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Endogenous Growth And Country Heterogeneity In Economic Growth: Evidence From Selected OECD Countries

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Abstract

Investment in human capital, innovation, and knowledge are significant contributors to economic growth. Theories of economic growth indicate that saving and investment are the main forces of economic growth. Nevertheless, empirical results are not unanimously consistent with theory. In addition, economic growth varies from country to country. Neglected country heterogeneity in cross-country empirical analysis can be spurious. Making empirical contribution, this paper attempts to address the abovementioned problems by empirically testing determinants of economic growth utilizing data from OECD countries. For comparison purposes, selected OECD countries are divided into two groups: richest economies and relatively less rich economies. Results of empirical estimation indicate that lagged investment and lagged saving play a negative role in economic growth. For both richest economies and relatively less rich economies, country heterogeneity influences economic growth.

Keywords: Economic Growth, Endogenous Growth, Country Heterogeneity

Introduction

A great deal of research pertains to the fundamental forces that drive economic growth over time. Despite the fact that economic growth is crucial to reduce world poverty, it is not a panacea for achieving sustainable and shared development process. This paper empirically tests determinants of economic growth utilizing data from OECD countries. For comparison purposes, selected OECD countries are divided into two groups: richest economies (Group 1) and relatively less rich economies (Group 2). Following Bhattarai (2004), this paper assesses the importance of investment and saving, trade openness, shares of government spending and tax revenue in GDP, and growth rate of population in economic growth.

Main growth theories emphasize the importance of factor accumulation and technological progress in the process underlying economic performance. Empirical estimation finds somewhat surprising results. For richest OECD countries, lagged investment, lagged saving, and government consumption are found to be significantly and negatively related to growth, while openness to trade is found to be significantly and positively related to growth. For relatively less rich countries, lagged investment, government consumption and population growth are all found to be significantly and negatively related to growth. For both groups, country heterogeneity influences economic growth.

The remaining part of this paper is organized as follows. Section 2 reviews related literature. Section 3 explains the economic rationale of potential explanatory variables. Section 4 describes the data. Section 5 introduces the econometric model and justifies econometric techniques. Section 6 interprets the results. Section 7 concludes.

Related Literature

This section focuses on empirical literature on growth related to advanced economies and, more specifically, on cross-country empirical works rather than growth accounting approaches[1].

A large amount of previous research emphasizes the importance of factor accumulation and technological change in the process underlying economic growth. Only a partial selection of literature is mentioned here. Mankiw *et al.* (1992) uses cross-country regressions on a sample consisting of 98 countries and supports the view that investments in physical and human capital are the driving forces of economic growth. This finding has been confirmed by subsequent research, for example Arnold *et al.* (2007). The rate of gross secondary school enrollment is widely used in previous literature as a proxy of human capital. Temple (1999) argues that focus on schooling rather than training is mainly due to data limitations. Easterly and Levine (2001) points out that the relation between human capital and economic development is still subject to debate. Besides, the economically and statistically significant positive relation between investment and growth has been challenged, since there is a potential endogeneity of investment to growth.

Moreover, it is widely acknowledged that research efforts are of the greatest importance for advanced economies, since R&D plays a substantial role in the production of knowledge and the process of technological change. However, Jones (1995) challenges the validity of research-driven growth models on the basis that accelerating R&D has not induced any persistent upwards trend in the economic growth rates of OECD countries.

The new growth theory emphasizes that appropriate public policies (related to education policy, fiscal and regulatory regimes, and financial systems) can exert a considerable influence on long-run economic growth by creating an environment more favorable to physical and human capital

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[1] Growth accounting aims at investigating how much growth can be attributed to the accumulation of factors and the unexplained component (Solow residual). Growth accounting has a long tradition in the literature of economic growth. For instance, Solow (1957) finds that technological change accounts for seven eighths of the total increase in the output per capita over the period of 1909-1949 in United States.

accumulation and to R&D efforts. Also, stability-oriented macroeconomic policy (associated with a low inflation rate, improved public finances, and an undistorted exchange rate) fosters stronger growth by creating a more conducive environment for private investment (Fisher, 1993; Bleaney, 1996; Temple and Sirimaneetham, 2006). Nevertheless, the direction of causality between growth and sound macroeconomic outcomes can be dubious.

Empirical studies (Edwards, 1998; Dollar and Kray, 2002) find that outward-oriented economies exhibit faster growth rates over long periods of time. Nonetheless, some research, in line with Rodriguez and Rodrik (1999), challenges the findings of such a strong and positive link between openness and growth. Foreign Direct Investment (FDI) has also been advocated as a source of growth when the host country is endowed with a sufficient human capital stock to absorb technology transfers (Borensztein *et al.*, 1998). Again, the direction of causality between FDI and growth is uncertain (poorer economies tend to attract less FDI).

On the basis of multivariate regressions of 21 OECD countries over the period of 1971-1998, Bassanini *et al.* (2001) confirms that policy variables related to macroeconomic conditions, trade openness and financial markets structure, physical and human capital accumulation, and R&D, influence economic growth.

Economic Rationale

Levine and Renelt (1992) asserts that no consensus on the theoretical framework underlies empirical works on growth. Similarly, Sala-i-Martin (1997) argues that growth theories are “not explicit enough” about what variables should be included as explanatory variables in empirical estimation. According to previous literature, a country’s economic growth rate tends to be linked to a variety of economic, political, and social variables. The decision over which specific variable to use is mainly driven by empirical results from previous literature. This paper follows the theoretical rationale of potential explanatory variables in Bhattarai (2004) and discusses related issues.

Physical investment rate. While the Solow Model indicates that physical capital accumulation affects growth only in the transitional period to the steady state, endogenous growth models argue for more persistent effects. Lucas (1988) claims that the main force behind long-run economic growth lies in the process of learning-by-doing, *i.e.*, workers improve their productivity as they spend longer hours doing their job. Hence, the accumulation of capital generates positive externality which offsets the diminishing returns underlined by the Solow Model. Alternatively, Barro (1990) proposes a model of public spending and growth, according to which returns to private investment may increase due to positive externality of public spending on infrastructure, which can be seen as free inputs for firms. Despite the theory that there exists a robust and positive link between physical capital accumulation and economic growth, empirical estimation requires further consideration, as the investment rate does not capture any information concerning the quality of investment. Furthermore, there is a potential endogenous growth of investment. Therefore, this paper utilizes lagged investment in the empirical estimation.

Saving rate. Higher saving rates translate into more capital accumulation, and therefore faster growth rates. The saving rate reflects, among other things, preferences and incentives to accumulate capital. It is substantially influenced by the age dependency ratio, the nature of the retirement system, and economic policy. Since there is also a potential endogenous growth of saving, lagged saving is used.

Openness to trade. There are strong theoretical reasons to expect a positive and robust correlation between the share of trade in GDP and growth. Trade openness allows the exploitation of comparative advantage and increasing returns to scale, technology transfers, diffusion of knowledge, as well as exposure to competition, which ultimately promotes economic growth.

Government consumption / GDP and Tax revenue / GDP. These variables are used as a proxy for the “government burden”. Public spending can play a beneficial role for the economy (Barro, 1990; Bleaney *et al.*, 2001). However, an excessive public sector, financed by high tax rates, may constitute a "heavy burden" by promoting and maintaining ineffective public programs, distorting market incentives and hindering private activity (Loayza and De Soto, 2002). We must acknowledge that tax revenue provides information related to average taxes in the economy only, while Ahn and Hemmings (2001) argues that incentives created by fiscal systems are more likely to be reflected by marginal taxes than average taxes. However, we must rely on the latter due to data limitations. Also, including the tax revenue to GDP ratio in our growth regression may not be relevant and may introduce an unnecessary element of multicollinearity, since tax revenues are more likely to affect government consumption than growth.

Population growth rate. Since the Malthus Growth Model, most theoretical works assessing the demographic-economic growth relation have emphasized that excessive population would retard growth due to excessive resources consumption. However, the composition of the population matters for growth. The neoclassical growth theory predicts that labor force growth is conducive to economic growth. On the other hand, a population growth rate driven by aging populations is deemed to be a hindrance to economic growth.

Data

The data are gathered from World Bank and OECD, spanning from 1972 to 2004 across 19 countries. All countries in the data set (Luxembourg, United States, Norway, Ireland, Switzerland, Denmark, the Netherlands, Australia, Austria, Finland, Sweden, Canada, United Kingdom, Belgium, France, Japan, Germany, Italy, and Spain) are classified as the most advanced economies in the world.

Due to data limitations, Iceland is eliminated from the sample (data on tax revenue as a share of GDP are not available) and the analysis of the determinants of growth of the selected OECD countries is restrained to the 1972-2004 period.

The dependent variable is the growth rate of real GDP per capita

(GROWTH). It is calculated by dividing nominal GDP with total population. Then, real GDP per capita, *y*, is given by dividing GDP per capita with GDP deflator. Finally, we takes the first difference of log-level of real GDP per capita and obtain GROWTH, *i.e.*, $\ln y_t - \ln y_{t-1} = \text{GROWTH}$.

The set of explanatory variables is as follows.

Investment rate (I) is the share of gross fixed capital formation in GDP and excludes inventories.

Saving rate (S) is the share of gross domestic savings in GDP. Gross domestic savings are calculated as GDP less total consumption.

Openness to trade (OPEN) is measured by the sum of imports and exports as a share of GDP.

Ratio of government consumption to GDP (G) is given by general government final consumption expenditure as a share of GDP. It includes all government current expenditures for purchases of goods and services (including compensation of employees) and also includes most spending on national defence and security.

Ratio of tax revenue to GDP (TAX) is a measure of compulsory transfers to the central government for public purposes as a share of GDP.

Population growth rate (POP) measures the annual change in total population.

The summary descriptive statistics of the variables are presented in Table 1.

Table 1 Summary Descriptive Statistics

Variables	Mean		Std. Dev.		Min (Country)		Max (Country)	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
GROWTH	0.023	0.021	0.023	0.02	0.008 CHE	0.017 SWE	0.041 IRL	0.024 FIN
I	0.224	0.221	0.037	0.04	0.188 USA	0.181 GBR	0.256 CHE	0.294 JAP
S	0.262	0.234	0.066	0.042	0.176 USA	0.175 GBR	0.362 LUX	0.313 JAP
OPEN	0.859	0.568	0.529	0.293	0.201 USA	0.218 JAP	2.002 LUX	1.316 BEL
G	0.184	0.201	0.042	0.038	0.109	0.147	0.254	0.273

					CHE	JAP	DNK	SWE
TAX	0.363	0.372	0.075	0.078	0.267 USA	0.259 JAP	0.465 DNK	0.488 SWE
POP	0.007	0.004	0.005	0.004	0.003 DNK	0.002 DEU	0.013 AUS	0.012 CAN

On average, the real GDP per capita tends to have grown at a faster rate in the richest OECD countries: 2.3% versus 2.1% in the remaining countries. Investment rates are similar in both groups, while the most advanced economies exhibit slightly higher saving rates over the period 1973-2004. Descriptive statistics show a clear difference between the two sub-samples regarding their openness to international trade. The richest economies are also the most outward-oriented. Standard deviations, however, tend to indicate a certain level of heterogeneity of openness within groups. The size of the public sector appears, to some extent, larger in the relatively less rich OECD economies. Lastly, both groups record low population growth rates. On average, population growth rates do not exceed 1%.

Econometric Model

For comparison purposes, selected OECD countries are divided into two groups (j = 1, 2): Group 1 includes the top 10 economies (excluding Iceland), and Group 2 consists of the remaining ten economies. Each sub-sample involves data on n_j countries observed over 32 periods[2], *i.e.*, $n_j \times 32$ observations.

We begin the empirical analysis by performing a series of preliminary tests. A pooled OLS regression is first estimated to allow comparisons across both cross-section and time dimensions. The paper hypothesizes the following linear equation:

$$\text{GROWTH}_{it} = \alpha + \beta_1 X_{1it} + \cdots + \beta_6 X_{6it} + \varepsilon_{it}\,, \qquad (1)$$

[2] The initial panel data spanned the period of 1972-2004. Since I and S are lagged once, one year is missing, making the time span 31 years.

where GROWTH is the dependent variable; the Xs are the explanatory variables; α is a single intercept for the entire model. The subscripts i and t represent country and year, respectively. Also, we assume that $\varepsilon_{it} \sim iid(0, \sigma_{\varepsilon}^2)$ for all i and t.

However, it is plausible that unobserved heterogeneity of countries affects the effect on growth of a change in our regressors. Since the pooled OLS estimators may be biased due to country fixed effects, we subsequently run a second regression:

$$\text{GROWTH}_{it} = \alpha + \beta_1 X_{1it} + \cdots + \beta_6 X_{6it} + \gamma_1 D_{1it} + \cdots + \gamma_{n_j-1} D_{n_j-1it} + +\varepsilon_{it}\,, \qquad (2)$$

where the Ds are country dummies. Since the regression includes a constant term, only (n_j-1) dummies are included[3]. The $\hat{\gamma}$s measure the individual change from the intercept. OLS is used to estimate the model. If the joint significance test of dummies coefficients reveals that at least some of them are statistically significant, pooled OLS estimators obtained from (1) are biased (due to omitting fixed effects dummies).

In that case, unobserved heterogeneity in the model specification must be controlled. Accordingly, the disturbance term must be decomposed as follows:

$$\varepsilon_{it} = \alpha_i + u_{it}\,. \qquad (3)$$

It is assumed that there is no time effect. α_i is an unobserved country-specific effect that may (fixed effects model[4]) or may not (random effects model) be correlated with explanatory variables. Also, we assume that u_{it} is uncorrelated with X_{it}. Accordingly, the following linear growth regression is estimated:

$$\text{GROWTH}_{it} = \alpha + \beta_1 X_{1it} + \cdots + \beta_6 X_{6it} + \alpha_i + u_{it}\,. \qquad (4)$$

[3] Luxembourg is the reference country of Group 1, and Finland is the reference country of Group 2.

[4] Equation (2) performs “least squares dummy variables” estimation, which are similar to fixed effects estimation. Only the intercept changes.

Both fixed effects model (FE) and random effects (RE) model assume that country specific-effects are constant across time. However, α_i can be regarded either as a "fixed effect" when it is treated as a parameter to be estimated for each country i, or as a "random effect" when it is treated as a random variable (Wooldridge, 2002). The OLS framework can be applied to the FE approach, whereas the RE approach requires the GLS framework. Hausman specification test is carried out to check whether the RE or FE model should be used.

Since the time span of the data is quite long (32 years), serially correlated disturbances are realistically expected, in which case the usual FE standard errors are very misleading (Wooldridge, 2002). Estimation method that computes standard errors robust to serial correlation is required. Also, since the data span countries of different sizes, heteroskedastic disturbances are also expected. Coefficient estimates are still unbiased, but standard errors tend to be underestimated. As a result, the probability of type I error increases. We address this issue by estimating a feasible GLS specification assuming the presence of cross-section heteroskedasticity in the error term (*i.e.*, different disturbance variances for the different countries). Diagnostic tests for serial correlation and heteroskedasticity find that serial correlation and heteroskedasticity both exist. As a result, for comparison purposes, the paper conducts robustness check and provides estimation results of the following cases: heteroskedasticity; serial correlation; neither heteroskedasticity nor serial correlation.

Given the lack of clear theoretical framework underlying the choice of the growth model specification, interpreting the empirical results should also be cautious. Levine and Renelt (1992) notably argues that empirical findings on the determinants of growth are not robust to changes in specification. Also, it cannot be ruled out that a specification error has been made in the growth model we estimated. Such misspecification issues may occur when an incorrect functional form is chosen and/or when relevant explanatory variables are omitted. The fixed effect estimation only controls for omitted variables that are persistent over time. While including an irrelevant variable does not lead to bias (but induces a loss in efficiency), omitting a relevant variable yields biased and inconsistent estimates.

Empirical Results

This paper provides, describes and attempts to explain our empirical findings for both sub-samples in turn. Similarities and differences between the latter are also discussed.

The Richest OECD Economies

The analysis of the pooled regression augmented with country dummies, Equation (2), shows that the initial pooled regression, Equation (1), produces biased coefficients. Indeed, a Wald test is performed to evaluate restrictions on the estimated dummies coefficient. Under the null hypothesis, all the $\hat{\gamma}$s are set equal to zero; *i.e.,* cross-section heterogeneity does not matter for growth since data are consistent with a single intercept for the entire model. Under the alternative, at least some of the dummy coefficients are different from zero and, therefore, our model specification should account for cross-section heterogeneity. The Wald test statistic for eight restrictions (92.57) is compared against the critical value of a Chi-square distribution with eight degrees of freedom (15.51 at the 5% significance level). The test statistic exceeds the critical value. Hence, the null hypothesis is rejected.

It follows that the growth model specification must be transformed to take account of country-specific effects. The next step is to check whether these latter should be treated as random or fixed. Hence, the Hausman specification test is performed. The Hausman test statistic (58.10) is compared against the critical value of a Chi-square distribution with six degrees of freedom (12.59). Since the test statistic exceeds the critical value, the null hypothesis is rejected. Hence, it is concluded that a FE model provides a better fit. The main empirical findings related to the determinants of growth are based on a FE model adequately estimated to take account of the presence of heteroskedastic and serially correlated errors.

The test of significance for the coefficient of TAX yields a p-value of 0.33, which largely exceeds the 5% significance level. Hence, we fail to reject the null hypothesis according to which the estimated coefficient is equal to zero. Given this result, and the fact that we are initially concerned with the explanatory power of the variable, TAX is excluded from the set of explanatory variables. POP is also found to be statistically insignificant[5], but we keep it in the regression. Estimation results are shown in Table 2.

Table 2 Estimation Results for Group 1

Dependent Variable : GROWTH				
Method: Fixed Effects Panel	Periods included: 32			
Cross-sections included: 9	Total panel (balanced) observations: 288			
	Regression 1	Regression 2	Regression 3	Regression 4
	Coef. (P-values)	Coef. (P-values)	Coef. (P-values)	Coef. (P-values)
C	0.245 (.000)	0.242 (.000)	0.245 (.000)	0.242 (.000)
I(-1)	-0.160*** (.000)	-0.159*** (.001)	-0.160*** (.000)	-0.159*** (.000)
S(-1)	-0.210*** (.000)	-0.207*** (.003)	-0.210*** (.000)	-0.207*** (.003)
OPEN	0.038** (.017)	0.04*** (.001)	0.038*** (.000)	0.040*** (.000)
G	-0.889*** (.000)	-0.892*** (.000)	-0.889*** (.000)	-0.892*** (.000)
POP	-0.169 (.655)	-0.005 (.992)	-0.169 (.593)	-0.005 (.988)
R^2	0.363	0.353	0.363	0.353

Note: (1) the estimation method of Regression 1 takes account of heteroskedasticity and serial correlation; the estimation method of Regression 2 takes account of serial correlation; the estimation method of Regression 3 takes account of heteroskedasticity; the estimation method of

[5] We also perform a Wald test to test the joint significance of TAX and POP. We fail to reject the null hypothesis that both coefficients are equal to zero. We decide to keep POP, because we are less sceptical about the link between population growth and economic growth than we are about the link between TAX and GROWTH.

Regression 4 does not take account of serial correlation nor heteroskedasticity. (2) *, ** and *** indicate rejection of the null hypothesis at 1%, 5% and 10% level of significance, respectively.

I(-1) and S(-1) are economically and statistically significant. Both coefficients (-0.160 and -0.210 respectively) take a negative sign, while a positive sign is expected. These findings are not consistent with economic theory. Higher investment and saving rates should translate into higher capital accumulation and therefore in economic growth. I reflects fixed physical capital accumulation. We argue that growth in advanced economies can be driven by R&D efforts, which are not taken into account in our measure of investment. Also, higher S allows for greater capital accumulation, which includes human capital investment. When OECD countries face a mismatch between demand and supply of workers' skills, human capital accumulation, resulting from higher saving rates, may not translate into higher growth rates. Also, higher saving means lower consumption, which may translate into slower economic growth rates when household consumption expenditures account for a substantial part of GDP. OPEN is statistically significant. Its coefficient (0.038) takes the expected positive sign but is quite low regarding the expected direct and indirect gains from international trade. Trade openness, measured as the sum of exports and imports divided by GDP, may be more closely linked to country size. Due to internal constraints, small economies like Luxembourg are likely to exhibit greater openness than bigger ones like United States. However, this phenomenon should be captured by our model which allows for omitted variables constant over time. Recent developments in international trade theory may bring an explanation for such a low coefficient. While the standard theory based on competitive trade models argues that free trade (reflected by the volume of trade) is the best policy, scholars have recently claimed that the policy prescription is not as clear when imperfect competition models are considered. International trade is still considered as a source of economic growth, the mechanism through which openness to trade is conducive to economic growth may not be captured by our model. G is economically and statistically significant. Its coefficient (-0.889) takes the expected negative sign. This is consistent with theory that regards an excessive government size as a hindrance for private activity. Taxes required to finance the public sector distort incentives and government intervention is likely to cause a less efficient allocation of resources.

R^2 takes the value of 0.36. Such a level for the goodness of the fit of our model is expected given the issue related to the uncertainty of the growth model specification. The Jarque-Bera statistic, distributed as a Chi-square with two degrees of freedom, is used to test the null hypothesis of residual normality (Figure 2). The p-value associated with is 0.20 Hence, the null is rejected at the 5% (and even 10%) significance level. Residuals are normally distributed. However, the violation of the normality assumption is not a problem, because our sample size is quite large. The Jarque-Bera test can also be regarded a test of mis-specification. Indeed, the non-normality of the residuals may be explained by the presence of many large residuals. The existence of a number of outliers would suggest that our growth model does not capture the data generating process.

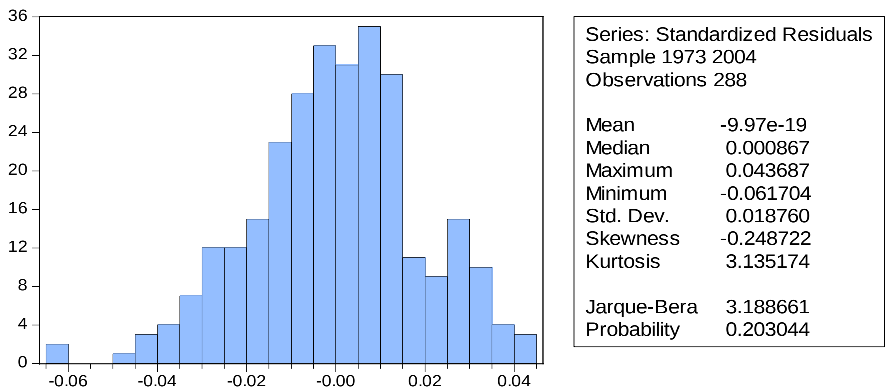


Figure 1 The Jarque-Bera Test for Normality of the Residuals

Correlations of explanatory variables with each other are presented below (Table 3). Data indicate a quite strong correlation between openness to trade and lagged saving rate, *i.e.*, OPEN and S(-1) are closely correlated.

Multicollinearity can lead to larger standard errors and smaller t-ratios. As a result, the probability of type II error increases.

Table 3 Correlation Matrix between the Explanatory Variables

	I(-1)	OPEN	G	S(-1)	POP
I(-1)	1				
OPEN	-0.13	1			
G	-0.27	-0.06	1		
S(-1)	0.26	0.65	-0.3	1	
POP	0.08	-0.02	-0.21	0.06	1

Finally, it is noticed that, whatever the estimation method used, the empirical findings do not change. Estimated coefficients keep the same sign and the amplitude of the response to a one unit change in the (statistically significant) explanatory variables is barely altered by a change in the estimator used (OLS or GLS) and by a change in the correction for serial correlation. The explanatory power of our growth model is slightly greater when heteroskedasticity is assumed.

The Relatively Less Rich OECD Economies

Analysis of the pooled regression augmented with country dummies, Equation (2), shows that the initial pooled regression, Equation (1), produces biased coefficients. This time, the Wald test statistic for nine restrictions (45.13) is compared against the critical value of a Chi-square distribution with nine degrees of freedom (16.92 at the 5% significance level). Following the testing methodology detailed previously, a growth model specification that takes account for country-specific effects is favored . Again, Hausman test finds that a FE model provides a better fit. Again, the main empirical findings are based on a FE model adequately estimated to take account of the presence of heteroskedastic and serially correlated errors.

Both TAX and OPEN are not statistically related to growth. The p-value associated with the Wald test statistic is 0.94. It greatly exceeds the 5% significance level. Hence, we failed to reject the null hypothesis that both estimated coefficients are equal to zero. However, TAX is only deleted, because it is believed that the link between TAX and GROWTH is dubious. Estimation results are reported in Table 4.

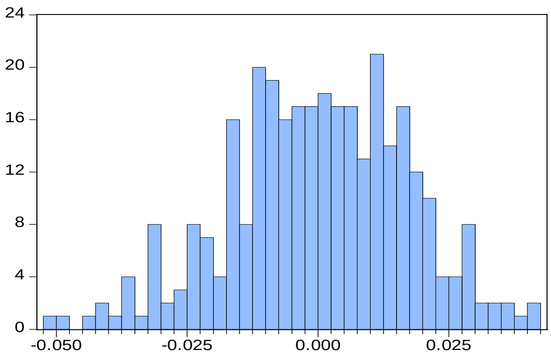
Table 4 Estimation Results for Group 2

Dependent Variable : GROWTH				
Method: Fixed Effects Panel Periods included: 32				
Cross-sections included: 10 Total panel (balanced) observations: 320				
	Regression 1	Regression 2	Regression 3	Regression 4
	Coef. (P-values)	Coef. (P-values)	Coef. (P-values)	Coef. (P-values)
C	0.229 (.000)	0.198 (.009)	0.229 (.000)	0.198 (.000)
I(-1)	-0.191** (.013)	-0.179* (.095)	-0.191*** (.000)	-0.179*** (.001)
S(-1)	-0.089 (.166)	-0.036 (.583)	-0.089* (.096)	-0.036 (.532)
OPEN	0.002 (.914)	0.006 (.836)	0.002 (.843)	0.006 (.635)
G	-0.704*** (.000)	-0.637*** (.000)	-0.704*** (.000)	-0.637*** (.000)
POP	-0.990*** (.001)	-1.032*** (.002)	-0.990*** (.008)	-1.032*** (.005)
R^2	0.269	0.241	0.269	0.241

Note: (1) the estimation method of Regression 1 takes account of heteroskedasticity and serial correlation; the estimation method of Regression 2 takes account of serial correlation; the estimation method of Regression 3 takes account of heteroskedasticity; the estimation method of Regression 4 does not take account of serial correlation nor heteroskedasticity. (2) *, ** and *** indicate rejection of the null hypothesis at 1%, 5% and 10% level of significance, respectively.

The results argue that trade openness is not related to growth, because relatively less advanced OECD economies may have insufficiently specialized in high-technology products to stay competitive in world markets against emerging countries. This time, POP is found to be economically and statistically significantly related to growth. Its coefficient (-0.990) takes the expected negative sign predicted by the theory when the population growth rate is substantially driven by aging population. I(-1) remains economically and statistically significant. Its coefficient (-0.191) is still negative and is inconsistent with economic theory and previous empirical studies. S(-1) is no longer significantly related to growth. G is still economically and statistically significant. The coefficient for the variable (-0.704) takes an expected negative sign. The negative effect on economic growth of a one unit change in government spending tends to be smaller in relatively less rich OECD economies as compared with the top 10. It is argued that the relatively less "advanced" countries may suffer from a lack of infrastructure. In that case, public spending may be beneficial to some extent. None of the estimated coefficients (excluding the intercept) appear to be positively related to economic growth.

Only 27% of the total variation in real GDP per capita growth rates are explained by the linear combination of our regressors (I(-1), S(-1), OPEN, G and POP). Again, the residuals do not appear normally distributed (Figure 3). The p-value associated with the Jarque-Bera test statistic is 0.20. Hence, the null is rejected at the 5% (and even 10%) significance level. The rejection of the normality assumption may be due to the existence of a number of outliers that would suggest that our growth model does not capture the data generating process.



Series: Standardized Residuals	
Sample 1973 2004	
Observations 320	
Mean	1.01e-18
Median	0.000513
Maximum	0.042331
Minimum	-0.051978
Std. Dev.	0.017116
Skewness	-0.219712
Kurtosis	2.914656
Jarque-Bera	2.671697
Probability	0.262935

Figure 2 The Jarque-Bera Test for Normality of the Residuals

Correlations of explanatory variables with each other are reported below (Table 5). This time, data indicate that a strong correlation exists between the lagged investment rate and the lagged saving rate. Again, it follows that it must be careful when interpreting inferential statistics, because they may be uninformative.

Table 5 Correlation Matrix between Explanatory Variables

	S(-1)	POP	OPEN	I(-1)	G
S(-1)	1				
POP	0.26	1			
OPEN	-0.19	-0.15	1		
I(-1)	0.79	0.29	-0.45	1	
G	-0.49	-0.18	0.42	-0.61	1

Lastly, it is obvious that the second set of empirical findings tend to be slightly more sensitive to the estimation method used. Estimated coefficients keep the same sign. However, when the GLS estimator is used, the estimated responses of a change in I(-1) and G tends to be greater, while the estimated responses of a change in OPEN and POP are smaller. Again, the explanatory power of the model tends to be greater when the estimation approach takes account of heteroskedastic disturbances. Also, POP is found to be statistically significant only when the model for heteroskedasticity and serial correlation is corrected.

Conclusion

This paper investigates determinants of economic growth and empirically test the determinants based on OECD countries. For comparison purposes, the sample is split into two groups so as to investigate the sources of growth in the most advanced countries (Group 1), and in the relatively less wealthy countries (Group 2).

Growth theory has identified physical and human capital as well as technological development as major factors underlying the process of economic growth. By allocating or by creating the conditions to allocate more resources to the capital accumulation and R&D efforts, public policies can exert a considerable influence on long-run growth. Previous literature on growth empirics, like Levine and Renelt (1992) and Sala-i-Martin (1997), tends to argue that growth theories are “not explicit enough” about what variables should be included in the right-hand-side of the growth regression. In our empirical work, we follow Bhattarai (2004) and assess the importance of investment and saving rates, trade openness, shares of government spending and tax revenue in GDP, as well as population growth rate in accounting for economic growth.

In line with Bhattarai (2004), country-specific factors are important determinants of economic growth among the two groups of OECD countries. However, some of our estimates are not consistent with the economic theory or with the findings of Bhattarai (2004). Tax revenue/GDP is removed from the set of explanatory variables, because it is found to be statistically insignificant and its explanatory power of growth is dubious. The most surprising result is that lagged investment and saving rates in the case of Group 1 and lagged investment rate solely in the case of Group 2 are negatively related to growth. Openness to trade contributes to explaining growth in the top 10 countries. Our estimate (0.04) is quite similar to Bhattarai’s estimate (0.06). The data suggest a more sizeable effect on growth of a one unit change in government spending/GDP (-0.89 and -0.70, versus -0.21 in Bhattarai (2004)), while they suggest a smaller response to a one unit change in population growth rate (-0.99, vs. -1.89 in Bhattarai’s paper). For both groups, the empirical results are robust to changes in the estimation method used (OLS/GLS, with/without correction for serial correlation).

It is well known that high saving rate will result in low growth due to the reduction of people’s investment and consumption. Also, there is a reasonable explanation for the negative relation between the investment rate and growth. To some extent, fixed assets investment is mainly dominated by the government and the government’s aggressive investment is mostly to keep economic growth during the recession. So it exists a negative correlation between them.

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