How important are foreign and domestic investments, exports and human capital for Greece's economic growth?

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ABSTRACT

This study investigates empirically the causal relationship between economic growth and its determinants (foreign direct investment, domestic investment, exports, human capital) in Greece over the period 1970-2012. It uses time series analysis and estimates the effect of these determinants on economic growth, by applying a modification of Mankiw, Romer and Weil (1992) model. The empirical analysis reveals that there is evidence of unidirectional long-run and short-run Granger causality running from foreign direct and domestic investments, exports and human capital to economic growth; and that there is a positive effect, in the long-run, of all determinants on economic growth. The contribution size of these economic variables, especially of foreign direct investment, is probably not adequate and sufficient to bring the Greek economy back to growth. Greece needs to implement many important structural reforms which will enhance the contribution of these determinants to economic growth.

1. INTRODUCTION

ECONOMIC GROWTH AND ITS DETERMINANTS have been a major and extensive area of study and research over the past few decades, especially in developing countries. According to the macroeconomic literature, as reflected after World War II, there are two main approaches that explain the sources of economic growth: the neo-classical approach, based on Solow's growth model (1956), and the new or endogenous approach, based on growth models developed by Lucas (1988), Romer (1986, 1990), Grossman and Helpman (1991), Aghion and Howitt (1992) and others (Sianesi and Van Reenen 2003).

Later, the augmented neo-classical growth model of Mankiw *et a*l (1992), extended the Solow model. The neo-classical growth model emphasises the importance of investment in physical capital, while endogenous growth models focus on the key role of human capital, research and development (R&D)

and innovation. The basic underlying assumption of the neo-classical growth model is that diminishing returns on capital exist in the production process, while endogenous growth models are based on the assumption that the production function exhibits increasing returns to scale. Despite these differences, both economic models and theories converge in the estimation that foreign direct investment (FDI), domestic investment, exports and human capital are key determinants of economic growth.

There are significant interactions and strong relationships between FDI, domestic investment, exports, human capital and economic growth. More specifically, FDI inflows can play a vital role in host countries, because it increases the supply of funds for domestic investment, through a knowledge diffusion effect often referred as externalities or efficiency spillovers, from the more advanced technology and management practices used by foreign firms (Findlay 1978). FDI has two potential effects on domestic investment, by competing in product and financial markets. Thus FDI can increase growth in two ways: first, it enhances total investment by attracting higher levels of domestic investment; and second, through the interaction of more advanced technology with the host's human capital, FDI may be more productive than domestic investment (Ewe-Ghee, 2001). Furthermore, FDI inflows not only increase the export capacity of the host country, but also induce new job vacancies (Stamatiou and Dritsakis 2013).

The adoption and application of new technologies require the accumulation of a substantial amount of human capital in the host economy. This means that human capital, especially those with higher education qualifications in the host economy, acts as a limit to the absorptive capability of a developing country (Borensztein *et al* 1998). Human capital determines the economy's ability to create new ideas and adapt old ones. It also spurs economic growth by attracting FDI used for capital intensive production processes (Ogunade 2011). FDI and human capital can complement each other in the process of productivity growth: FDI creates potential spillovers of knowledge to the local labour force while, at the same time, the host country's level of human capital determines how much FDI it can attract and whether local firms are able to absorb the potential spillover benefits (Adefabi 2011). Education, as an indicator of human capital, is one of the main factors that influences the development of trade and is one of the building blocks of productivity. A workforce with higher levels of education will have potential for change and for being innovative. Human capital and foreign trade are complementary factors; they interact with each other and work together to strengthen economic growth and development (Levin and Raut 1997).

The motivation for this study comes from the necessity to identify the relationship between economic growth and its determinants in Greece. Greece experienced political stability during the examined period 1970-2012, with the exception of the period 1970-1974 due to the dictatorship; and the period 2010-2012 as a result of accession to the European support mechanism and

the signature of the memorandum. During the examined time period, two major milestones influenced the development of the Greek economy, namely the accession of the country to the European Community (EC) in 1981, and accession to Economic and Monetary Union (EMU) in 2001. As a result, Greece became a member of the hard core of the European Union, it transformed into a developed country, and its economy was based mainly on the tertiary sector. During this transition period, some structural reforms and adjustments were implemented, more or less successfully. Generally, however, the Greek economy passed into the 21st century facing a number of unsolved problems, mainly high temporal twin debts and deficits.

For many years the Greek government's strategy was not effective enough in attracting investment, especially FDI. The main obstacles were high business taxes and excessive bureaucracy. These issues are closely related with the determinants of economic growth that will be examined in this paper. In 2009, the global financial and economic crisis, which started in 2007, triggered the diachronically underlying structural and functional deficiencies of the Greek economy, its public sector and its administration. As a result, in 2010 Greece entered the European support mechanism (comprised of the European Commission, the European Central Bank and the International Monetary Fund), and thereafter an austerity-frontloaded fiscal consolidation process was followed and difficult structural reforms implemented. Today, Greece remains under the strict supervision of the three institutions, has signed a new, third, bailout programme and faces prolonged recession and high unemployment.

The purpose of this study is to investigate empirically the long-run and short-run causal relationships between FDI, domestic investment, exports, human capital and economic growth, and to estimate the effect of each variable on economic growth in Greece over the period 1970-2012. This paper attempts to provide new evidence on this issue from the perspective of a single country, rather than a cross-country viewpoint. To the best of our knowledge, this is the first study which investigates in the same empirical economic model the impact of FDI, domestic investment, exports and human capital on economic growth in a single European country that belongs in the periphery of the European Union.

The rest of the paper is organised as follows. Section 2 reviews the empirical literature on the relationships between domestic and foreign investment, exports, higher education and economic growth. Section 3 presents the empirical analysis, discusses the methodology, explains sources and data and reports the empirical results based on econometric analysis and discussion. Section 4 presents the concluding remarks.

2. Review of empirical studies

The current literature review involves studies which have dealt with the effect of FDI, domestic investment, exports and human capital in economic growth,

either for each variable separately or for some of them together, or even for all variables simultaneously.

FDI and economic growth

Many studies have been conducted in the fields of FDI and economic growth. Some of them are reviewed below. De Gregorio (1992) found a positive effect on growth for twelve Latin American countries over the period 1950-1985. Chakraborty and Basu (2002) suggested that GDP in India is not affected by FDI, and the causality runs from GDP to FDI. Chowdhury and Mavrotas (2003), examining the casual relationship between FDI and economic growth for Chile, Malaysia and Thailand covering the period 1969-2000, concluded that GDP affects FDI in the case of Chile, while for both Malaysia and Thailand, there is a strong evidence of a bi-directional causality between the two variables. Apergis *et al* (2004) investigated the causal relationship between FDI and growth for a set of transition economies. Their results indicated bidirectional causality between the two variables. In the case of East European countries, similar results were found by Bhandari *et al* (2007). The main conclusion is that an increase in the stock of domestic capital and inflows of FDI positively affect economic growth.

Exports and economic growth

Alici and Ucal (2003) found only unidirectional causality from exports to output for Turkey, using seasonally unadjusted quarterly data for the period 1987-2002. Shirazi and Manap (2004) found strong evidence of unidirectional causality from exports to economic growth in Pakistan over the period 1960-2003. Jordaan and Eita (2007) concluded that export-led growth strategy has had positive impact on economic growth in Namibia over the period 1970-2005.

Human capital and economic growth

The impact of human capital and, more specifically, the impact of higher education on economic growth, has been examined extensively in the economic literature. Barro and Sala-i-Martin (1995) conducted a cross-sectional study of 111 countries and concluded that an increase of 0.09 years in higher education raises the annual growth rate by 0.5 percentage points. They also found an interaction between initial GDP and human capital, which means that countries that lag behind tend to grow faster if they observe higher levels of human capital.

De Meulemeester and Rochat (1995) found a significant causal link from higher education to economic growth in Japan, the United Kingdom, France and Sweden but lack of significant effects in Italy and Australia. Simoes (2004), by using average years of schooling for estimating the impact of educational levels on economic growth in a sample of 23 OECD countries, found a positive and significant relationship between higher education and growth.

Loening (2005) investigated the impact of human capital on economic growth in Guatemala over the period 1951-2002. The results showed that the share of the labour force with higher education has positive and significant effects on growth. Bloom et al (2006) concluded that increasing the stock of tertiary education by one year could raise the output of Sub-Saharan African countries by 0.12 percentage points per year. Pegkas and Tsamadias (2014) investigated the case of Greece over the period 1960-2009 and found that there is a positive long-run cointegrating relationship between higher education and economic growth; and unidirectional long-run and short-run Granger causality running from higher education to economic growth.

FDI, exports and economic growth

Several studies have investigated the impact of FDI and exports on economic growth. Liu et al (2002) found bidirectional causality between each pair of GDP, exports, and FDI for China, using seasonally adjusted quarterly data over the period 1981-1997. Ahmad *et al* (2004) found unidirectional causality from exports and FDI to GDP for Pakistan, using annual data capturing the period 1972-2001. Dritsaki *et al* (2004) investigated the causal relationship between FDI, exports and economic growth for Greece over the period of 1960-2002. Their findings showed that there is a long run relationship between these variables, bidirectional causality between GDP and exports, and unidirectional causalities running from FDI to exports and GDP.

Hsiao and Hsiao (2006) set up a panel vector autoregressive model for a set of countries (China, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Philippines, and Thailand). Their results revealed that FDI has unidirectional effects on GDP directly; and also through exports indirectly, while bidirectional causality between exports and GDP for the group also exists. Yao (2006) investigated the effect of exports and FDI on economic growth, using a panel data set encompassing 28 Chinese provinces over the period 1978-2000. The results of the study showed that both exports and FDI have a strong and positive effect on economic growth. Stamatiou and Dritsakis (2013) investigated the relationship between exports, FDI and economic growth in five eurozone countries (Greece, Portugal, Ireland, Spain, and Italy) for the period 1970-2011. The results revealed that there is bidirectional causality between exports and economic growth, while there is no causality between economic growth and FDI neither between FDI and exports.

FDI, domestic investment, human capital and economic growth

Other studies have investigated the impact of foreign and domestic investment and human capital on economic growth. Blomstrom *et al* (1994), for a combination of 78 developing and 23 developed countries, found that over the period 1960-1985, FDI has a significant positive influence on economic growth, but the influence seems to be confined to higher-income developing countries. The authors also found that domestic investment and human capital have a

positive effect on economic growth. Borensztein *et al* (1998) for 69 developing countries over the period 1970-1989, found that while FDI is an important vehicle for the transfer of technology and a positive contributor to economic growth, its impact is greater the higher the level of human capital in the host economy. Their results indicated that for host countries with very low levels of human capital, the direct effect of FDI on growth is negative, otherwise it is positive. They also found that FDI is more productive than domestic investment.

FDI, domestic investment, exports, human capital and economic growth
To the best of our knowledge there are very few studies which have taken into consideration these four variables together. Shahbaz and Rahman (2010) investigated the relationship between FDI, public investment, human capital and trade openness with economic growth in Pakistan over the period 1971-2008. Their results indicated that all variables have positive effects on economic growth. Anwar and Nguyen (2011), in their study for 61 provinces of Vietnam over the period 1996-2005, found that FDI, domestic investment, exports and human capital have positive effects on economic growth.

The basic findings from the empirical literature can be summarised as follows. Almost half of the studies have investigated the case of a single country, using time series data in their econometric analysis. The rest of the studies have investigated the case of many countries, using cross sectional data or panel data. The majority of the studies does not use a particular theoretical growth model, but use the VAR methodology to find long-run and short-run relationships between the variables, based on a simple linear theoretical model. A few studies have followed a specific growth model (for instance, the study of Pegkas and Tsamadias (2014) has used the Mankiw *et al* (1992) model).

The majority of the studies that have investigated a sample of many developed countries have found that there is positive long-run relationship, with causality stemming from domestic investment, FDI and human capital to economic growth; and with bidirectional causality between exports and economic growth. The majority of the studies that have investigated a sample of less developed countries showed that there is positive long-run relationship, and mainly bidirectional causality, between FDI and economic growth. The majority of the studies that have investigated one developed country have found a positive long-run relationship, with causality stemming from domestic investments and human capital to economic growth, and bidirectional causality between exports and economic growth and between FDI and economic growth. The results of our study are consistent with the results of these studies. Finally, the majority of the studies that have investigated one less developed country showed that there is positive long-term relationship and, mainly, a unidirectional causality, from FDI and exports to economic growth. All the results mentioned above hold regardless to the proxy of the human capital that all studies have used.

The results of our study are in line with the studies of De Meulemeester and Rochat (1995) and Pegkas and Tsamadias (2014), who have used enroll-

ment rates in higher education as a proxy of human capital. In general, the empirical literature suggests that there are interactions between domestic investments, FDI, exports and human capital and positive relation among these variables and economic growth. The level of economic growth in every country plays an important role in this. That is because, for developed economies, the interactions will be more powerful. That holds because most developed countries have a more highly-qualified and productive human capital stock; and they have the expertise to make important domestic investments to allow for more spillover effects from the foreign direct investments. In this way these countries can increase exports and thus the economy is growing.

3. Empirical analysis

This section presents the methodology, the data, the sources and the econometric analysis (stationarity properties of the data, cointegration test, vector error correction model, Granger causality test, impulse response functions and variance decomposition analysis). Finally, the section presents the results and a discussion of the findings.

3.1 Methodology and model

The neo-classical model, originally proposed by Solow (1956), assumes an aggregate production function, with arguments of effective labour and physical capital. Technological progress, population growth and capital depreciation take place at constant, exogenous rates. The empirical analysis of this paper uses the methodology of the Solow model, extended with human capital, as in Mankiw *et al* (1992), whereby investment is comprised of its domestic and foreign direct components, and the production function is expanded by adding exports as an extra variable. Regardless of criticisms, neo-classical growth theory has dominated economic thought because it can explain much of the economic growth in the world and because it is mathematically elegant.

In order to capture the explicit role of human capital in determining economic growth, Mankiw *et al* (1992) augmented the Solow model by including human capital as well as physical capital. They concluded that an augmented Solow model with both human and physical capital provides an excellent explanation for economic growth. The simple theoretical framework provided by Mankiw *et al* (1992) has been very influential and much cited in the time series and cross-country growth regression literature. The generalised Mankiw *et al* (1992)-type framework that we have developed here, by using the variables domestic investments, foreign direct investments, exports and human capital, has the potential to prove helpful in describing economic growth in Greece. Also, the availability of data for Greece fits better the Mankiw *et al* (1992) model.

Mankiw *et al* (1992), assume a Cobb-Douglas production function with constant returns to scale and decreasing returns on physical and human capital. We assume a production function of the following form:

$$Q = K_d^{\alpha} K_f^{\beta} H^{\gamma} E^{d} (AL)^{1-\alpha-\beta-\gamma-\delta} \quad (1)$$

where Q stands for aggregate output, K_d is domestic investment in physical capital, K_f is FDI in physical capital, H is human capital, E represents exports, A is a technical efficiency index and L stands for labour. We assume that L and A grow at constant and exogenous rates n and g, respectively. The exponents α, β, γ and δ measure the elasticity of output to the respective inputs.

Considering decreasing returns to scale, that is: $\alpha + \beta + \gamma + \delta < 1$, we transform equation (1) into a linear equation on income per worker and get the following function:

$$\ln q_t = a_0 + a_1 \ln k_{dt} + a_2 \ln k_{ft} + a_3 \ln(n + g + \delta)_t + a_4 \ln h_t + a_5 \ln(ex_t) + \varepsilon_t \quad (2)$$

where q_t refers to GDP per worker during each period, k_d is domestic investment as a percentage of GDP taking place in the economy, k_f is FDI, n, g and δ, are the exogenous growth rates of labour, technology and depreciation rate of capital respectively, h_t is the gross percentage of the people enrolled in higher education, ex_t is total exports as percentage of GDP, and ε_t is the error term.

3.2 Sources and data

Data on Gross Domestic Product (GDP), total domestic (including private and public) investment, exports and employment are annual and obtained from the AMECO database (2014), while data on FDI were taken from the World Bank database (2014). GDP per worker ($\ln q_t$) is measured at 2005 constant prices, total domestic investment ($\ln k_{dt}$) is the gross capital formation as percentage of GDP at 2005 constant prices for the total economy, foreign investment ($\ln k_{ft}$) is FDI as percentage of GDP at 2005 constant prices for the total economy, exports ($\ln ex_t$) is the total exports as percentage of GDP at 2005 constant prices for the total economy and labour force ($\ln n_t$) includes all persons classified as employees and self-employed for the whole economy. For the variable ($\ln n+g+\delta$), only the growth rate of the labour force is used. It should be noted that according to the Mankiw *et al* (1992) model, the growth rates of technology and depreciation rate of capital remain constant for all countries, assuming that $g + \delta = 0.05$, considering that technology (and therefore its rate, g) is a public good available to all countries. These assumptions we apply to Greece. The proxy of human capital used in this study is higher ($\ln h_t$) enrolment rates, including enrolment rates in the higher education system. Data for constructing a human capital proxy are taken from the Hellenic Statistical Authority (HSA) database (2014). The estimation of this variable is achieved using the following function (World Bank 2014):

$$GHER^t = \frac{E^t}{P^t} * 100 \quad (3)$$

where $GHER^t$ = Gross Higher Enrolment Ratio in school year t, E^t = Enrolment for higher level of education in school year t (age 18-22), P^t = Population in age-group which officially corresponds to higher level of education in school year t (age 18-22).

In Greece, over the period 1970-2012, a significant GDP increase is observed. Specifically, positive growth rates were achieved, but especially in the 1970s and the period 1995-2007. The average annual growth rate of GDP, over the whole period, was approximately 2.03 per cent in real terms, but there were periods of very high growth rates and periods of stagnation. In particular, the average annual growth rate of GDP was approximately 5.15 per cent and 0.78 per cent in the 1970s and 1980s respectively, 1.91 per cent in the 1990s, 3.04 per cent in the 2000s and -6.14 per cent during the period 2010-2012. Furthermore, over this period, Greek GDP per worker increased by an average of 1.60 per cent, with the highest growth rate during the 1970s and the lowest (negative) rate during the 1980s and the period 2010-2012.

Table 1: GDP, domestic and foreign investment, exports and higher education

Years	*GDP per worker (2005=base year)*	*Domestic investment (2005=base year) as percentage of GDP*	*Foreign direct investment (2005=base year) as percentage of GDP*	*Exports (2005 = base year) as percentage of GDP*	*Higher enrollment rates*
1970	21.697	32.369	0.399	5.632	14.770
2012	41.341	13.576	0.667	25.042	66.027
1970 - 2012	33.178	22.084	0.818	16.316	33.894
1970 - 1979	27.902	29.990	0.604	8.798	19.108
1980 - 1989	30.054	18.887	1.030	14.019	26.435
1990 - 1999	32.406	18.722	0.835	17.369	28.728
2000 - 2009	40.707	22.646	0.928	22.841	52.342
2010 - 2012	40.981	15.722	0.409	23.781	63.775
Years	*GDP per worker average growth rate*	*Domestic investment as percentage of GDP average growth rate*	*Foreign direct investment as percentage of GDP average growth rate*	*Exports as percentage of GDP average growth rate*	*Higher enrollment rates average growth rate*
1970 - 2012	1.60	-1.63	82.88	3.94	3.83
1970 - 1979	4.50	-3.84	108.97	9.11	4.91
1980 - 1989	-0.25	-1.58	-0.49	2.49	3.55
1990 - 1999	1.22	2.21	-7.61	4.49	0.19
2000 - 2009	1.85	-1.51	247.64	-0.85	6.69
2010- 2012	-0.45	-8.38	34.95	7.39	3.98

Source: AMECO database and Hellenic Statistical Authority (EL.STAT.) All data are obtained from Authors' calculations

The average domestic capital investment rate was 22 per cent of GDP for the entire examined time period. The average annual growth rate of domestic capital investment over the whole period was approximately -1.63 per cent in real terms. Indeed, this growth rate was negative for all years, except for the period 1990-1999. Foreign direct investment averaged 0.82 per cent of GDP for the entire examined time period, but FDI growth averaged about 82.88 per cent per year over the period 1970-2012. The highest FDI growth rate occurred during the 2000s and the lowest (negative) during the 1990s.

Exports averaged 16.31 per cent of GDP over the entire time period, during which Greek exports experienced an average annual increase of 3.94 per cent; with the highest growth rate seen during the 1970s and the lowest (negative) rate during the 2000s. During the examined time period, and mainly in the last three decades, the higher education system has expanded rapidly. The enrolment rate in higher education has increased from almost 15 per cent of adults aged 18-22 in 1970, to 66 per cent in 2012, exhibiting an average annual growth rate of 3.83 per cent (Table 1). However, when this time period is split into five 10-year periods, it becomes obvious that this increase shows no uniformity. During the 2000s we observe the highest growth rate of enrolled students, while in the 1990s the lowest. Furthermore, by examining such a long time period (43 years), variable bias is limited by allowing enough time for the effect of human capital on economic growth to take place.

3.3 Econometric analysis

This section focuses on the effect of foreign and domestic investment in physical capital, exports and higher education on economic growth, using a VAR methodology. First, the order of integration is checked and then cointegration tests are used to examine the existence of long-run relationships between the variables. Second, Granger (1986, 1988) causality tests, based on a vector error correction approach, are applied. Third, the impulse response functions and variance decomposition are plotted and calculated, to investigate the dynamic relationships between the variables of the models.

3.3.1 Stationarity Test

Initially, the stationarity of the variables (GDP per worker, domestic investment, FDI, exports and higher education) is examined, using the Augmented Dickey-Fuller (ADF) (1981), the Kwialkowski-Phillps-Schmidt-Shin (KPSS) (1992) and the Perron (1997) structural break tests. We test for the presence of unit roots and identify the order of integration for each variable in levels and first differences. The variables are specified including intercept and intercept and trend. The optimal lag length of the ADF regressions is determined by the Akaike (1974) criterion. KPSS statistics are obtained by the Bartlett Kernel and the automatic bandwidth parameter approach as suggested by Newey and West (1994). For the Perron structural break test, the maximum lag length is specified by the user to be equal to 4. For the ADF test the null hypothesis is

non-stationarity, for the KPSS test is stationarity and for the Perron test is non-stationarity with a structural break. Unit root test results are provided in Table 2.

Table 2: Results of unit root tests

Variables (in levels and first differences)	*ADF test*		*KPSS test*		*Perron test*	
	With intercept in equation	*With intercept and trend in equation*	*With intercept in equation*	*With intercept and trend in equation*	*With intercept in equation*	*With intercept and trend in equation*
lnq	-1.5712	-2.6330	0.7652*	0.0991	-4.0422	-3.8936
Δlnq	-5.2348*	-5.2276*	0.2006	0.1250	-5.9530*	-6.1271**
$\ln k_d$	-1.1563	-1.4914	0.4721**	0.2040**	-3.5813	-2.1498
$\Delta\ln k_d$	-6.1901*	-6.1082*	0.1532	0.1580**	-6.6257*	-6.7854*
$\ln k_f$	-2.3881	-2.2924	0.7601*	0.2427*	-7.2662*	-6.9627*
$\Delta\ln k_f$	-8.6114*	-8.6357*	0.0526	0.0430	-12.559*	-12.814*
lnex	-2.6898	-3.0842	0.7961*	0.1620**	-3.9641	-3.4861
Δlnex	-5.4737*	-5.6908*	0.3079	0.0991	-6.0976*	-6.0316**
lnh	-1.0309	-2.4864	0.7552*	0.1491**	-4.3147	-4.4444
Δlnh	-3.6284*	-3.5726**	0.0794	0.0768	-4.4724	-4.4143
$\ln(n+g+\delta)$	0.3749*	0.7352*	0.2214	0.1210	-2.8878	-6.5787*
$\Delta\ln(n+g+\delta)$	-9.2081*	-9.6737*	0.3221	0.1348	-10.6156*	-11.611*

Notes: *, ** indicates the rejection of the null hypothesis of non stationarity for (ADF) and Perron tests or stationarity (KPSS) at 1% and 5% level of significance respectively. For ADF test MacKinnon (1996) critical values have been used for rejection of hypothesis of a unit root. For KPSS test KPSS (1992, Table 1) critical values have been used for rejection of hypothesis of stationarity. For structural break test critical values are those reported in Perron (1989).

With the variables specific in levels, the results indicate that, with a few exceptions, we cannot reject the null hypothesis of non stationarity at 5 per cent. The cases that the variables provide mixed results are for GDP, the KPSS test in the case with intercept and trend, and for the variable of FDI, the Perron test in the cases with intercept and with intercept and trend. For the variable of $n+g+\delta$, all tests show stationarity except for the Perron test in the case with intercept. With the variables specified in first differences the results reveal that, with a few exceptions, we can reject the null hypothesis of non stationarity at 5 per cent. More specifically, for two variables the results are mixed. For the variable of domestic investment, the KPSS test in the case with intercept and trend shows non stationarity and, for the variable of human capital, the Perron test shows non stationarity in the cases with intercept and with intercept and trend. From the above stationarity tests analysis we con-

clude that the combined results show that all variables are I(1) except the variable of $n+g+\delta$, which is I(0).

3.3.2 Cointegration test

Stationarity tests show that all variables which are non-stationary in levels become stationary in first differences: they are integrated of order (1). Thus there is the possibility that the variables output per worker, foreign and domestic investment in physical capital, exports and higher education are cointegrated. The variable $(n+g+\delta)$ is taken as exogenous in the model. In order to account for other influences on GDP per worker, three dummy variables are added to the VAR model. The first dummy variable is for 1974, when the international oil crisis took place and GDP experienced a significant fall. The second dummy variable is for 2002, when Greece as a full member of eurozone adopted the single currency and was among the first wave of countries which launched euro banknotes and coins on 1 January 2002. The third dummy variable is for 2010, when Greece entered a trilateral financial support mechanism led by the European Commission, the European Central Bank and the International Monetary Fund.

To determine the lag length of the VAR, three versions of the system are estimated initially: a four, a three and a two-lag version. Then, taking into account information and criteria, we identify two lags as the optimal lag length. The cointegration test was conducted using the reduced rank procedure developed by Johansen (1988) and Johansen and Juselius (1990). The Johansen multivariate cointegration approach is used to examine the long-run relationship between the variables. The estimation procedure assumes an intercept and trend in the VAR estimation. This cointegration method recommends two statistics to check the long-run relationship: the Trace and the maximum Eigenvalue tests. The null hypothesis in the Trace and maximum Eigenvalue tests is that there is no cointegrating vector. Comparing[3] the Trace and the maximum Eigenvalue cointegration tests and taking into account the results from Table 3, we conclude that the null hypothesis of one cointegrating vector can be rejected at 5 per cent and cannot be rejected for more than one cointegrating vectors at 5 per cent, which implies that there is only one cointegrating vector. For that reason, the variables GDP per worker, FDI, domestic investment, exports and higher education are cointegrated and there is a long-run relationship between them in Greece over the examined period.

The estimated cointegration relationship is presented in the following equation (t-statistics in parentheses):

$$\ln q = \underset{(9.56)***}{0.48\ln k_d} + \underset{(2.69)\ ***}{0.04\ln k_f} + \underset{(8.38)\ ***}{0.38\ln ex} + \underset{(3.04)\ ***}{0.11\ln h} \qquad (4)$$

From the equation above it can be concluded that, in the long-run, domestic physical capital investment ($\ln k_d$), FDI ($\ln k_f$), exports ($\ln ex$) and higher education ($\ln h$) have a significant positive effect on economic growth. All the coeffi-

cients are statistically significant at the one per cent level. More specifically, the elasticity of GDP per worker (q) with respect to domestic investment is 0.48. This means that a one per cent increase in domestic investment will boost economic growth by about 0.48 per cent. Furthermore, the elasticity of GDP per worker with respect to FDI is 0.04. This means that a one per cent increase in FDI will boost economic growth by about 0.04 per cent. In addition, the elasticity of GDP per worker with respect to exports is 0.38. This means that a one per cent increase in exports will boost economic growth by about 0.38 per cent. Finally, the elasticity of GDP per worker with respect to higher education is 0.11. This means that a one per cent increase in higher education will boost economic growth by about 0.11 per cent.

Table 3: Johansen and Juselius cointegration test GDP per worker, foreign and domestic investment, exports and higher education: sample 1970-2012

Series: lnq $\ln k_d$ $\ln k_f$ lnex lnh

Hypothesised No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*5 Percent Critical Value*	*Max-Eigen Statistic*	*5 Percent Critical Value*
None*	0.7046	103.105	69.818	50.001	33.876
At most 1	0.4600	53.104	47.856	25.785	27.584
At most 2	0.3390	27.318	29.797	16.979	21.131
At most 3	0.1783	10.339	15.494	8.0548	14.264
At most 4	0.0542	2.2848	3.8414	2.2848	3.8414

Notes: [a] *r* indicates the number of cointegrating relationships. Trace and Maximum Eigen test statistics are compared with the critical values from Johansen and Juselius (1990). *Trace and Max-Eigen tests indicate 1 cointegrating equation at the 5% level. [b] Lags interval:1 to 1

These findings are consistent with most of the literature review mentioned above. Specifically, the positive result of the cointegration equation with respect to domestic and foreign investment, exports and higher education, is in line with the studies that examine the case of one country, such as Jordaan and Eita (2007) for Namibia, Loening (2005) for Guatemala, Pegkas and Tsamadias (2014) for Greece, Dritsaki et al (2004) for Greece, Anwar and Nguyen (2011) for Vietnam and Shahbaz and Rahman (2010) for Pakistan.

3.3.3 Vector Error Correction Model and the Granger causality test

Having verified that the variables are cointegrated, the vector error-correction model can be applied. The vector error-correction model can give the correction term that reflects influences of the deviation of relation between variables from long-term equilibrium upon short-term changes. The size and statistical significance of the error-correction term measures the extent to which each

dependent variable has the tendency to return to its long-run equilibrium. The lagged residuals from the cointegrating regression with the appropriate number of lags are included in the Granger causality test structure. The vector error-correction model passes all the standard diagnostic tests for residual serial correlation, normality and heteroscedasticity. The results[4] of the vector error-correction model show that the growth rate of labour has a negative and statistically significant impact on GDP per worker. All the dummy variables have a negative and statistically significant influence on GDP per worker.

The next step is to examine short-run and long-run Granger causality between GDP per worker, domestic investment, foreign investment, exports and higher education. Although the existence of a long-run relationship between these variables suggests that there must be Granger causality in at least one direction, it does not indicate the direction of temporal causality between the variables. The direction of the causality in this case can only be determined by the F-statistic and the lagged error-correction term (ECT). While the t statistic on the coefficient of the lagged error-correction term represents the long-run causal relationship, the F-statistic on the explanatory variables represents the short-run causal effect (Narayan and Smyth, 2006). More specifically, the Wald-test applied to the joint significance of the sum of the lags of each explanatory variable and the t-test of the lagged error-correction term will imply statistically the Granger exogeneity or endogeneity of the dependent variable.

The non-significance of ECT is referred to as long-run non-causality, which is equivalent to saying that the variable is weakly exogenous with respect to long-run parameters. The absence of short-run causality (Granger causality in the strict sense) is established from the non-significance of the sums of the lags of each explanatory variable. Finally, the non-significance of all the explanatory variables, including the ECT term in the VECM, indicates the econometric strong-exogeneity of the dependent variable that is the absence of Granger-causality (Hondroyiannis and Papapetrou, 2002).

Table 4 reports the findings for the endogeneity of GDP per worker, domestic investment, FDI, exports and higher education, based on the error-correction equations. The error-correction term measures the proportion by which the long-term imbalance in the dependent variable is corrected in the short-run period. The negative sign, the size and statistical significance of the error-correction term measures the extent to which each dependent variable has the tendency to return to its long-run equilibrium. Estimates of the parameters show that the error-correction term measuring the long-run disequilibrium is negative and statistically significant for GDP per worker equation at the one per cent significance level. The t-test for the GDP per worker error-correction term indicates the significance of the long-run causal effect at the one per cent level. This confirms the result of the cointegration test: only GDP per worker is not a weakly exogenous variable. In addition, the t-tests of the error-correction term for the domestic investment, foreign investment and

higher education variables are not statistically significant, while for exports it is statistically significant at 10 per cent, but it is positive. These results imply that the domestic investment, foreign investment, exports and higher education are weakly exogenous variables.

In the long-run, there is unidirectional Granger causality running from domestic investment, foreign investment, exports and higher education to GDP per worker. In the short-run dynamics, the Wald tests indicate that there is unidirectional Granger causality running from domestic investment, exports and higher education to GDP per worker. Also, the results show that there is a bidirectional Granger causality relationship between GDP per worker and foreign investment; and unidirectional Granger causality running from domestic investment to exports. There is no other causality identified between GDP per worker, domestic investment, foreign investment, exports and higher education, neither in the short-run nor the long-run. Finally, the significance levels associated with the Wald tests of joint significance of the sum of the lags of the explanatory variable and the error-correction term, provide more information on the impact of domestic investment, foreign investment, exports and higher education on economic growth and vice versa. Only for GDP per worker and exports do the results indicate Granger-endogeneity. Finally, the empirical results reveal that for all variables except for higher education, we can reject the hypothesis of strong exogeneity. This means that there is a relationship between domestic investment, foreign investment, exports, higher education and economic growth in Greece.

The finding of causality is consistent with the literature reviewed above. Specifically, studies which examined the case of one country and found unidirectional causality running from domestic and foreign investment, exports, higher education to economic growth include Chowdhury and Mavrotas (2003) for Malaysia and Thailand, Shirazi and Manap (2004) for Pakistan, Alici and Ucal (2003) for Turkey, De Meulemeester and Rochat (1995) for Japan, United Kingdom, France and Sweden, Ahmad *et al* (2004) for Pakistan, Dritsaki *et al* (2004) for Greece and Pegkas and Tsamadias (2014) for Greece.

3.3.4 Impulse response functions

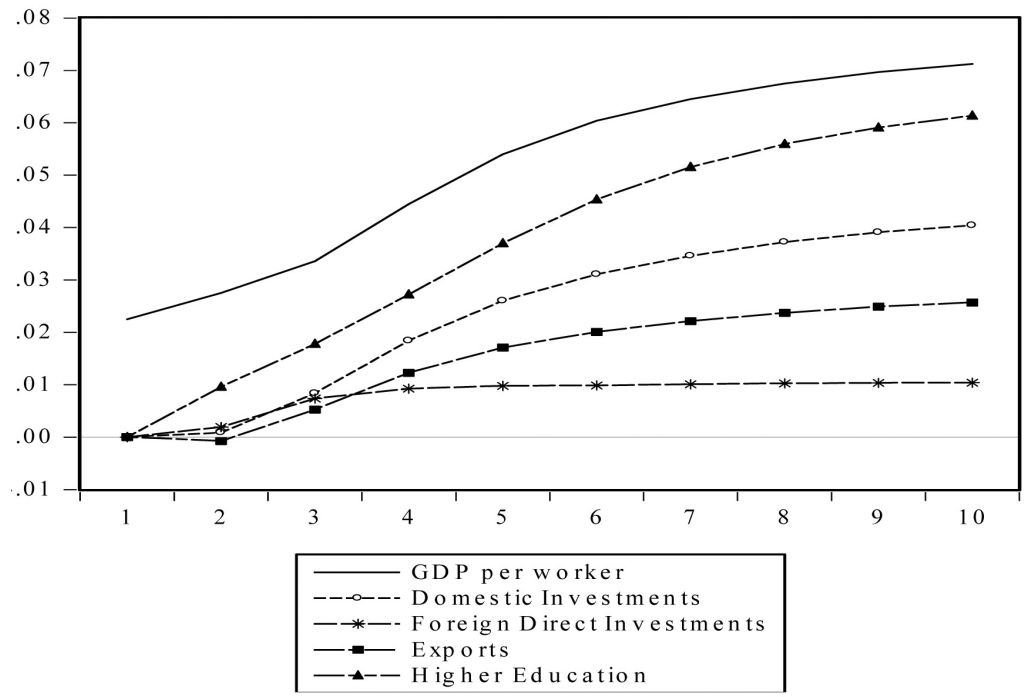
In order to study the dynamic properties of the VAR model, impulse response function (IRF) analysis is applied, using the Cholesky decomposition. The IRF is the dynamic response of each dependent variable to other variables contained in the VAR model, for a standard deviation shock to the system. These functions show the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. In other words, this approach is designed to show how each variable responds over time to an earlier shock in that variable, and to shocks in other variables. The time period of IRF spreads over ten years, which is long enough to capture the dynamic interactions between domestic investment, foreign investment, exports and higher education to economic growth. The IRF[5] derived from the unrestricted VAR is illustrated in Figure 1.

Table 4: Summary of tests for weak and strong exogeneity of variables based on vector error correction model

	Short-run dynamics non-causality					*Weak exogeneity*	*Tests of Granger non-causality (joint short run dynamics and ECT)*					*Test for strong exogeneity*
	Dq	*Dk_d*	*Dk_f*	*Dex*	*Dh*	*ECT*	*Dq and ECT*	*Dk_d and ECT*	*Dk_f and ECT*	*Dex and ECT*	*Dh and ECT*	
Dq	—	6.99*** (0.008)	5.99** (0.02)	3.53* (0.06)	3.81** (0.05)	- 0.275*** [-2.49]	—	13.45*** (0.001)	15.09*** (0.000)	8.46** (0.014)	23.49*** (0.000)	65.06*** (0.000)
Dk_d	0.12 (0.720)	—	0.52 (0.46)	0.08 (0.77)	1.26 (0.26)	0.161 [0.34]	0.64 (0.723)	—	2.31 (0.314)	0.68 (0.709)	0.15 (0.924)	12.26** (0.031)
Dk_f	5.14** (0.02)	0.45 (0.49)	—	0.89 (0.34)	2.63 (0.104)	1.47 [0.71]	5.64* (0.059)	1.13 (0.567)	—	1.91 (0.384)	0.91 (0.632)	11.02* (0.051)
Dex	2.01 (0.15)	4.79** (0.02)	0.33 (0.56)	—	2.16 (0.14)	0.38* [1.95]	11.22*** (0.003)	7.69** (0.021)	5.52* (0.063)	—	5.83* (0.054)	37.02*** (0.000)
Dh	0.19 (0.66)	0.01 (0.93)	1.33 (0.24)	0.01 (0.99)	—	-0.23 [-1.13]	1.81 (0.40)	1.61 (0.44)	1.54 (0.461)	1.50 (0.470)	—	3.80 (0.577)

Notes: The Wald test statistics reported are distributed as a chi-square distribution with degrees of freedom the number of restrictions. The p-values are presented in parentheses. In the short-run dynamics, asterisks indicate rejection of the null hypothesis that there is a short-run non-causal relationship between the two variables. The asterisks of the lagged ECTs are distributed as t-statistics and indicate rejection of the null hypothesis that the estimated coefficient is equal to zero (weak exogeneity). The t-statistics are presented in brackets. Finally, in the tests for Granger non-causality and strong exogeneity, asterisks denote rejection of the null hypothesis of Granger non-causality and strong exogeneity respectively. The asterisks indicate the following levels of significance: *10%, **5% and ***1%.

Figure 1: Impulse Response Function for GDP- Combined Graphs
(Response of GDP to Cholesky One S D Innovations)



First and foremost, from Figure 1 it becomes apparent that a one standard deviation shock of all the variables has a positive impact on economic growth. More specifically, a one standard deviation innovation in domestic investment causes a 0.03 percent increase in economic growth. Similarly, a one standard deviation innovation in FDI causes a 0.01 per cent increase in economic growth. Furthermore, a one standard deviation innovation in exports causes a 0.02 per cent increase in economic growth; and finally, a one standard deviation innovation in higher education causes a 0.06 per cent increase in economic growth. The conclusion of the IRF results is that the response of economic growth to a one standard deviation shock in domestic investment is positive and bigger than for FDI and exports. But the strongest positive impact arises from higher education to economic growth.

3.3.5 Variance decomposition analysis

The variance decomposition (VDC) is now estimated for each variable in the VAR models, for a period of ten years. VDC provides information about how much of the forecast error variance for each endogenous variable in the VAR model can be explained by each disturbance. A shock to a particular variable

will affect that variable directly, but this shock will also generate variations to all other variables in the system, through the dynamic structure of the VAR model. The VDC estimation results[6] are presented in Table 5.

Table 5: Variance Decomposition

	Variance Decomposition of q					
Period	*SE*	*q*	k_d	k_f	*ex*	*h*
1	0.02247	100	0	0	0	0
2	0.03688	92.8681	0.05454	0.28243	0.03917	6.75564
3	0.05436	80.8388	2.39816	1.97410	0.96219	13.8267
4	0.07906	69.8937	6.54981	2.30725	2.86319	18.3859
5	0.10772	62.7788	9.37265	2.06993	4.06533	21.7132
6	0.13702	58.2225	10.9432	1.79986	4.65865	24.3756
7	0.16547	55.122	11.8739	1.60712	4.98657	26.4103
8	0.19266	52.9339	12.4874	1.47011	5.19681	27.9116
9	0.21844	51.3463	12.9168	1.36868	5.34106	29.0271
10	0.24280	50.1626	13.2263	1.29116	5.44224	29.8775

The variables of the VAR order as following: GDP per worker, domestic investment, foreign direct investment, exports and higher education (q, kd, kf, ex, h respectively).

Over time, domestic investment, exports and higher education gradually affect the variation of economic growth more significantly. More precisely, 13.22, 5.44 and 29.87 per cent, respectively, of economic growth forecast error variance in a ten year period is explained by disturbances of domestic investment, exports and higher education. 2.30 per cent of economic growth forecast error variance is explained by disturbances of foreign investment until the fourth year, while in the following years the variation is decreased. One explanation could be that FDI represents a channel for international technology transfer. Increased technological levels in the FDI host sector can be transmitted to the rest of the domestic economy through a spillover effect. In Greece, this effect holds for about four years, then the positive impact of this effect is transferred to other production factors.

To conclude, higher education innovation explains much more than the other variables the variation of economic growth. This figure is quite substantial, underlying the importance of higher education on economic growth. The fact that both IRF and VDC experience a stronger and longer reaction of economic growth to a shock in higher education than shocks in other variables is supported by the hypothesis that higher education influences economic growth more than the other variables. These results are consistent with those of the long-run causality tests mentioned above. The overall results from VDC

seem to be in agreement with those of IRF, providing evidence in favour of the importance of higher education, domestic investment, exports and FDI, to explain variation in economic growth.

4. Concluding remarks

The main objective of this study has been to investigate empirically the causal relationship between FDI, domestic investment, exports, human capital and economic growth in Greece, over the period 1970-2012. The literature suggests that there are causal relationships between these variables. The results indicate a positive relationship between FDI, domestic investment, exports and higher education with economic growth. The study estimates the effect of these variables on economic growth using the augmented neoclassical model of Mankiw *et al* (1992). The empirical analysis reveals that in the long-run, the variables are cointegrated. This implies that long-run movements of the variables are determined by an equilibrium relationship. In both the long-run and short-run, there is unidirectional Granger causality running from FDI, domestic investment, exports and higher education to GDP per worker. Also, in the short-run there is unidirectional Granger causality running from GDP per worker to FDI and unidirectional Granger causality running from domestic investment to exports.

The role of the examined variables on economic growth are found to be significant. The results of a positive contribution of FDI, domestic investment, exports and higher education on economic growth are consistent with most of the studies mentioned in the literature review. The most noticeable result is the low contribution of FDI to economic growth in Greece. One explanation could be that, in Greece, economic growth is influenced not only by the level of FDI, but also by the efficiency of these investments. Also, another important explanation for the low contribution of FDI to economic growth could be the low quality of education. The quantity of human capital has increased rapidly in recent decades, but the quality of education remains low (as confirmed by the PISA 2012 Results from the OECD). In addition, a connection of education, especially at higher levels, is required with research and development, innovation and entrepreneurship.

Therefore, in Greece, as a developed country and member of the eurozone, many important structural reforms in various sectors need to be implemented, in order to further improve the competitiveness of the economy and to attract foreign and domestic investors, to increase exports and to improve the quality of human capital. In this case, the country may be expected to return to high growth rates. Major prerequisites are macroeconomic stability and a reduction in market distortions. Finally, regarding future research, two areas seem to be most promising: first, an investigation in pairs of the relationship between these determinants of economic growth in Greece and, second, an investigation into the promotion of cooperation among higher education, research and technological development, innovation and FDI in Greece.

We believe that these are crucial variables for the development of Greece in an internationally competitive and dynamic global environment.

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ENDNOTES

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2. This variable was taken as exogenous in this model, because the Mankiw *et al* (1992) model assumes exogenous rates of labour, technology and depreciation rate of capital.

3. In addition, following Johansen and Juselius (1990) and Lutkepohl *et al* (2001), we note that if the Johansen test gives a different result between the trace and maximum eigenvalue statistics, the latter is preferred.

4. The results of VECM are available from the authors upon request.

5. The overall results of IRFs are available from the author upon request.

6. The overall results of VDCs are available from the author upon request.

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