Determinants of growth in OECD countries revisited

George Sfakianakis
Hellenic Ministry of Finance and Technological Educational Institute of Chalkis
gsfak@mnec.gr

Anastasios Magoutas
Technological Educational Institute of Chalkis
amag@teihal.gr

George Papadoudis
Technological Educational Institute of Chalkis
gpapadoudis@netpads.eu

Abstract
Drawing on recent developments in the determinants of growth literature and using the latest datasets and modern techniques, this paper aims at assessing the relative importance of various factors for the growth of OECD countries. Special emphasis is placed on factors affecting total factor productivity in a globalized environment, while the specific econometric techniques allow us to account for institutional and other differences between countries. The main conclusion is that human capital and innovation are key drivers of growth for the specific group of countries, with the outward orientation, competitiveness and institutional variables also contributing positively while the opposite holds for the size of the public sector. These results are robust to the choice of estimation methods, while the statistical properties of variables are properly taken into account. Using these results, the current economic policy mix in Greece is evaluated from a growth perspective.

Keywords: economic growth, human capital, R&D, openness, technology transfer, institutions
JEL classification: O3, O43, E24

Introduction[1]

This paper aims at identifying the determinants of GDP per capita in OECD countries in a comprehensive framework with emphasis on human capital and innovation, openness, competitiveness, the size of the public sector and institutional variables. Apart from "traditional" variables, new elements are introduced in the analysis. The latter mostly pertain to specific aspects of the increasingly globalised environment, such as the ability of countries to take advantage of technology transfer channels depending, among others, on the degree of their outward orientation and their degree of competitiveness. Following another strand of the literature, a variable aimed at capturing the degree of market inefficiencies and / or distortions is also introduced.

[1] The views expressed in this paper do not necessarily reflect those of the institutions the authors are affiliated with.

A secondary aim of the paper is to use the conclusions from our empirical work in order to evaluate the current economic policy mix in Greece from a growth perspective. This is very important, as growth could prove to be the critical point for the success of the Adjustment Program: apart from a welfare issue, growth is a prerequisite for fiscal consolidation; otherwise, Greece may find itself trapped in a vicious circle of recession – missing the fiscal targets – implementing new measures resulting to a deeper recession and so on and so forth.

The structure of the paper is as follows: in section 2, links with the existing literature are established, while in section 3 the model to be estimated is described and elaborated. In the section that follows details are provided on data sources and definitions, with empirical results presented in section 5, including stationarity issues and a simulation exercise with Greece being used as a case study. Section 6 concludes.

Links to the existing literature

Following the article by Romer (1990), which rekindled the interest in endogenous growth, there were numerous contributions building on the already existing basis. Only indicatively, we should mention the reviews on the issue of Cameron (1996), Klenow and Rodriguez-Clare (1997), Jones and Manuelli (1997), Barro and Sala-i-Martin (2003), Weil (2008), Acemoglu (2009), Aghion and Howitt (2009). Regarding the empirics of growth, initially many researchers attempted to test the theoretical models, often facing the objections by others (such as Jones, 1995) who questioned whether the basic conclusions of these theoretical models (e.g., scale effects) are compatible with hard data and the stylized facts of growth[2]. Another strand of the empirical literature was based on ad-hoc ("atheoretical") empirical models incorporating the variables economic theory would suggest regardless of specific functional forms. Among the most notable examples, we find Coe and Helpman (1995) Coe, Helpman qand Hoffmaister (1997), followed by a vast literature of articles in the spirit of growth regressions (see, among others, Barro and Sala-i-Martin (2003), and empirical research by international organizations such as the O.E.C.D., the European Commission, the I.M.F. and the World Bank[3]). The econometric methods used and the conclusions of these articles are usually very interesting, although not directly related to theoretical developments. Durlauf et al. (2005, 2009) provide a very useful review of the relevant literature.

The model

The starting point of our analysis is the seminal work of Mankiw et al. (1992), which for many years served as a benchmark for assessing the value of empirical approaches to neoclassical growth theories incorporating additional factors (initially, human capital). Bernanke and Gurkaynak (2001) provided an insightful criticism of the aforementioned paper and proceeded to compile empirical estimates

[2] For example, see Temple (1999).

[3] Indicatively we should mention Bassanini and Scarpetta (2001), Ahn and Hemmings (2000) and the European Commission (2003).

with newer data and methods. Regarding the paper at hand, we opted to add variables suggested by several distinct contributions to the literature and then estimate the resulting model with the latest data available. More specifically we add:

a) a variable aimed at capturing distortions imposed by the participation of the public sector in economic activity[4]. These distortions pertain, among others, to market inefficiencies, weaknesses of the regulatory framework, increases in administrative burden, red-tape and the lower productivity of public enterprises. Ideally, we would opt to add also a variable directly measuring product market regulation, but the relevant time series provided by the OECD is not long enough.
b) a variable to capture the effect of R&D, not at the country level but at a more global sense: more specifically, we opt to investigate the effect of R&D undertaken by all OECD countries together. The implicit assumption here is that knowledge "produced" in one advanced country or the other is available at no cost (or, at least, at negligible cost) to other advanced countries through technology transfer and diffusion channels. The degree to which each country can exploit these channels depends, *inter alia*, on its outward orientation (see below on openness). The other important assumption is that it is not the *flow* of R&D expenditure that is relevant in this context, but the *stock* (as first analyzed by Coe and Helpman, 2005). The construction of this variable is explained in the following section. The rate of growth of Total Factor Productivity (TFP) for advanced countries was additionally tried to capture aspects of the innovation / knowledge accumulation process not necessarily incorporated in R&D.
c) openness, which measures the ability of countries to best utilize the access in greater markets and the resulting economies of scale. Openness can also approximate the ability of exploiting the channels of technology transfer and diffusion, which consist a close substitute of primary involvement in R&D.
d) competitiveness, which is a growth driver for countries in a globalized environment, in the sense that more competitive countries are better placed in order to penetrate and take advantage of growing export markets; in this way, these countries are not limited by the size of their domestic market thus enjoying the benefits of, for example, cost-reducing technologies.
e) hours worked, in the sense used by, among others, the European Commission (2003), i.e., in an attempt to further capture the effect of the labour input utilization "intensity".

Data sources and definitions

The main source of the data used in our empirical estimates is the Penn World Tables database (Mark 7.0, Heston et al., 2011). These data are largely considered the most reliable for international comparisons and have been widely used in the empirical literature. The variables used from this database are the following:

rgdpch: per capita GDP (chain series)
ci: investment share in GDP
pop: population

[4] Only indicatively, see De la Fuente and Vives (1997) and Barro and Sala-i-Martin (2003) for the theoretical underpinnings of this idea and Sfakianakis (2007) for a recent empirical estimate.

openc: (imports + exports) / GDP
cg: government share in GDP

The population variable is used to construct *n* for each country (the rate of change of the population). The variable (*n+g+d*) is constructed by adding 0.03 to the rate of change of the population in order to take account of depreciation and productivity growth. This method of constructing (*n+g+d*) is often used in the literature (see, for example, Bernanke and Gurkayanak, 2001).

For data on human capital, we used the Barro-Lee database (ver. 2.0, Barro and Lee, 2010), from which we extracted variable *tys* (total years of schooling) as a proxy for human capital. This variable is available at 5-year intervals, with missing observations calculated with linear interpolation.

We also extracted the variable *Hours Worked* from the OECD online statistical database *Sourceoecd* along with data on R&D expenditure for OECD Total. The latter is used in order to construct the variable R&D capital using the perpetual inventory method (with the first observation calculated as the ratio of the R&D expenditure this year divided by the average growth rate of the relevant series for the whole period[5]). The same source was used for the competitiveness variable.

The AMECO online database of the European Commission was used in order to construct a variable which could serve as a proxy for the rate of change in Total Factor Productivity at the international level[6].

In order to incorporate the concept of institutions and governance the average of the six governance indicators is used, according to World Governance Indicators ratings. According to these definitions, (i.e., the World Bank definition, Kaufmann et al., 2010), governance is described as "the traditions and institutions by which authority in a country is exercised. This includes (a) the process by which governments are selected, monitored and replaced; (b) the capacity of the government to effectively formulate and implement sound policies; and (c) the respect of citizens and the state for the institutions that govern economic and social interactions among them." Based on this definition six governance dimensions emerge, namely (i) Voice and Accountability, (ii) Political Stability and Absence of Violence/Terrorism, (iii) Government Effectiveness, (iv) Regulatory Quality, (v) Rule of Law, (vi) Control of Corruption. We opt to use an (unweighted) average of the six indicators.

Empirical results

Estimates for alternative specifications

The empirical estimation of our preferred specifications are presented in Tables 1 - 3. All equations were estimated using Panel EGLS, with country weights and diagonal correction of standard errors for heteroscedasticity and autocorrelation (using the methodology of White). Specifications with both fixed and random effects were tried,

[5] Following Coe and Helpman (1995).

[6] This variable averages the growth rate of Total Factor Productivity of EU-15 countries, USA, Japan and Canada.

but their performance was relatively inferior based on the usual statistical / econometric criteria[7]. Also, apart from allowing for a different residual variance for each cross section (captured by the country weights), there is no indication that the data structure is characterized by period specific heteroskedasticity, contemporaneous covariances, and between-period covariances (given, in any case, the relatively small time dimension). The latter does not hold for the third specification, where the time dimension is larger; in this case the test proposed by Wooldridge (2002) was used and the null hypothesis of no autocorrelation could not be rejected.

Table 1: Initial Specification

Dependent Variable: GDP per capita				
Sample: 1996 – 2008				
Periods included: 10				
Cross-sections included: 29				
Total panel (unbalanced) observations: 273				
(variables in logs)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	10.06240	0.926342	10.86251	0.0000
Investment share in GDP	0.104255	0.016778	6.213750	0.0000
Population (variable n+g+d)	-0.063064	0.020474	-3.080267	0.0023
Human capital	0.292308	0.052535	5.564039	0.0000
Government share	-0.559003	0.034301	-16.29694	0.0000
R&D capital	0.358992	0.016496	21.76250	0.0000
Openness	0.037974	0.014704	2.582570	0.0104
Growth of total factor productivity	-0.026070	0.132769	-0.196354	0.8445
Hours worked	-0.745697	0.103246	-7.222527	0.0000
Institutions	0.032939	0.011565	2.848043	0.0048
R-squared	0.997524	**Mean dependent var**		20.34443
Adjusted R-squared	0.997134	**S.D. dependent var**		18.80930
S.E. of regression	0.035811	**Sum squared resid**		0.301372
F-statistic	2558.738			
Prob(F-statistic)	0.000000			

[7] However, our results are robust to the choice of alternative econometric methods. Results of alternative methods are not presented due to space limitations, but are available upon request.

The overall fit and explanatory power of this model are very satisfactory, as indicated by the corrected R^2 and the significance level of the F-statistic. All estimators have the expected signs and are statistically significant at the 1% significance level (with the exception of the growth of total factor productivity). Real GDP per capita is positively affected by the investment share in GDP, human capital, openness, R&D capital and the quality of institutions / governance. The opposite holds for the impact of the population variable, the government share and hours worked (the latter possibly inducing a negative productivity effect, albeit in the medium to long-run)[8].

Table 2: Specification including competitiveness

Dependent Variable: GDP per capita				
Sample: 1996 – 2008				
Periods included: 10				
Cross-sections included: 27				
Total panel (unbalanced) observations: 253				
(variables in logs)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	12.29824	1.055564	11.65087	0.0000
Investment share in GDP	0.075573	0.019194	3.937381	0.0001
Population (variable n+g+d)	-0.061352	0.027350	-2.243253	0.0259
Human capital	0.242970	0.057791	4.204315	0.0000
Government share	-0.630587	0.032508	-19.39780	0.0000
R&D capital	0.333195	0.016628	20.03816	0.0000
Openness	0.064235	0.019455	3.301711	0.0011
Hours worked	-0.961779	0.117661	-8.174161	0.0000
Institutions	0.027074	0.012694	2.132804	0.0341
Competitiveness	0.000319	0.000147	2.173926	0.0308
R-squared	0.997848	**Mean dependent var**		20.05446
Adjusted R-squared	0.997500	**S.D. dependent var**		16.37263
S.E. of regression	0.034684	**Sum squared resid**		0.261045
F-statistic	2874.193			
Prob(F-statistic)	0.000000			

In this model we opted to omit the growth of total factor productivity (which turned out to be statistically insignificant) and to add a competitiveness variable. Again, the overall fit and explanatory power of this model are very satisfactory, as indicated by the corrected R^2

[8] European Commission (2003).

and the significance level of the F-statistic. All estimators have the expected signs and are statistically significant at the 5% significance level (with the majority of them being significant even at the 1% significance level). Real GDP per capita is positively affected by the investment share in GDP, human capital, openness, R&D capital, competitiveness and the quality of institutions / governance. The opposite holds for the impact of the population variable, the government share and hours worked.

Table 3: Specification allowing for a longer time series

Dependent Variable: GDP per capita				
Sample: 1981 – 2008				
Periods included: 28				
Cross-sections included: 27				
Total panel (unbalanced) observations: 588				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	15.11347	1.110686	13.60733	0.0000
Investment share in GDP	0.182918	0.025771	7.097832	0.0000
Population (variable n+g+d)	-0.207252	0.051451	-4.028165	0.0001
Human capital	0.294166	0.040962	7.181474	0.0000
Government share	-0.438059	0.041816	-10.47578	0.0000
R&D capital	0.260517	0.017529	14.86180	0.0000
Openness	0.080652	0.022607	3.567592	0.0004
Hours worked	-1.230096	0.132771	-9.264781	0.0000
Competitiveness	0.000436	0.000180	2.418988	0.0159
R-squared	0.987643	**Mean dependent var**		10.10790
Adjusted R-squared	0.986884	**S.D. dependent var**		0.451779
S.E. of regression	0.051741	**Sum squared resid**		1.480455
F-statistic	1299.997			
Prob(F-statistic)	0.000000			

For this last specification, we omitted the institutional variable because of the fact that it was restricting the sample in the time series dimension; as a result, we are able to capture the medium-term dynamics of GDP per capita. All estimators have the expected signs and are statistically significant at the 1% significance level. The impact of all variables on real GDP per capita is as expected and explained for the previous two specifications.

Stationarity Concerns

In this section, test results for stationarity are presented for the series used in the regressions of the previous section in order to ensure that the spurious correlation problem has been avoided. Should this be the case, estimators could be inconsistent, rendering t-statistics unreliable[9].

These test results are depicted in Table 4. More specifically, the results of the Levin, Lin & Chu (2002) test assuming one unit root for the panel series, along with the results of the Im, Pesaran and Shin (2003) and Maddala – Wu (1999) - Choi (2001) tests, based on which the ADF - Fisher Chi-square and PP - Fisher Chi-square statistics are computed. These last three statistics are based on the assumption that a distinct unit root exists for each unit of the panel. In most cases, test results coincide on the rejection of the hypothesis of a unit root at conventional levels of statistical significance. In those cases where test results are contradictory, the results of the Fisher-type tests are adopted following Maddala – Wu (1999).

The overall conclusion is that the empirical results of this section are valid and that there is no issue of a spurious relationship.

Table 4: Results of Panel Unit root tests

	Levin, Lin & Chu t*	**Im, Pesaran and Shin W-stat**	**ADF - Fisher Chi-square**	**PP - Fisher Chi-square**
Logarithm of real GDP per capita	-5,82260	0.70545	52.1481	36.1024
Marginal probability of rejection of H_o	0,0000	0.7597	0,4681	0,0304
Log of investment ratio in GDP	-1.85698	0.486653	57,8854	41.3065
Marginal probability of rejection of H_o	0,0317	0.00000	0,0008	0,0403
Population variable	-2.77479	5.13962	146.893	109.112
Marginal probability of rejection of H_o	0,0028	0.0000	0,0000	0,0000

[9] According to Phillips and Moon (1999), however, the problem of spurious correlation is less likely to occur when using panel data compared to using time series data.

Human capital	--6.52626	-26.5109	57.2058	189.955
Marginal probability of rejection of H_o	0,0000	0.0000	0,0004	0,0000
Size of the public sector	-2.15871	-1.4386	56.4659	21.3834
Marginal probability of rejection of H_o	0,0154	0.09568	0,3117	0,03543
R&D capital	2.70902	-14.3904	0.41132	50.1357
Marginal probability of rejection of H_o	0.5966	0.0000	0.39658	0.0062
Openess	-4.63981	-3.17974	83.2087	24.2852
Marginal probability of rejection of H_o	0.0000	0.0009	0.0039	0.03874
Hours worked	-5.3289	0.45454	2.3404	5.5630
Marginal probability of rejection of H_o	0.2971	0.17530	0.01765	0.03843
Competitiveness	-0.90558	-3.84398	114.305	118.672
Marginal probability of rejection of H_o	0.1826	0.00001	0.0000	0.0000

Simulation exercise for Greece and an economic policy evaluation

In trying to quantify the significance of our results, we calculated the effect of a 10% increase in variables positively affecting real GDP per capita (and, respectively, a 10% decrease of variables negatively affecting the dependent variable). The estimates, using as benchmark the values for all variables for the latest year available and the estimated coefficients of specification 3 are presented in Table 4.

Independent variable	Effect on GDP	% change of GDP
Human capital	795.3	2.8%
Openness	215.8	0.8%
Size of the public sector	1321.2	4.7%
Hours worked	3870.4	13.8%
Investment as a ratio to GDP	491.9	1.8%

The main conclusions from this simulation exercise are the following:

a) The restrictive fiscal stance can be pro-growth, albeit in the medium-to-long-term.
b) Investment in human capital should probably be an exception to expenditure cuts at the current juncture; however, taking (a) into account, should increases in spending for education be decided, they should achieved at the expense of other expenditure items, thus not leading to an expansion of the general government: as our estimate for the size of the government is negative, an increased public spending on education should be financed only through a reallocation of resources.
c) The result for hours worked point strongly in the direction that the problem of the Greek economy is not a problem of *intensity* but, rather, one of *productivity*.
d) Structural reforms are needed as far as the business environment is concerned so that it becomes more investment-friendly. This, apart from obvious aggregate demand effects, would facilitate the much needed technological restructuring process, thus boosting productivity and enhancing competitiveness[10].

On another note, attempting an evaluation of the economic policy mix currently implemented in Greece based on the results of section 5.1, the conclusion is that Greece should pursue a fiscal consolidation strategy and that it should indeed aim at a more outward oriented and competitive economy with more investment in human capital and innovation; also, that it should elaborate a strategy to improve the institutions currently in place.

However, the real question is not whether these targets (which are already included in the economic policy program) are appropriate - most economists would probably agree without serious reservations. The critical point is whether the means and the tools used to pursue the targets are the right ones. Also, we should add that all these sound fine for the medium-term, but a short-run growth strategy is probably missing, thus undermining the fiscal consolidation effort as well - in the sense of the vicious circle we mentioned in section 1. This is something that should be urgently addressed by any government finds itself in office after the forthcoming elections.

[10] This is also obvious from the effect of the R&D capital variable. This variable was excluded from the simulation exercise, as it is not a variable affected by individual countries' policy choices. The competitiveness variable was also excluded, as the OECD database does not provide data for Greece for the specific variable.

Conclusions

Using insights from the traditional determinants of growth models, which we opted to enrich with recent developments, we proceeded to estimate a model aiming at explaining differences in GDP per capita among OECD countries. Using the latest datasets available (such as PWT 7.0), we confirmed the crucial role of knowledge / innovation variables (human capital and R&D capital) along with the positive impact of a) the outward orientation of economies and competitiveness b) investment in physical capital and c) the quality of institutions / governance. On the other hand, a negative impact of the size of the government was detected, as expected based on previous contributions. The same holds for the intensity of the labour input utilization (captured by total hours worked). Using Greece as a case study, we also proceeded to quantify the potential incremental contribution of increases / decreases in dependent variables, thus identifying possible drivers of growth in this very critical phase of the economic cycle: growth could well prove to be the key for the success of the currently implemented economic policy mix, with a properly elaborated growth strategy urgently complementing the adjustment program.

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