AN EMPIRICAL INVESTIGATION OF THE FDI & EXPORT LED GROWTH HYPOTHESIS (ELGH): EVIDENCE FROM THE GREEK ECONOMY

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We present time series evidence theoretically consistent with the Export-Led- Growth (ELGH) and the FDI-Led-Growth Hypothesis (FLGH), applying annual data over the period 1976 – 2004 of the Greek Economy. The empirical analysis employs an eclectic causality model for income growth, using the ARDL approach to cointegration. Evidently, FDI financing, under changing fiscal and monetary regimes, and Exports advancement, along with Debt management are inextricably linked, within the long run growth process. These intimate links still remain challenging and demanding research needs.

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INTRODUCTION

What seems to be a common sense conclusion, given the vast literature on growth, is the fact that there is no unique and single factor upon which economic growth could be totally based. Nevertheless, from the neoclassical paradigm up to endogenous growth, economic theories seem to identify investment(s) as the main, but not unique, factor leading to long run growth (Knight *et al.*, 1993; Nelson & Singh, 1994; Easterly & Rebelo, 1993). Further, remembering Jones (1995), we still contemplate whether endogenous growth stands true, since permanent increase in investment(s) does not lead to permanent increase in growth rates; and, R&D expenses do not affect long run growth, unless we foresee a future of centuries ahead (McGrattan, 1998).

On the other hand, certain need arises, within the empirical quest for growth, to incorporate elements of a demand oriented theory of economic growth in which major constraints on demand in open economies seem to be the balance of payments and the relevance of export-to-import volumes (McCombie & Thirlwall, 1997).

Besides, another economic issue still under debate is whether fluctuations in money could affect fluctuations in income (nominal or real) and prices over time, in a regular and systematic way. Conflicting evidence on the role of money and/or interest rates on income is reported in the relevant empirical literature (Sims, 1972; 1980; Bernanke & Blinder, 1988; Friedman & Kuttner, 1992; King & Levine, 1993).

A basic reference on the Export–Led-Growth hypothesis (ELGH) is also necessary in this paper. The latter hypothesis postulates that export expansion is a major determinant of income growth, but the evidence over the last thirty years is far from conclusive[1]. Additionally, the role of FDI as an important vehicle of economic growth seems to be crucially relevant to the host country's institutional characteristics, such as its legal system, the enforcement of property rights, and human capital formation (Blomstrom *et al.*, 1994; Borensztein *et al.*, 1998). In short, FDI is assumed to be an important vehicle for transfer of technological and business know-how; where, these knowledge transfers may have substantial spillover effects for the entire host economy.

Accordingly, in this paper we study the link(s) between foreign direct investment(s) (FDI), real aggregate exports and GDP growth, with reference to the Greek Economy; given the currently existing and available yearly data from 1976 up to 2004 (applying the corresponding OECD – 2006, Statistical Compendium). The main purpose of the paper is to provide new and additional evidence on the role of certain real variables within the income growth process. In fact, the export-led growth hypothesis as well as the FDI-Led-Growth hypothesis (FLGH) are clearly considered within this context.

More particularly, our research contribution is threefold. First, we provide new evidence with respect to the Greek Economy, considering simultaneously the long run effect of FDI inflows and exports on income growth up to 2004. Second, the ARDL approach to cointegration is applied, considering the small samples advantages of the method and the stringent official long-run time series data availability problem of the Greek Economy. Third and final, our eclectic modeling approach takes into account the important missing variables issue, by incorporating government investment(s) and primary government deficit along with inflation as exogenous variables.

The paper is organized in 5 sections. Specifically, section 2 refers to the fundamental theoretical foundation pertaining to the income growth literature, with a short basic note on the latest fundamentals of the Greek Economy. Next section 3 describes our methodology and the model structure that we follow. Section 4 clarifies our empirical results, whereas; last section 5 presents a short summary and the main conclusions of the paper. Our appendix, at the end, reports in table form, all our findings.

THEORETICAL BACKGROUND

Our theoretical foundation relies on the fundamentals of the main determinants of economic growth and proceeds with the presentation of some minimal characteristics of the country of current interest; that is, the Greek Economy of the last few decades.

Since the early work of C. A. Sims (1972) empirical validation of money and income fluctuations has been established (Sims, 1972; 1980). Friedman and Kuttner (1992) show

that the U.S. experience does not provide any strong long run causal relationship between money and non-financial economic activity, for the whole time period under investigation. In contrast, they report significant effects from interest rates on income after 1980. Thus, they conclude that as long as monetary variables no longer contain evidenced information about the non-financial economic variables up to the early 1990's, new sources of potential information must be sought.

Murdock and Stiglitz (1993) argue that by lowering the cost of borrowing, government increases the profitability of firms and thus their investment. As a result of lower interest rates, banks will attract safer applicants for loans, thus lowering the probability of default and enhancing the safety of banks. Consequently, the greater safety by banks and a more efficient and productive financial system may induce more savings towards investment (Murdock and Stiglitz, 1993)[2].

In the process of economic growth, governments, intending to transfer economic revenues towards public investments, finance public activities by expanding money supply above real money balances, thus inducing inflation. Inflation, next, is a mechanism of transferring resources to the government through seigniorage. Bruno (1995) showed that for a sample of 127 countries over the 1960-1992 period, inflation rates up to 5 per cent contribute positively to growth; whereas, inflation rates above 30 per cent induce negative economic growth relationships.

In addition, less emphasis in the literature has been explicitly and directly placed upon the impacts of national budget deficits/debt on the role of economic growth per se. Given the concern in the economics literature, it is expected that accumulated budget deficits act to significantly reduce the economic growth rate (Cebula, 1995; Martin & Fordmanesh, 1990; Tanzi, 1985). More recently, Taghavi (2000) argues that debt causes significant adverse effects on investment, but its impact on growth is not clear cut. He also concludes that debt appears to be inflationary in most cases (EU countries), in the long run, although it produces no clear short run pattern on inflation.

Poole (2007) argues strongly that long run "price stability", that is long run "low and stable rate of inflation", is the most powerful tool the Central Bank has to promote economic growth, high employment and financial stability. Thus, maintaining low and stable inflation is indeed central to achieving maximum employment and the highest possible rate of economic growth (Poole, 2007).

Under such conditions, firms have less incentive to invest, and growth will be lower, due to price and inflation instability. Significant research (Levine & Renelt, 1992; Bruno & Easterly, 1996; 1998; Barro, 1996) suggests that inflation is not closely related to growth, so long as inflation is not too high; that is, below a general threshold of around 20 percent. So it seems that there is a range of inflation rates where prices are perceived as stable, and thus allow sound business decisions, providing the basis for strong revenue growth through credible investments, rational consumer decisions and reliable demand growth.

A last, but not least, reference on the export-led growth hypothesis (ELGH) is necessary to clarify the theoretical perspective in this paper. The export-led growth hypothesis postulates that export expansion is a major determinant of income growth. Exports

expansion can perform as an "engine-of-growth". Despite the vast amount of research concerning the ELGH during the past thirty years, the evidence available is far from conclusive and this situation explains some of the reasons as to why the debate on ELGH real economic effects still exists in the economic literature[3].

Recent additional evidence (Pereira & Xu, 2000) supports the view that export growth affects positively the evolution of GDP, domestic employment, and investment in outward –looking countries, so that their results strongly support the ELGH hypothesis. After all, the long run rate of growth of income per capita depends ultimately on technological progress, including the improvement of human, financial and physical capital, as well as creative and innovative entrepreneurship.

It is certain that economists continue to debate the rather complex relationships between increasing openness of economies and their ability to grow sustain ably. Moreover, FDI investment, in an open economy, can be theoretically a catalyst to growth and to a more rapid diffusion of modern technology. Empirically, current evidence supports the view of positive influence of FDI on economic growth rates, pending upon the per capita income level (Blomstrom *et al.*, 1994).

In theory, there are several potential ways in which FDI can affect growth rates. The Solow-type neoclassical growth models suggest that FDI increases the capital stock and thus growth rates in the host economy, by financing capital formation (Brems, 1970). The positive effect of FDI on growth through capital accumulation requires that FDI does not *crowd-out* equal amounts of investment from domestic resources.

Indeed, Agosin and Mayer (2000) argue that FDI in the form of mergers and acquisitions do not necessarily increase the capital stock in capital scarce economies, since cross border mergers and acquisitions merely represent a transfer of existing assets from domestic to foreign hands. The most plausible explanation for the negative effects of FDI on domestic growth is that foreign firms reduce the productivity of domestic firms through competition effects, as suggested by Aitken and Harrison (1999). Despite these potential negative effects, the empirical evidence generally suggests that FDI has a positive impact on economic growth in developing countries (Lim, 2001; Hansen and Rand, 2006).

The Case of the Greek Economy: Basic Characteristics

This section briefly presents the course of the economic growth rate in the Greek Economy of the last few decades. Namely, in short note, Greece (Hellenic Republic) is a small open EU economy; where, fairly remarkable growth rates, these being above 3 per cent annually, achieved after the early nineties, have enabled the country to enter the euro zone by 2001.

Until the early 1980's, the Greek Banking system was functioning under a complex system of tight credit rules, within a financial environment of administrative fixed interest rates (Lenive and Zervos, 1996, 1998). Throughout the 80's, a process of gradual market liberalization was motivated by certain economic needs for participation in the single European Market. During the early 1990's (1991-1992), recent modernization of the capital market included the operation of the credit institutions (Basic Banking Law), the operation of the Parallel Stock Exchange for smaller firms, and the Central Securities Depository

Company was established. Also, the number of credit institutions increased from 41 to 50, and the role of the Athens Stock Exchange (ASE) was upgraded substantially. Ever since, interest rates are freely determined, the public sector meets its borrowing requirements through the money and capital markets, and the banks are allowed to extend credit on competitive terms. Consequently, the major deregulation of the banking sector in 1992 is considered a major breakpoint in the history of the sector itself (See also, Garganas and Tavlas, 2001).

In December 1997, the Greek Parliament approved Central Bank independence. Price stability became the Bank's main goal, along with control over the exchange rate policy within a framework agreed with the government. During this period of the late 1990's, the basic policy innovations were the development of a hard exchange rate policy, commencing in 1995; and, a prohibition of monetary financing of the deficit. The hard exchange rate policy worked to squeeze inflation under 3 per cent by 1999, and the prohibition of the monetary financing of the deficit eventually reduced the fiscal deficit itself.

Monetary policy took the burden of controlling disinflation during 1995-2000, whereas both fiscal and incomes policies were tightened for overall economic policy sustainability and credibility purposes. Inflation fell from about 9 per cent in 1995 to under 3 per cent in 2000, while real income growth averaged more than 3 per cent annually during the last years. As inflation subsided, along with seigniorage, nominal interest rates fell significantly, converging towards E.U. member states having low inflation rates (Garganas and Tavlas, 2001).

The Greek Economy stands out for both the consistently small role of FDI and also for the fact that there was no boost to FDI after accession to the EU. FDI averaged only about 1,5 per cent of GDP in the 1970s, further declining in subsequent years. FDI remained in the range of about one per cent of GDP throughout the 1990s. Moreover, there has been a substantial deterioration of Greek competitiveness, since exports declined as a proportion of GDP over the past 20 years, and FDI has averaged, as mentioned, only about one per cent of GDP.

The obstacles for Greece to become a regional attractor of FDI seem to be problems of infrastructure in some areas (postal service, and electricity generation), the rigidity of labor markets, and the need for product-market, tax and pension, and labor market structural reforms (Bosworth and Kollintzas, 2001). Inferior performance in terms of export volume, the increase in the trade deficit and the decline of share of exports in GDP, along with the trade deficit widening to about 14 per cent in 1999 point to a demand shift away from Greek exporting goods and to non-price factors, such as quality and marketing along with vulnerability of Greek exports to intense competition from other industrializing countries (Spraos, 2001).

METHODOLOGY AND MODEL STRUCTURE

The autoregressive distributed lag (ARDL) approach to cointegration applied in this paper is a relatively recent technique for detecting possible long-run relationships among economic variables. The ARDL approach is a more efficient technique for determining cointegrating relationships in small samples. An additional advantage of the ARDL

approach is that it can be applied irrespective of the regressors' order of integration (Pesaran and Shin (1999)); that is, it can be applied regardless of the stationary properties of the variables in the sample, thus allowing for statistical inferences on long-run estimates which are not possible under alternative cointegration techniques. Hence, we are not concerned whether the applied series are $I(0)$ or $I(1)$. The general form of the ARDL model (Pesaran and Shin, 1999) is defined as:

$$\Phi(L)y_t = \alpha_0 + \alpha_1 w_t + \beta'(L)x_{it} + u_t, \tag{1}$$

where:
$$\Phi(L) = 1 - \sum_{i=1}^{\infty} \Phi_i L^i, \quad \text{and} \quad \beta(L) = \sum_{j=1}^{\infty} \beta_j L^j,$$

with (L) being the lag operator and (w_t) being the vector of deterministic variables such as the intercept, seasonal dummies, time trends or any exogenous variables (with fixed lags). This approach follows three steps; namely, step one is the establishment of the long-run relationship between the variables (unrestricted error correction mechanism regression). Step two is the estimation of the ARDL form of equation (1), where the optimal lag length is chosen according to the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC). Step three refers to the estimation of error correction equation, using the differences of the variables and the lagged long-run solution, where the speed of adjustment of the equilibrium is determined.

DATA AND EMPIRICAL RESULTS

Our empirical analysis engages currently available annual data of the Greek economy taken from the OECD – 2006, Statistical Compendium and the period covered runs from 1976 up to 2004. The key determinants of income growth (dLYR), which is proxied by the first difference of the log of the real income (LYR), have been considered by including as regressors the log of the real export(s) (LXPR), the log of real Foreign Direct Investment(s) (LFIR); whereas, the ratio of government investment(s) over GDP (GIOY), second the ratio of the primary government deficit over GDP (DOY), and third the log of the consumer's price index (DLP) as a proxy for monetary policy performance constitute a group of relevant *control variables* to avoid model misspecification, as well as the problem of important omitted variables. The above variables have been included aiming to capture both the FDI-Led-Growth and the Export-Led-Growth characteristics of the Greek Economy, given the specific exogenous variables in this modeling.

We proceed with the examination of the joint integration properties of the series using the ARDL cointegration methodology. Actually, instead of employing the traditional methodology proposed by Johansen (1988 and 1989), which requires non-stationary variables of integration order $I(1)$, we apply the ARDL Cointegration method proposed by Pesaran (1992). The ARDL method has the advantage to avoid the problem of pre-testing for the order of integration of the individual series; besides, ARDL is a singe equation estimation technique and requires the estimation of a fairly smaller number of parameters compared to the Johansen's method. Consequently, ARDL proves to be more efficient when small data samples are available. The optimal lag structure of the model is chosen based on the Akaike Information Criterion (AIC), using a max lag length of three periods. The *F*-test along with the critical value bounds are reported in Table (1). Given that

$F = 12.192$ is far above the upper bound value the evidence is in favor of the existence of a long-run equilibrium relationship with long-run causality running from $LXPR$ and $LFIR$, towards LYR.

In fact, we estimate the unrestricted error correction (EC) model (2), with $DLYR$ as the dependent variable and apply the aforementioned F-test on the group of the lagged level variables. Model (2) is described as follows:

$$DLYR = a_0 + \sum_{j=1}^{n} b_j \, DLYR_{t-j} + \sum_{j=0}^{n} c_j \, DXPR_{t-j} + \sum_{j=0}^{n} d_j \, DLFIR +$$

$$+ \lambda_1 \, LYR_{t-1} + \lambda_2 \, LXPR_{t-1} + \lambda_3 \, LFIR_{t-1} + exog + \varepsilon_{1t} \,, \tag{2}$$

where, the parameter λ_i, $(i = 1, 2, 3)$, is the corresponding long-run multiplier, while the parameters b_j, c_j, d_j, are the short-run dynamic coefficients of the underlying ARDL model; whereas, $exog$ represents a set of selected control variables, that is the ratio of government investment(s) over the GDP (GIOY), the ratio of the primary government deficit over the GDP (DOY), the inflation rate (DLP) and a time trend.

Having confirmed the existence of cointegration among the involved variables, we proceed with the estimation of the appropriate ARDL model for the LYR variable. The optimal ARDL (3, 2, 3) specification has been chosen based on the AIC and is presented in Table (2). The corresponding diagnostic tests validate the estimates while the plots of the corresponding CUSUM and CUSUMSQ tests, based on the recursive residuals (Graphs 1 and 2), identify long-run structural stability for the model's coefficients.

The estimated long-run coefficients from the implied ARDL structure are reported in Table (3). The estimates reveal strong positive causal effects directed from the real and standardized for LYR, exports (at a smaller than the 1% level of statistical significance) and the foreign direct investment(s) (at a smaller than the 5% level of statistical significance) towards income. Moreover, the ratio of government investment(s) over GDP and the ratio of the primary government deficit over GDP are found to be also highly statistically significant and positively related to long run growth. However, DLP is found statistically insignificant.

Finally, Table (4) presents the estimates from the EC specification. The existence of a long-run causal relationship among the examined variables is confirmed once again since the coefficient of the lagged EC term is found statistically significant (the p-value of the applied t-test is smaller than the 1%) and has the correct sign suggesting that any deviation from the long-term income path is corrected by 85 per cent over the following year. With regard to the short-run dynamics of the estimated relationship, there is evidence of significant Granger-type causal effects running from real exports (Wald p-value = 0,082), and foreign direct investment (Wald p-value = 0,000), to income growth.

SHORT SUMMARY AND CONCLUSIONS

Summarizing our work, we restate that using annual data over the 1976-2004 period of the Greek economy, our analysis employs an eclectic model for explaining impacts to income growth using the ARDL approach to Cointegration.

We further note our emphasis on the macroeconomic role of real exports firstly and, foreign direct investment(s) secondly, for explaining long-run income growth in the Greek economy over the specific time period. We follow the Export-Led-Growth hypothesis (ELGH) and the FDI-Led-Growth hypothesis (FLGH), as our theoretical foundation, given our specific emphasis on the exogenously taken role of the Keynesian themes described by the variables of government investment(s) and the government deficit ratios over GDP.

The empirical findings presented in this paper clearly show that evidence based on the most official and recent Greek economic data does indicate a close and reliable relationship between real exports and income growth, in the long run. The study finds that the ELGH is valid in the particular case of the Greek Economy, given the certain role of our exogenous variables. Similar conclusions were derived regarding the examination of the broadly known and debatable FLGH.

Moreover, our observable and verifiable empirical relationships bear certain implications for the design and implementation of fiscal policy with respect to government investment(s) and long run deficit management. In the presence of the given evidence, there is sound empirical necessity to direct focused research on the detailed functioning of the long run fiscal policy and the special role of productive state investment(s) along with prudent deficit management along the EU directives, so that long run growth maintains its velocity, under the currently depressing global turmoil.

NOTES

1. See especially the relevant works of Edwards (1998), Barro and Sala-I-Martin (1998), Frankel and Romer (1999).

2. See for additional details, Angeloni *et al.*, (2003). Further evidence reveals that the exogenous components of financial intermediary development are positively associated with economic growth (Levine *et al.*, 2000). For the relevant role of the monetary process and the financial sector, see, in particular, Stock and Watson , 1989; Feldstein and Stock, 1994; Friedman and Kuttner, 1992; Bernanke and Blinder, 1992; Swanson, 1998).

3. The relevant works of Edwards (1998), Barro and Sala-I-Martin (1998), Frankel and Romer (1999), are all excellent sources. As part of an export-led strategy, by the mid-1980s especially the economic literature concerning development economics placed great emphasis on the export promotion policies for policy makers in Developing Countries, in order to induce income growth and economic adjustment. Nevertheless, in only a few cases have the empirical results confirmed that export expansion was indeed substantial to income growth (Kugler, 1991; Afxentiou and Serletis, 1991; Henriques and Sadorsky, 1996).

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APPENDIX I

RESULTS

Table 1
Testing the Existence of a Long Run Relationship

Dependent Variable	K	AIC Lags	F-Statistic	Intercept	Trend	Bounds Testing (at 90%)	Outcome
F (LYR/ LXPR, LFIR)	2	2	F (3, 11) = 12.1924 [.001]	Yes	Yes	Lower : 4.205	Cointegration
						Upper : 5,109	

Table 2
Autoregressive Distributed Lag Estimates

Autoregressive Distributed Lag Estimates ARDL (3, 2, 3) Selected Based on Akaike Information Criterion

Dependent variable is LYR
26 observations used for estimation from 1979 to 2004

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
LYR (−1)	1.6082	.34675	4.6378 [.001]
LYR (−2)	− .17230	.57155	− .30145 [.769]
LYR (−3)	− 1.0717	.77108	− 1.3899 [.192]
LXPR	.53451	.32491	1.6451 [.128]
LXPR (−1)	1.0099	.54229	1.8623 [.089]
LXPR (−2)	.76955	.33371	2.3060 [.042]
LFIR	.033835	.044901	.75354 [.467]
LFIR (−1)	.10123	.051962	1.9482 [.077]
LFIR (−2)	.22091	.082028	2.6931 [.021]
LFIR (−3)	.23202	.10530	2.2035 [.050]
C	− 37.8130	14.7608	− 2.5617 [.026]
T	− .19158	.062745	− 3.0534 [.011]
GIOY	31.3031	14.2619	2.1949 [.051]
DOY	.017201	.0069725	2.4669 [.031]
DLP	.0013716	.10653	.012875 [.990]

R-Squared	.99563	R-Bar-Squared	.99006
S.E. of Regression	.071980	F-stat. $F (14, 11)$	178.8318 [.000]

Diagnostic Tests

*	Test Statistics	*	LM Version	*
*		*		*
A : Serial Correlation CHSQ (1) = .552 [.457]			B : Functional Form *CHSQ (1) = .0810 [.776]	
*		*	*	*
C : Normality CHSQ (2) = .0828 [.959]*			D : Heteroscedasticity*CHSQ (1) = .542 [.461]	

Table 3
Estimated Long Run Coefficients using the ARDL Approach

Estimated Long Run Coefficients using the ARDL Approach
ARDL (3, 2, 3) Selected Based on Akaike Information Criterion

Dependent variable is LYR
26 observations used for estimation from 1979 to 2004

| Regressor	Coefficient	Standard Error	T-Ratio [Prob]
LXPR	3.6393	.67129	5.4213 [.000]
LFIR	.92479	.33040	2.7990 [.017]
C	− 59.4712	17.1558	− 3.4665 [.005]
T	− .30132	.036598	− 8.2332 [.000]
GIOY	49.2326	14.9734	3.2880 [.007]
DOY	.027052	.011368	2.3796 [.037]
DLP	.0021572	.16748	.012880 [.990]

Table 4
Error Correction Representation for the Selected ARDL Model

Error Correction Representation for the Selected ARDL Model
ARDL (3, 2, 3) Selected Based on Akaike Information Criterion

Dependent variable is dLYR
26 observations used for estimation from 1979 to 2004

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
dLYR1	1.2440	.46402	2.6809 [.019]
dLYR2	1.0717	.77108	1.3899 [.188]
dLXPR	.53451	.32491	1.6451 [.124]
dLXPR1	− .76955	.33371	− 2.3060 [.038]
dLFIR	.033835	.044901	.75354 [.465]
dLFIR1	− .45293	.18416	− 2.4595 [.029]
dLFIR2	− .23202	.10530	− 2.2035 [.046]
dC	− 37.8130	14.7608	− 2.5617 [.024]
dT	− .19158	.062745	− 3.0534 [.009]
dGIOY	31.3031	14.2619	2.1949 [.047]
dDOY	.017201	.0069725	2.4669 [.028]
dDLP	.0013716	.10653	.012875 [.990]
ecm (−1)	− .63582	.18635	− 3.4121 [.005]
R-Squared	.86752	*R*-Bar-Squared	.69891
S.E. of Regression	.071980	*F*-stat. *F*(12, 13)	6.0026 [.002]

Table 5
Testing for Short-Run Causality (Wald X² test results)

Group of Lagged Variables	Wald Statistic	p-value	Outcome
LXPR	5.0027	0.082	Weak Causality
LFIR	39.6599	0.000	Strong Causality

Graph 1
Plot of Cumulative Sum of Recursive Residus

The straight lines represent critical bounds at 5% significance level
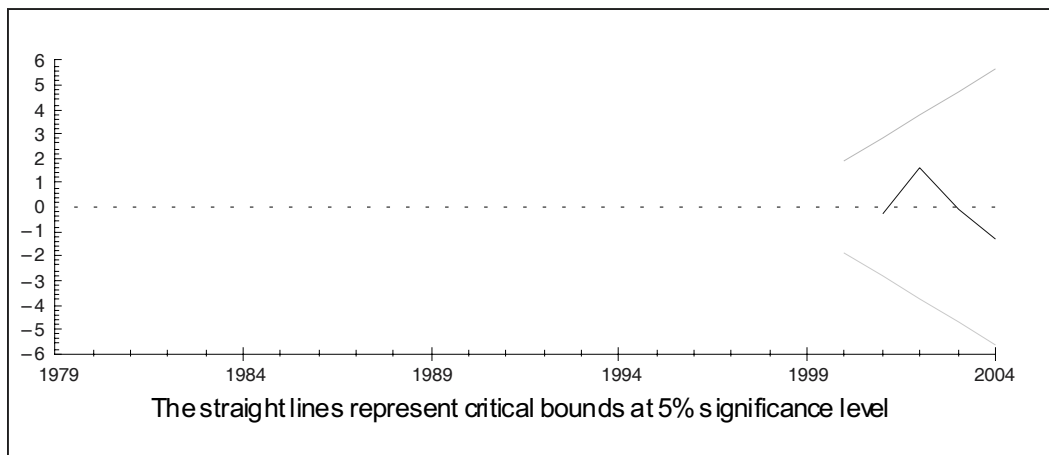
Graph 2
Plot of Cumulative Sum of Squares of Recursive Residus

The straight lines represent critical bounds at 5% significance level
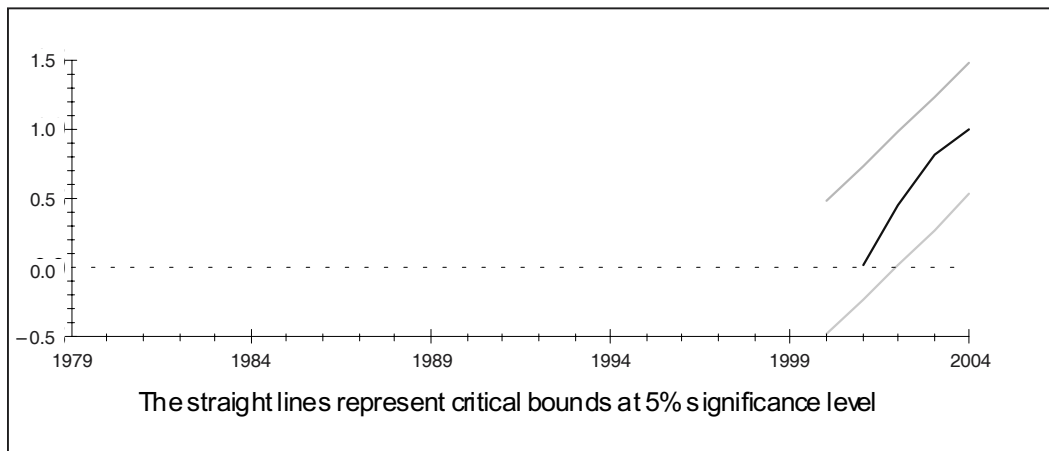
APPENDIX II

Figure 1
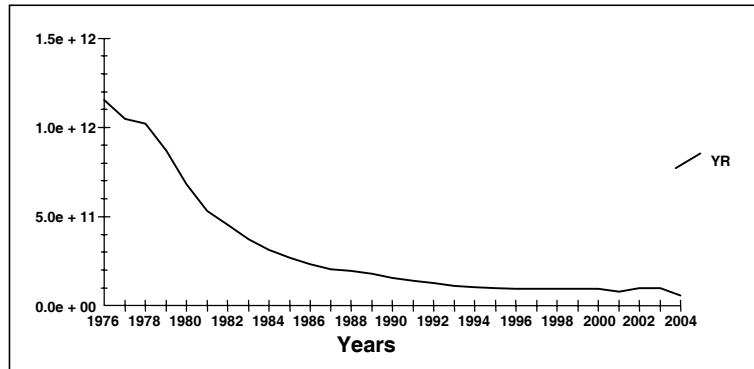**Real Income Growth**
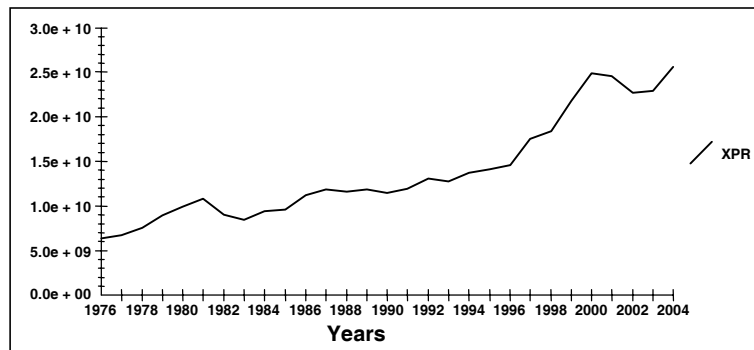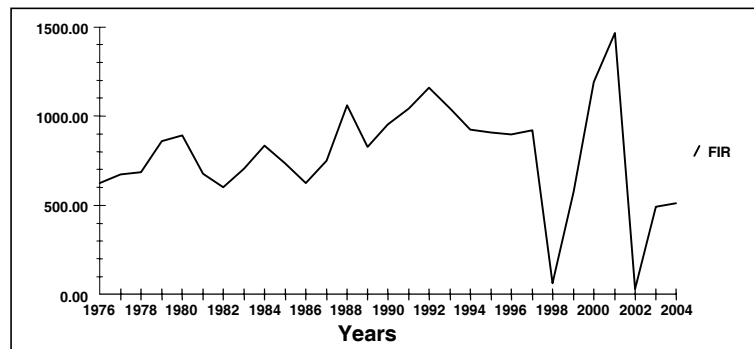

Figure 2
Real Exports

Figure 3
Real FDI

APPENDIX III

ARDL METHOD: A BRIEF THEORETICAL DESCRIPTION

The augmented autoregressive distributed lag model $ARDL(p, q_1, q_2, ..., q_k)$ is given by

$$\varphi(L, p)\, y_t = \sum_{i=1}^{k} \beta_i(L, q_i)\, x_{it} + \delta' w_t + u_t \, , \tag{A1}$$

where
$$\varphi(L, p) = 1 - \varphi_1 L - \varphi_2 L^2 - ... - {}_p L^p \tag{A2}$$

$$\beta_i(L, q_i) = \beta_{i0} + \beta_{i1} L + ... + \beta_{iq_i} L^{q_i}, \quad i = 1, 2, ..., k \tag{A3}$$

w_t is a $s \times 1$ vector of deterministic variables (intercept, dummies, trend, exogenous variables with fixed lags) and L is a lag operator defined as $L^r y_r = y_{i-r}$.

At the first step the procedure estimates a total of $(m + 1)^{k+1}$ different $ARDL$ models, by means of the OLS method, for all possible values of p ($p = 0, 1, ..., m$), q ($q = 0, 1, ..., m$) and i ($i = 1, ..., k$). The maximum lag length can be determined by the researcher though the frequency of the data is crucial. The appropriate $ARDL$ specification can be then chosen by means of alternative criteria such as the Akaike Information Criterion (AIC), the Schwarz Bayesian Criterion (SBC), the Hannan and Quinn (HQC), the R^2 and others.

The long run coefficients for the response of y_t to a unit change of x_{it} are estimated by (Pesaran *et al.*, 1997, pp. 393-394):

$$\hat{\theta}_i = \frac{\hat{\beta}_i(1, \hat{q}_i)}{\hat{\varphi}(1, \hat{p})} = \frac{\hat{\beta}_{i0} + \hat{\beta}_{i1} + ... + \hat{\beta}_{i\hat{q}_i}}{1 - \hat{\varphi}_1 - \hat{\varphi}_2 - ... - \hat{\varphi}_{\hat{p}}} \, , \quad i = 1, 2, ..., k \tag{A4}$$

where $\hat{p}$ and $\hat{q}_i$, $i = 1, 2, ..., k$ are the selected values of p and q_i. The long run coefficients associated with the deterministic and exogenous variables with fixed lags are estimated by

$$\hat{\psi} = \frac{\delta(\hat{p}, \hat{q}_1, \hat{q}_2, ... \hat{q}_k)}{1 - \hat{\varphi}_1 - \hat{\varphi}_2 - ... - \hat{\varphi}_{\hat{p}}} \tag{A5}$$

where $\hat{\delta}(\hat{p}, \hat{q}_1, \hat{q}_2, ..., \hat{q}_k)$ denotes the OLS estimates of δ in (A1) for the selected $ARDL$ specification.

The ECM representation associated with the implied ARDL model can be obtained by writing (A1) in terms of the lagged levels and the first differences of y_t, x_{1t}, ..., x_{st} and w_t.

Based on (A4) and (A5) the error correction term EC_t is defined by

$$EC_t = y_t - \sum_{i=1}^{k} \hat{\theta}_i\, x_{it} - \psi' w_t \, . \tag{A6}$$