIMA(3,0,2)**	0.9220	0.0139[b]	0.2465[b]	0.7938[a]	1.4123[a]	0.6596[a]	~
$I_{3,t}$	**ARIMA(1,1,3)**	0.1775	0.1743[b]	~	~	– 1.3862[a]	1.3424[a]	– 0.8507[a]
$I_{4,t}$	**ARIMA(3,1,1)**	0.5536	– 1.2739[a]	– 0.1564[b]	0.4960[a]	0.9973[a]	~	~
$I_{5,t}$	**ARIMA(3,0,1)**	0.6579	1.6388[a]	– 1.3385[a]	0.8214[a]	– 0.9371[a]	~	~
$I_{6,t}$	**ARIMA(1,0,1)**	0.1738	1.0244[a]	~	~	– 0.7916[a]	~	~
$I_{7,t}$	**ARIMA(1,0,0)**	0.8642	1.0055[a]	~	~	~	~	~
$I_{8,t}$	**ARIMA(3,0,3)**	0.8909	0.0783[b]	0.2156[b]	0.7066[a]	0.7666[a]	1.0646[a]	0.8598[a]
$I_{9,t}$	**ARIMA(2,1,2)**	0.4945	– 0.9595[a]	0.0831[b]	~	0.3661[a]	1.0453[a]	~
$I_{10,t}$	**ARIMA(0,2,3)**	0.8493	~	~	~	– 2.4146[a]	1.9252[a]	– 0.4614[a]
$I_{11,t}$	**ARIMA(0,1,3)**	0.3404	~	~	~	– 0.6759[a]	0.8290[a]	– 0.8062[a]
$I_{12,t}$	**ARIMA(1,0,0)**	0.5365	0.8844[a]	~	~	~	~	~
$I_{13,t}$	**ARIMA(2,1,3)**	0.2801	0.0680[b]	0.5800[a]	~	– 0.5352[a]	– 0.6125[a]	0.9137[a]

Note: Index a (b) indicates statistically significant (insignificant) coefficients at 5% significance level.

The visual examination of the time plot of actual series $I_{j,t}$, $j = 1, \ldots, 13$, reveals an upward movement of the magnitude of nominal gross investments from 1974 to 2001 in the case of almost all Greek regions. This upward movement is milder in the 1970s and more rapid in the 1980s. The region of Peloponnese is an exception to this motive of movement since the region's series reveals a very mild upward movement from the begging of the sample period (1974) up to the mid 1990s. The rise of the magnitude of nominal regional gross investments in the 1970s and 1980s, could be largely attributed to the high inflation rates that characterizes the Greek economy as a whole[7].

After the mid 1990s the series present a very strong upward movement which could be partly be attributed to the funded by the European Union development programs. At the end of the 1990s and, especially, after the replacement of drachma by Euro as Greece's national currency in 2002, almost all series exhibit a downward movement. This type of movement could be largely attributed firstly, to the stock exchange crises in 1999 and secondly, to the loss of country's ability to depreciate its currency after the adoption of Euro in 2002 in order to boost the competitiveness of the domestically produced goods.

In the third and final step of the specified in section II procedure, we determine the magnitude of regional net capital series for two different depreciation periods.

Diagram 1: Time Evolution of the Simulated and Actual Series $I_{j,t}$, $j = 1, \ldots, 8$, over the Periods 1949 to 1973 and 1974 to 2006 Respectively

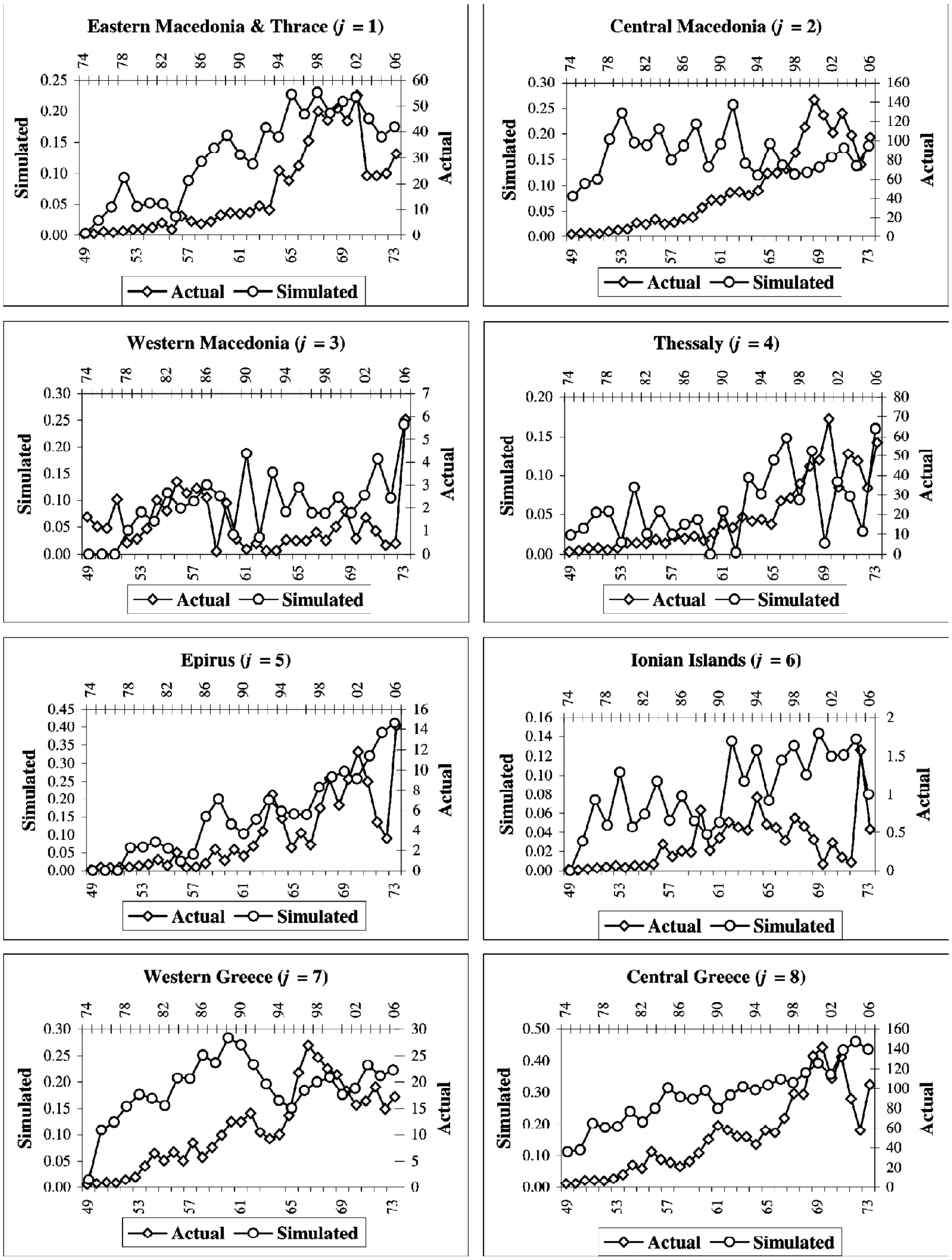
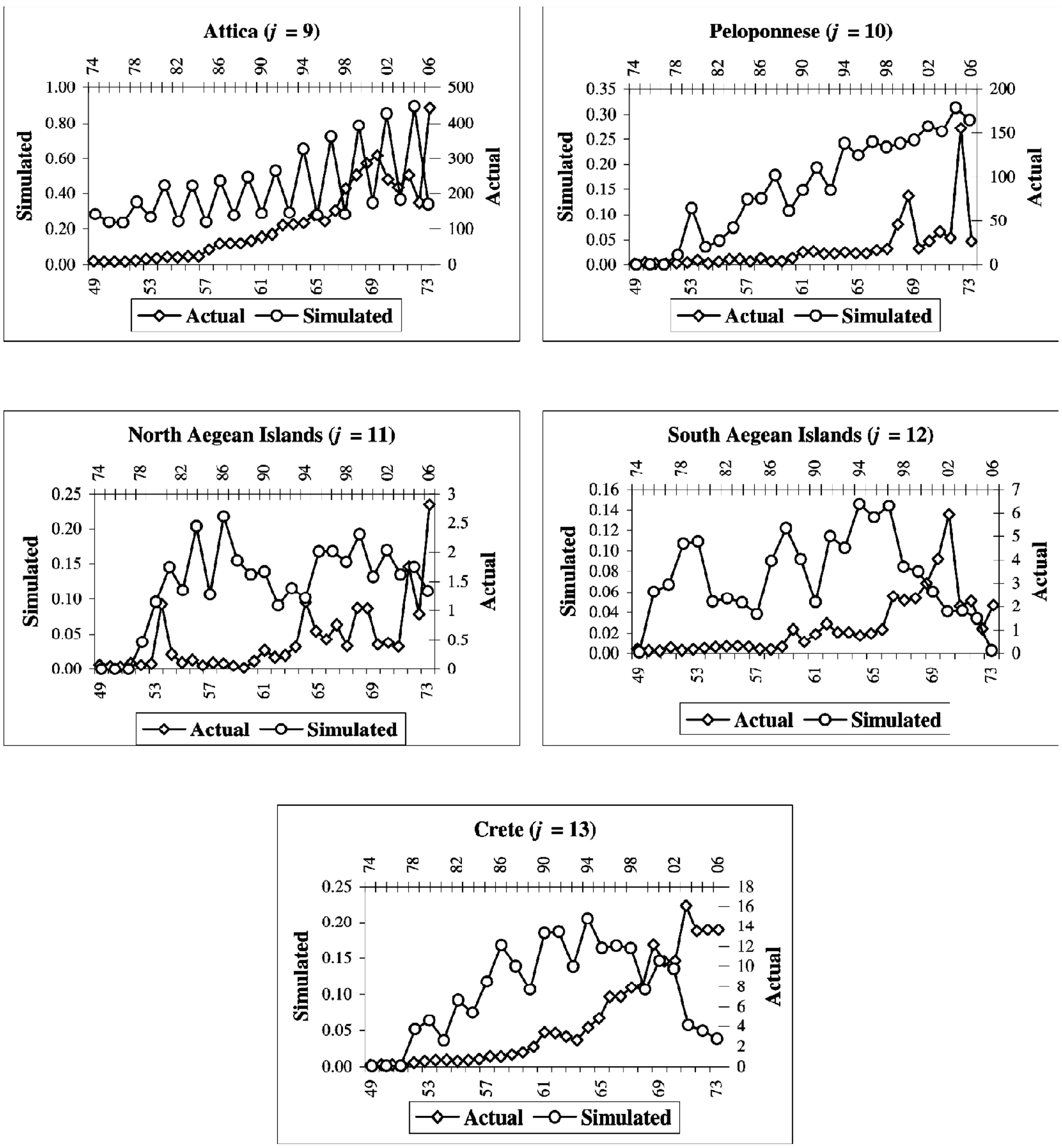


Diagram 2: Time Evolution of the Simulated and Actual Series $I_{j,t}$, $j = 9, \ldots, 13$, over the Periods 1949 to 1973 and 1974 to 2006 Respectively



More specifically, assuming that capital's service life (n) is either 18 or 25 years, we use the specified in the former step series $\left\{I_{j,t}\right\}_{t=1949}^{2006}$ to determine, in the context of relations (11), (13), (15) and (18) and for n = 18 & n = 25, the regional series of net capital over the period 1974 to 2006.

The time evolution of the series $\left\{NK_{j,t}\right\}_{t=1974}^{2006}$, j = 1, …. , 13, is graphically illustrated in diagrams 3 to 6. From the visual examination of these diagrams it is quite evident that firstly, regardless of the assumed time span of capital's service life, the use of *straight line* (*sld*) and *one – hoss shay* (*ohs*) method of depreciation result to the specification of net capital series with data observations that are very close in magnitude to each other. Secondly, among the four methods of capital depreciation that were used, the *straight line* (*sld*) and *one – hoss shay* (*ohs*) methods resulted to the specification of net capital series that were greater in magnitude. On the contrary, the smaller in magnitude series were determined in the case of all thirteen regions after the use of the *sum of the years digits* (*syd*) method of capital depreciation. Third, through out the sample period and regardless of capital's assumed service life and the used method of its depreciation, the net capital series exhibit an upward movement in the case of all regions with the exception of the regions of Western Macedonia and Ionian Islands. Fourth, in the case of Western Macedonia (j = 3) and Ionian Islands (j = 6), the $NK_{j,t}$ series exhibits a local maximum in 1987 and 1999 respectively. This is also the case in the line plot of net capital series of Western (j = 7) & Central (j = 8) Greece and Southern Aegean Islands (j = 12), all of which exhibit a local maximum in 2004.

IV. CONCLUSIONS

In the present paper the nominal net capital series of thirteen Greek regions were derived covering the period from 1974 to 2006. The main problem that was encountered in determining these series was the lack of sufficient statistical data concerning the nominal series of regional gross investments ($I_{j,t}$) during a period of 25 years prior to the benchmark year of 1974.

In order to resolve the above-stated problem a three-step procedure was followed in order, firstly, to identify the *ARIMA*(p,d,q) models that describe the diachronic evolution of the series $I_{j,t}$, j = 1, …. , 13 , over the period from 1974 to 2006 for which statistical data are available and, secondly, to use these models in the context of a calibration analysis in order to define, after 1000 replications, the yearly observations of the $\left\{I_{j,t}\right\}_{t=1949}^{1973}$ as the mean yearly observations of the 1000 simulated series $\left\{I_{j,t}\right\}_{t=1949}^{1973}$.

Diagram 3: Diachronic Evolution of Regional Net Capital Series $NK_{j,t}$, $j = 1, \ldots, 4$, over the Period 1974 to 2006 for $n = 18$ & $n = 25$ Years

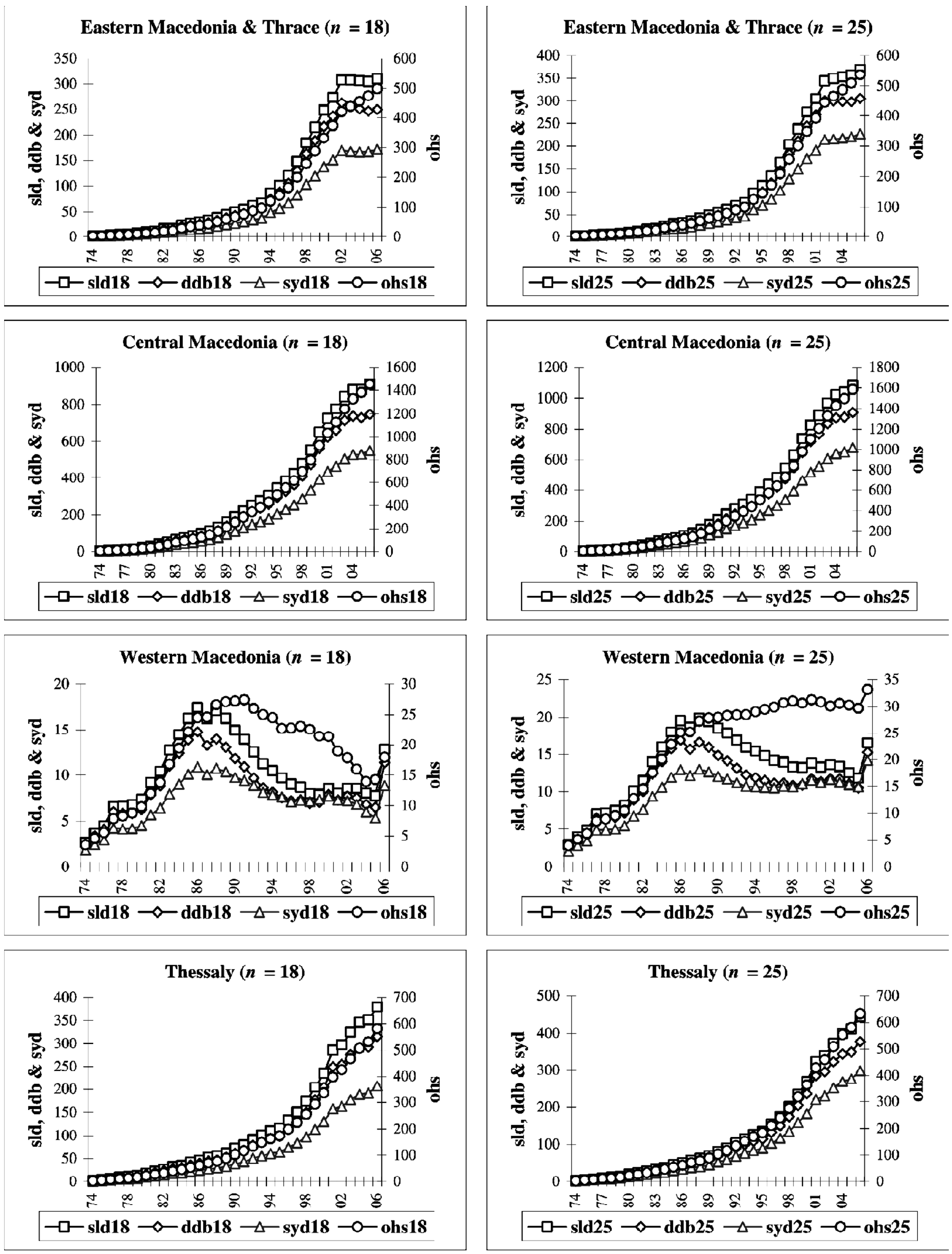


Diagram 4: Diachronic Evolution of Regional Net Capital Series $NK_{j,t}$, $j = 5, \ldots, 8$, over the period 1974 to 2006 for $n = 18$ & $n = 25$ Years

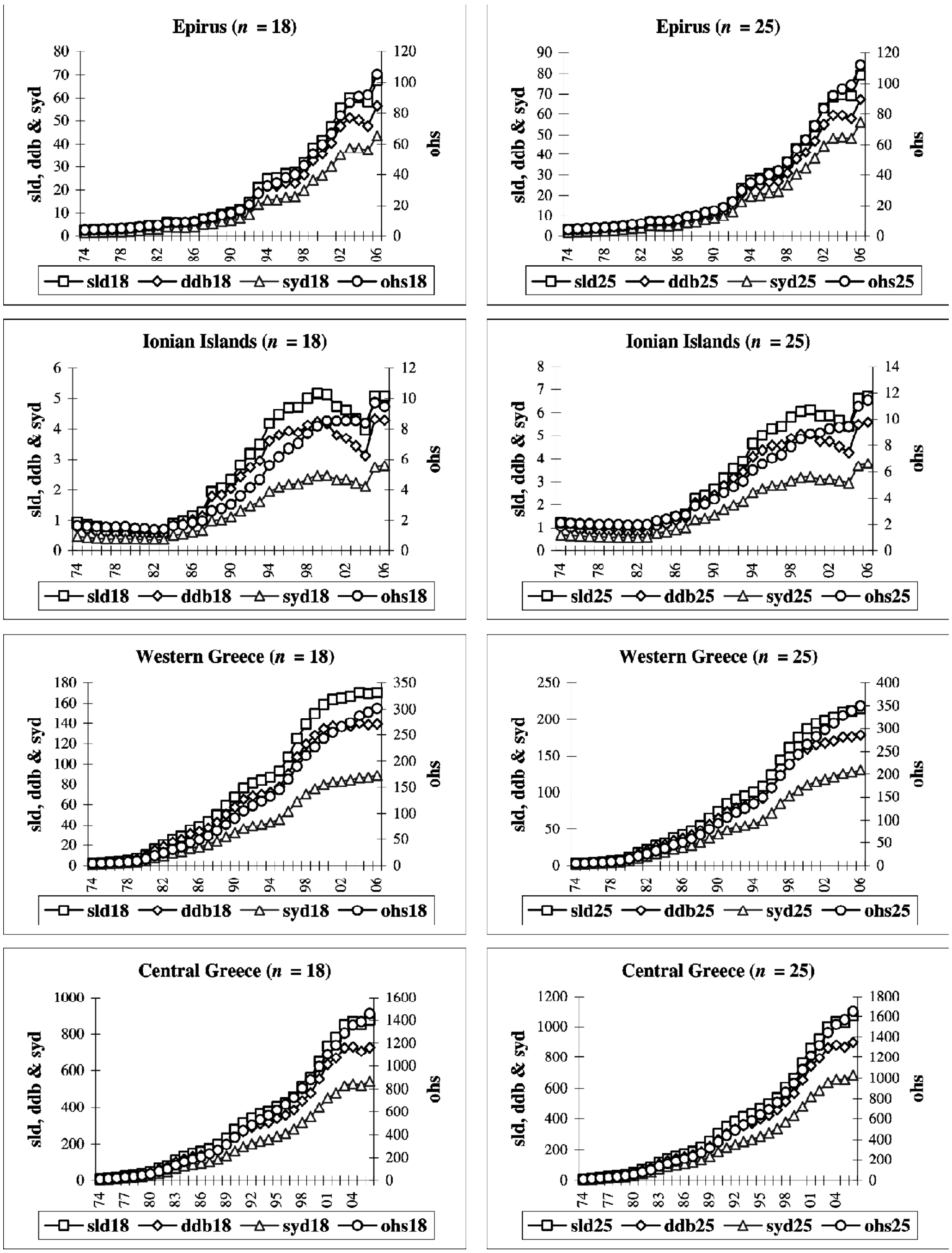


Diagram 5: Diachronic Evolution of Regional Net Capital Series $NK_{j,t}$, $j = 9, \ldots, 12$, over the Period 1974 to 2006 for $n = 18$ & $n = 25$ Years

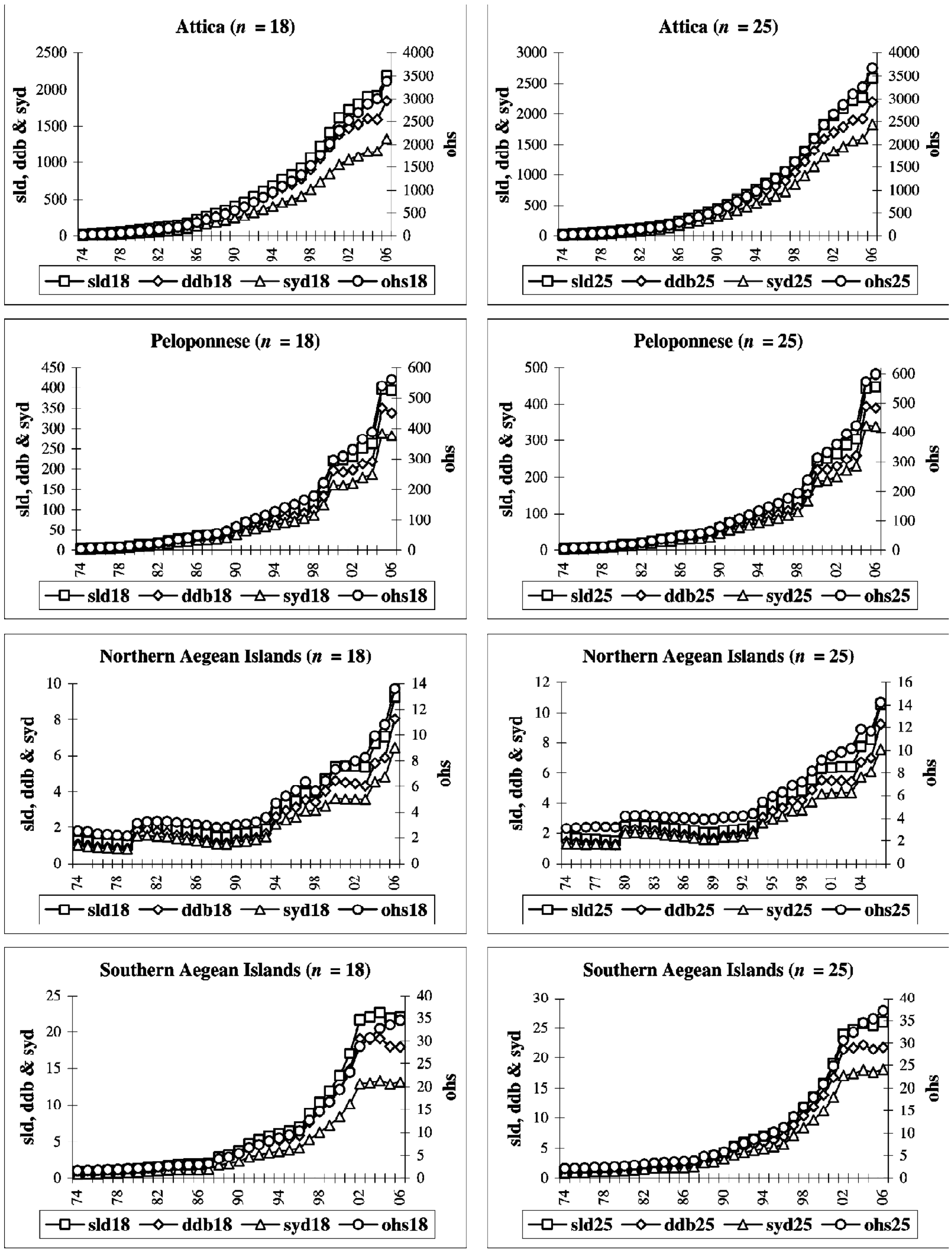
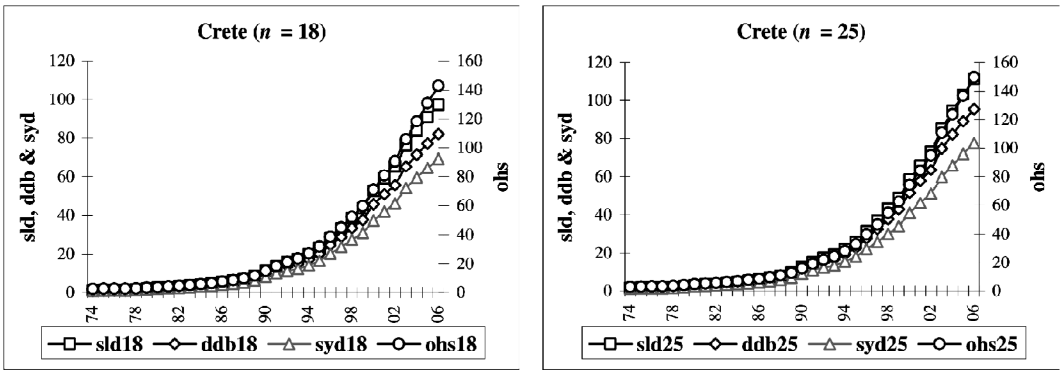


Diagram 6: Diachronic Evolution of Regional Net Capital Series $NK_{j,t}$, j = 13, over the Period 1974 to 2006 for n = 18 & n = 25 Years



After the determination of $\left\{I_{j,t}\right\}_{t=1943}^{2006}$, j = 1, …. , 13 , series, the regional series of net capital ($NK_{j,t}$) were determined, assuming that capital's service life was either 18 or 25 years and using four different methods of capital depreciation, that is the *straight line* (*sld*), the *double declining balance* (*ddb*), the *sum of the years digits* (*syd*) and the *one – hoss shay* (*ohs*) method of capital depreciation.

The use of the *sld* & *ohs* (*syd*) method of capital depreciation resulted in the determination of regional net investment series that were higher (lower) in magnitude in most of the examined series. The $\left\{NK_{j,t}\right\}_{t=1974}^{2006}$ series are proved to be positively related to time regardless of the assumed service life of capital and the mechanism of its depreciation, in the case of the regions of Eastern Macedonia & Thrace (j = 1), Central Macedonia (j = 2), Thessaly (j = 4), Epirus (j = 5), Attica (j = 9), Peloponnese (j = 10), Northern Aegean Islands (j = 11) and Crete (j = 13). In the cases of the regions of Western Macedonia (j = 3), Ionian Islands (j = 6), Western (j = 7) & Central (j = 8) Greece and Southern Aegean Islands (j = 12), the line plot of $\left\{NK_{j,t}\right\}_{t=1974}^{2006}$ series exhibits a local maximum that takes place (*i*) in 1987 for j = 3, (*ii*) in 1999 for j = 6 and (*iii*) in 2004 for j = 7, j = 8 & j = 12.

Notes

1. This specific significance level will be used throughout our empirical analysis, in order to investigate the statistical significance of the null hypothesis in the context of various statistical tests.

2. In the context of these selection methods bandwidth is selected using the *Newey – West* method and the magnitude of the lag length in the test equations is determined using the *Schwarz Information Criterion* (*S.I.C.*).
3. The autocorrelation of residuals is tested using the *Breusch – Godfrey* LM statistic including 3 lags in the test equation, while the hypothesis of homoskedasticity is tested by performing an *ARCH* LM test with the inclusion of 1 lag in the test equation.
4. As an example we could mention the case of an asset that is sold right after its purchase. In this case the reduction in price comes as a result of the asset's sale as a second hand and not because of its use.
5. *Op. cit.* page 55.
6. The six spectral estimation methods result to the same conclusion concerning the series' stationarity only in three out of thirteen (23%) Greek regions, that is Central Macedonia, Ionian Islands and North Aegean Islands.
7. In yearly bases the mean percentage change of national *Consumer Price Index* (*C.P.I.*) over the periods 1974 ~ 1980, 1981 ~ 1990, 1991 ~ 2000 & 2001 ~ 2006 was 16.6%, 18.9%, 8.6% & 3.2% respectively (Bank of Greece – Statistical Data).

References

Boskin, M. J.; Robinson, M. S. & Huber, A. M., (1987), "New Estimates of State and Local Government Tangible Capital and Net Investment", N.B.E.R. Working Paper Series, No 2131.

Coen, R. M., (1975), "Investment Behavior, The Measurement of Depreciation, and Tax Policy", *The American Economic Review*, 65 , 1 , 59 ~ 74.

Dadkhah, K. M. & Zahedi, F., (1986), "Simultaneous Estimation of Production Function and Capital Stocks for Developing Countries", *The Review of Economics and Statistics*, 68, 3, 443 ~ 451.

Dean, G. & Irwin, J. O., (1964), "The Stock of Fixed Capital in the United Kingdom in 1961", *Journal of the Royal Statistical Society*. *Series A* (*General*), 127, 3, 327 ~ 358.

Domar, E. D., (1953), "The Case for Accelerated Depreciation", *The Quarterly Journal of Economics*, 67, 4, 493 ~ 519.

Garafalo, G. A. & Yamarik, S., (2002), "Regional Convergence: Evidence from a New State – by – State Capital Stock Series", *The Review of Economics and Statistics*, 84, 2, 316 ~ 323.

Georganta, Z.; Kotsis, K. & Kounaris, E., (1994), "Measurement of Total Factor Productivity in the Manufacturing Sector of Greece, 1980 ~ 1991", Discussion Paper, 35, Athens: Centre of Planning and Economic Research.

Goldberg, L., (1955), "Concepts of Depreciation", *The Accounting Review*, 30, 3, 468 ~ 484.

Linhart, P. B., (1970), "Some Analytical Results on Tax Depreciation", *The Bell Journal of Economics and Management Sciences*, 1, 1, 82 ~ 112.

Melachroinos, K. & Spence, N., (2000), "Constructing a Manufacturing Fixed Capital Stock Series for the Regions of Greece", *European Planning Studies*, 8, 1, 43 ~ 67.

Nevin, E., (1963), "The Life of Capital Assets: An Empirical Approach", *Oxford Economic Papers*, 15, 3, 228 ~ 243.

O.E.C.D., (1987), Flows and Stocks of Fixed Capital 1960 ~ 1985, Department of Economics and Statistics, Paris: O.E.C.D.

O.E.C.D., (1994), Flows and Stocks of Fixed Capital 1967 ~ 1992, Department of Economics and Statistics, Paris: O.E.C.D.

Redfern, P., (1955), "Net Investment in Fixed Assets in the United Kingdom, 1938 – 1953", *Journal of the Royal Statistical Society*. Series A (General), 118, 2, 141 ~ 192.

Scountzos, T. & Mattheou, G., (1991), Measurement of the Capital Stock of the Greek Economy, Internal Document, Athens: Centre of Planning and Economic Research.