Estimates of the steady state growth rates for some European countries

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Abstract

This paper estimates the steady state growth rates for the main European countries with an extended version of the Solow (1956) growth model. Total factor productivity is assumed a function of human capital, trade openness and investment ratio. We show that these factors, with some differences, have played an important role to improve the long run growth rates of Italy, Spain, France, UK, and Ireland. A few policies to improve the long-run growth rates for these countries are suggested.

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1. Introduction

In the Solow (1956) growth model the long-run equilibrium growth of output (expressed in per worker terms) is determined by total factor productivity (TFP). TFP is usually estimated as a residual from the growth accounting framework of Solow (1957) and for this reason is also known as the Solow Residual (SR). Endogenous Growth Models (ENGMs) identify factors on which the TFP/SR may depend. Although there is a large number of cross-country empirical works based ENGMs, empirical work with country-specific time series data is limited.1 In addition, the major part of these studies is on the developing countries2 and very few on the matured industrial economies.3 Therefore, it is not known what are the long run growth rates of such industrialized countries and what are the important factors on which their TFPs depend. This paper aims to fill this gap but uses an extended Solow (1956) growth model for this purpose. We estimate the long run growth rates for a selected group of European countries: Italy, France, UK, Spain, and Ireland and our methodology can also be used to estimate the long run growth rates for other countries.

In the empirical work on the ENGMs many potential determinants of the long-run growth have been used although it is difficult to develop theoretical frameworks to justify each and every potential determinant. For example, Durlauf et al. (2005) make a list of more than 100 potential growth determinants in the empirical works. However, Jones (1995) cited no more than 10 potential determinants of the long-run growth such as physical investment rate, human capital, export share, government consumption etc.4 Due to limited sample size (50 observations) in the country specific time series data, only a few such potential explanatory variables can be considered. Although we experimented with several variables, we found that trade openness5 (TRADE), an index of human capital (HKI) and investment ratio (IRAT) are adequate to explain TFP in our selected countries. After having estimated our extended growth model, we estimate the steady state growth rate (SSGR) defined as a situation in which the rate of growth of physical capital (expressed in per capita

1 Greiner et al. (2005) is one of the few attempts to estimate endogenous ENGMs with country-specific time series data. More recent studies are Rao (2010a) and Rao (2010b) for example.
3 See for example Paradiso and Rao (2011) for a study on Italy.
4 Levine and Renelt (1992), using the extreme bounds analysis, have found that only the investment ratio is a robust explanatory variable of growth.
5 Trade openness (or short: openness) measure is based on the share of nominal exports and imports in GDP. Several measures of openness have been used in the empirical growth literature. The ratio between exports and imports and GDP has increasingly become the variable of choice in empirical growth analysis. See for example Bergheim (2008) on this point.
worker terms) goes to zero and output per worker grows at the same rate of TFP \((\Delta \ln y^* = g)\). This permits us to make a sensitivity analysis to understand which variables have to be stimulated to favor growth.

The paper is organized as follows. In Section 2 we discuss the extended Solow model and develop our specification used in estimations. Section 3 presents a description of the countries’ characteristics. Section 4 shows the estimation results for Italy, Spain, France, UK, and Ireland. Section 5 concludes.

2. Specification

The starting point is the steady state solution for the level of output in the Solow (1956) growth model and this is:

\[
y^* = \left(\frac{s}{d + g + n}\right)^{\frac{1}{\alpha}} A
\]

where \(y^*(= Y/L)\) is the steady state level of income per worker, \(s = \text{the ratio of investment to income}, d = \text{depreciation rate of capital}, g = \text{the rate of technical progress}, n = \text{the rate of growth of labour}, A = \text{the stock of knowledge and} \alpha = \text{the exponent of capital in the Cobb–Douglas production function with constant returns (see below). This implies that the steady state level of growth of per worker output (SSGR), assuming that all other ratios and parameters are constant, is simply TFP because:}

\[
\Delta \ln y^* = \text{SSGR} = \Delta \ln A = \text{TFP}
\]

However, since the determinants of TFP are not known and are exogenous in the Solow (1956) growth model, the Solow model is also known as the exogenous growth model. The new growth theories based on ENGM use optimization framework and suggest several potential determinants of TFP. However, to the best of our knowledge there is no ENGM which rationalizes that TFP depends on more than one or two selected variables. We take the view that the Solow model can be extended by making TFP a function of a few of the determinants identified by the ENGMs. For example, if the findings of Levine and Renelt (1992, see footnote 4) are valid, then TFP depends only on the investment ratio in spite of the findings by Durlauf et al. (2005) and Jones (1995).

We extend the Solow model as follows. Note that the SSGR can be estimated by estimating the production function. The production function can also be extended by assuming that the stock of knowledge \((A)\) depends on some important variables identified by the ENGMs. We start with the well-known Cobb–Douglas production function with constant returns:

\[
Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}
\]

Following Rao (2010b) and Paradiso and Rao (2011) we assume the following general evolution for the stock of knowledge \(A\) as follows:\(^\text{6}\):

\[
A_t = A_0 e^{\left(\sigma T + \sigma R_t + \gamma W_t + \sigma T + \sigma \ln S_{t-1} + \sigma \ln X_t\right)}\]

where \(T\) is time and \(R, Z, W, S\) and \(X\) are variables on which TFP depends in different ways. This can be explained by taking the logs of Eq. (4) below with lower case letters denoting the logs as:

\[
\ln A_t = \ln A_0 + \sigma T + \sigma R_t + \gamma_1 \ln Z_t + \gamma_2 \ln Z_t^2 + \omega \ln W_t + \theta \ln S_{t-1} + \delta \ln X_t
\]

Taking the first difference gives:

\[
\Delta a_t = TFP = a + \alpha \Delta R_t + T + \alpha \ln R_{t-1} + \gamma_1 \Delta Z_t + \gamma_2 \Delta Z_t^2 + \varphi \Delta W_t + \theta \Delta \ln S_{t-1} + \delta \Delta \ln X_t
\]

Eq. (6) captures the actual growth rate of output due to changes in variables, other than factor accumulation. The effects of these other variables may be trended and linear, or some of them may be transitory and either linear \((\gamma_1 \Delta Z_t + \gamma_2 \Delta Z_t^2)\) or transitory and linear \((\Delta W_t)\) or nonlinear but with some transitory and some permanent \((\theta \Delta \ln S_{t-1} + \theta \ln S_{t-1})\). Our choice of the variables is made on the basis of empirical considerations.

The steady state growth rate (SSGR) is defined as the situation when all differences go to zero:

\[
\cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \·
change that started in the 1970s. Education started increasing from a very low level of 3.3 average years of education in the 1960s and reached a value of 10.4 by 2010, which is above Italy’s value and in line with France.

UK exhibits a somewhat stable GDP growth in the two sample periods. Investment ratio increased slightly in the second sample. Employment increased in the second sample, in particular in the second half of 1980. Trade openness passed from an average of 30% in the 1960–1985 to a value of 52% in the 1986–2010 period. UK started from a high value in education in 1960 (6.3 average years of schooling) and increased to 9.6 in 2010, with an average value of 8.7 over the sample 1986–2010.

Ireland’s growth rate was high in the 1960s with the exception of the 1965–1966. In these two years its average growth rate was of 1.4% against an average growth rate of 4% in the previous 5 years. This growth was sustained during the period examined, and increased during 1986–2010. However, during 2008–2009 there was a banking crisis and a deep recession. In these two years Ireland experienced its worst financial crisis to date (O’Sullivan and Kennedy, 2010). The GDP growth fell to 3.6% in 2008 and 7.9% in 2009. Investment ratio has declined in the second sample even though it was above 20%. Ireland is one of the most open economies in the OECD area after Belgium, Hungary, Luxembourg, and Slovak Republic. The time-series data reveal a growing trend towards openness after the 1970s and since its membership in the European Economic Community. Another characteristic of Ireland is the steep rise in the educational attainment since the 1990s, which brought Ireland in line with countries that have high historical level of education. According to the Barro and Lee (2010) dataset, Ireland is a leading country in education, in line with schooling levels in Sweden, Germany and the Republic of Korea.

For France the 1960s and in particular in the second half of 1960s was a period of high economic growth. The average growth rate in the period 1965–1970 was 5.4%. This performance was the result of government investment programs and industrial policy that promoted large-scale economic projects in the fields of high-tech aeronautics, information technology (IT), and telecommunication (Estrin and Holmes, 1983). In addition, this period was characterized by large immigration to sustain the production by French manufacturers (in particular in the car industry). Employment accelerated in particular in the late of 1990s partially due to a shift in the demand for labour (Pisani-Ferry, 2003). Investment ratio slightly decreased from an average value of 21% in the first sample to 19% in the second sample. Trade openness increased strongly as other countries investigated. Starting from a lower education value, France passes Italy and UK over the years.

4. Estimation results

Data from 1960 to 2010 are used to estimate the production function (3) augmented with (4) for these five European countries. Definitions of variables and sources of data are in Appendix A. Two cointegration techniques are used to estimate the long run relationships viz., the Phillips and Hansen (1990) Fully Modified OLS (FMOLS) and Stock and Watson (1993) Dynamic OLS (DOLS). These estimators deal with the problem of second-order asymptotic bias arising from serial correlation and endogeneity and are asymptotically equivalent; see Gonzalo (1994).

Our estimation strategy is the following. We first estimate the long-run relationships with these two methods. If these techniques show plausible and similar results, we identify the existence of cointegrating relationship through the Engle–Granger (EG) residual test. If the test confirms the existence of cointegration, we construct an Error Correction Model (ECM) with the long-run relationship and we study the factor loading and the tests of correct specification (normality, absence of autocorrelation, and no heteroskedasticity in the residuals). If all these conditions are satisfied, we conclude that there is a cointegrating relationship. To conserve space only reasonable final results are reported in the tables. In estimation some dummies are also used to account for a few outliers. Details of these are in Section 3 and are briefly summarized in the Data appendix.

4.1. Italy

According to Eq. (4), for Italy we selected the following:

\[ X_t = TRADE, \quad Z_t = HKI, \quad R_t = IRAT_t \]

This indicates that Italian economy was driven mainly by the dynamics of trade, human capital and investment ratio. Results for 1960–2010 are reported in Table 2 below. Both the estimates of this equation are satisfactory in that all of the coefficients are correctly signed and statistically significant. The EG residual test confirms the existence of a cointegrating relationship, whereas diagnostic tests on ECM residuals are not serially correlated, normally distributed, and not heteroskedastic. The coefficient representing the share of profits seems a bit high, but it is plausible.

The corresponding SSGR and the actual rate of growth per worker output are presented in Fig. 1 below. The value of SSGR corresponds to the IRAT series multiplied for its coefficient. SSGR is somewhat stable around 0.3% to 0.4%. This suggests that the long run Italian growth rate is stagnant and can be seen from the actual growth rate since the mid 1990s. Earlier positive growth rates seem to be due to positive factor accumulation and not due to TFP. Our estimates suggest that to reach a SSGR of 0.5% it is necessary to increase IRAT to a value close to 30%, a value very close to the IRAT in the early years of 1960s.

4.2. Spain

For Spain the best results are obtained when it is assumed that:

\[ Z_t = HKI, \quad R_t = HKI_t \]

Spain’s growth dynamic seems to be driven mainly by education. This is the result of a political strategy that started in the 1970s.

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Table 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Average $\Delta \ln y$</th>
<th>Average $(1/Y)$</th>
<th>Average $\Delta \ln L$</th>
<th>Average TRADE</th>
<th>Average HKI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>4.05%</td>
<td>1.34%</td>
<td>22.76%</td>
<td>20.01%</td>
<td>0.28%</td>
</tr>
<tr>
<td>Spain</td>
<td>4.50%</td>
<td>2.80%</td>
<td>21.18%</td>
<td>24.56%</td>
<td>-0.29%</td>
</tr>
<tr>
<td>UK</td>
<td>2.32%</td>
<td>2.23%</td>
<td>14.93%</td>
<td>16.51%</td>
<td>0.11%</td>
</tr>
<tr>
<td>Ireland</td>
<td>3.98%</td>
<td>4.67%</td>
<td>25.47%</td>
<td>20.82%</td>
<td>0.01%</td>
</tr>
<tr>
<td>France</td>
<td>3.99%</td>
<td>1.90%</td>
<td>20.63%</td>
<td>19.12%</td>
<td>0.36%</td>
</tr>
</tbody>
</table>

---

Our selection for $X, Z$ and $R$ variables for Italy and other countries is based on empirical considerations.
the SGGR to a value above 1.6%, it is necessary to increase the investment ratio from its current value of 16% to 20% and also minimize fluctuations in this ratio. A graph of UK IRAT is in Appendix A.

4.4. Ireland

For Ireland the following formulation of Eq. (4) gave the best results:

\[ Z_t = HKI_t, \text{IRAT}_t = \text{TRADE} \]

Ireland is the only country for which both variables TRADE and HKI enter as the determinants of SSGR. Ireland is one of the most open economies in the world and its trade ratio has been well above 100% from the 1990s. The impressive gains in labour productivity experienced since the 1990s were underpinned by a steep rise in educational attainment of the working age population. The average years of education in 2010, according to Barro and Lee (2010) dataset is consistent with the level in Sweden, Germany and Republic of Korea (countries with historical high values in education). Estimation results are reported in Table 5.

Ireland’s SSGR is well above 2.5% and shows an accentuated upward trend in Fig. 4 due to impressive gains in productivity. Although SSGR is still very high in Ireland, our estimates suggest that further improvements can be made by improving education through job training schemes or by increasing the openness of the economy.

### Table 2

Results for Italy: 1960–2010.

<table>
<thead>
<tr>
<th></th>
<th>FMOLS</th>
<th>DOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln \gamma = \text{Intercept} + \alpha \ln k + \gamma_1 \text{HKI} + \gamma_2 \text{HKI}^2 + \text{IRAT}, T = \delta \ln \text{TRADE} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\text{Intercept}</td>
<td>-2.770</td>
<td>-2.541</td>
</tr>
<tr>
<td></td>
<td>(0.147)</td>
<td>(0.391)</td>
</tr>
<tr>
<td>\ln k</td>
<td>0.630</td>
<td>0.754</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>\ln \text{TRADE}</td>
<td>0.308</td>
<td>0.206</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.100)</td>
</tr>
<tr>
<td>\text{HKI}</td>
<td>0.373</td>
<td>0.324</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.116)</td>
</tr>
<tr>
<td>\text{HKI}^2</td>
<td>-0.029</td>
<td>-0.023</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>\text{IRAT} T</td>
<td>0.017</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>\lambda</td>
<td>-0.700</td>
<td>-0.699***</td>
</tr>
<tr>
<td></td>
<td>(0.338)</td>
<td>(2.071)</td>
</tr>
<tr>
<td>EG residual test</td>
<td>-6.697***</td>
<td></td>
</tr>
<tr>
<td>LM(1) test (p)-value</td>
<td>0.449</td>
<td></td>
</tr>
<tr>
<td>LM(2) test (p)-value</td>
<td>0.413</td>
<td></td>
</tr>
<tr>
<td>LM(4) test (p)-value</td>
<td>0.340</td>
<td></td>
</tr>
<tr>
<td>JB test (p)-value</td>
<td>0.768</td>
<td></td>
</tr>
<tr>
<td>BPG test (p)-value</td>
<td>0.618</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Standard errors are reported in ( ) brackets, whereas \( t \)-statistics in [ ] brackets. *, **, *** denotes significance at 10%, 5%, and 1%, respectively. FMOLS = Fully Modified Ordinary Least Squares; DOLS = Dynamic Ordinary Least Squares. EG = Engle–Granger \( t \)-test for cointegration. \( \lambda \), factor loading in the ECM. BPG = Breusch–Pagan–Godfrey heteroskedasticity test; JB, Jarque–Bera normality test. LM = Breusch–Godfrey serial correlation LM test. FMOLS uses Newey–West automatic bandwidth selection in computing the long-run variance matrix. In the DOLS leads and lags are selected according to SIC criteria. The standard errors for the DOLS estimation are calculated using the Newey–West correction. A dummy for recession in 1975 (due to oil price shock) is added in ECM formulation.

Spanish politicians laid the ground stone for the increase in education even before the end of the Franco dictatorship. Other important reforms were the University Reform Act of 1983 and University Act of 1993. The result was a huge increase in average years of education among the Spanish population. The results for Spain are reported in Table 3.

The resulting SSGR shows a value equal to 1% towards the end of the sample, but more interestingly SSGR for Spain shows a continuous upward pattern (Fig. 2). Our estimates show that if the current level of schooling years of 10.4 increases to 11.9 years, SSGR in Spain increases by an additional 0.2% points.  

### 4.3. United Kingdom

For the UK the following formulation for Eq. (4) gave the best results:

\[ Z_t = HKI_t, \text{IRAT}_t = \text{TRADE} \]

The investment ratio (IRAT) seems to be the most influential determinants of the long-run growth. Results are in Table 4.

From the plots of actual growth rate and SSGR in Fig. 3, it can be seen that SSGR oscillates around 1.3–1.4% in the last 15 years. This may be due to the fluctuations in the investment ratio. To increase the SSGR to a value above 1.6%, it is necessary to increase the  

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\(^8\) In Germany the average years of schooling is near 12 years.
In this paper we showed that the Solow growth model can be extended and used to estimate country specific SSGRs. In empirical works this is done so far mainly for the developing countries (see for example Rao, 2010a; Rao and Vadlamannati, 2011a, 2011b). We showed that this can be also done for the developed countries. In our study we estimated SSGRs for 5 developed European countries who benefited from three long-run factors viz., trade openness (TRADE), human capital index (HKI), and investment to GDP ratio (IRAT). Our results showed that these factors are significant in these countries for their long-run growth with some differences. We have computed the SSGRs for these countries and found that IRAT explains the SSGR dynamics for Italy and UK, HKI for Spain and France and HKI and TRADE for Ireland.

Using these estimates of SSGR, we suggested policies to improve the SSGRs for these countries. For example, for Italy to reach a SSGR of 0.5% it is necessary to increase IRAT to a value close to 30%. For Spain our estimates show that if the current level of schooling years of 10.4 increases to 11.9 years, SSGR in Spain increases by an additional 0.2%. For France the following formulation of Eq. (4) gave the best results.

\[ X_t = \text{TRADE}, \ R_t = \text{HKI}, \ Z_t = \ln(\text{HKI}) \]

Like for Spain, the main driver of SSGR appears to be the education. The results are reported in Table 6.

France's SSGR in Fig. 5 shows that although it is below the 1%, it shows an upward trend. To reach a value close to 1% (0.9%), it is necessary to increase the average years of education by 1.5 years from its actual value of 10.5 years to 12 years in 2010.

5. Conclusions

In this paper we showed that the Solow growth model can be extended and used to estimate country specific SSGRs. In empirical works this is done so far mainly for the developing countries (see for example Rao, 2010a; Rao and Vadlamannati, 2011a, 2011b). We showed that this can be also done for the developed countries. In our study we estimated SSGRs for 5 developed European countries who benefited from three long-run factors viz., trade openness (TRADE), human capital index (HKI), and investment to GDP ratio (IRAT). Our results showed that these factors are significant in these countries for their long-run growth with some differences. We have computed the SSGRs for these countries and found that IRAT explains the SSGR dynamics for Italy and UK, HKI for Spain and France and HKI and TRADE for Ireland.
Ordinary Least Squares; DOLS = Dynamic Ordinary Least Squares. EG = Engle-Granger t-test for cointegration. λ, factor loading in the ECM. BPG, Breusch-Pagan-Godfrey heteroskedasticity test; JB, Jarque–Bera normality test. LM, Bresuch-Godfrey serial correlation LM test. FMOLS uses Newey–West automatic bandwidth selection in computing the long-run variance matrix. In the DOLS leads and lags are selected according to SIC criteria. The standard errors for the DOLS estimation are calculated using the Newey–West correction. A dummy for 2008 financial crisis is added in ECM formulation.

Note: Standard errors are reported in ( ) brackets, whereas t-statistics in [ ] brackets. *, **, *** denotes significance at 10%, 5%, and 1%, respectively. FMOLS = Fully Modified Ordinary Least Squares; DOLS = Dynamic Ordinary Least Squares. EG = Engle–Granger t-test for cointegration. λ, factor loading in the ECM. BPG, Breusch–Pagan–Godfrey heteroskedasticity test; JB, Jarque–Bera normality test, LM, Breusch–Godfrey serial correlation LM test. FMOLS uses Newey–West automatic bandwidth selection in computing the long-run variance matrix. In the DOLS leads and lags are selected according to SIC criteria. The standard errors for the DOLS estimation are calculated using the Newey–West correction. A dummy for first oil shock in 1970s is added in ECM formulation.

Table 5

<table>
<thead>
<tr>
<th></th>
<th>FMOLS</th>
<th>DOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln γₙ = Intercept + α ln kₙ + γ₁ ln HKI + γ₂ ln HKI² + ϖ ln TRADEₙ + δ ln TRADEₙ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>−9.663</td>
<td>−9.489</td>
</tr>
<tr>
<td>ln kₙ</td>
<td>(0.503)</td>
<td>(2.149)</td>
</tr>
<tr>
<td></td>
<td>[19.212]</td>
<td>[4.415]</td>
</tr>
<tr>
<td>ln HKIₙ</td>
<td>0.242</td>
<td>0.363</td>
</tr>
<tr>
<td></td>
<td>(0.052)</td>
<td>(0.175)</td>
</tr>
<tr>
<td></td>
<td>[4.639]</td>
<td>[2.071]</td>
</tr>
<tr>
<td>ln TRADEₙ</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td></td>
<td>[12.446]</td>
<td>[8.794]</td>
</tr>
<tr>
<td>ln HKI²</td>
<td>0.004</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td></td>
<td>[4.038]</td>
<td>[4.423]</td>
</tr>
<tr>
<td>λ</td>
<td>−0.073</td>
<td>−0.079</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.014)</td>
</tr>
<tr>
<td></td>
<td>[17.071]</td>
<td>[5.800]</td>
</tr>
<tr>
<td>EG residual test</td>
<td>−5.812***</td>
<td></td>
</tr>
<tr>
<td>LM(1) test (p-value)</td>
<td>0.460</td>
<td></td>
</tr>
<tr>
<td>LM(2) test (p-value)</td>
<td>0.555</td>
<td></td>
</tr>
<tr>
<td>LM(4) test (p-value)</td>
<td>0.662</td>
<td></td>
</tr>
<tr>
<td>JB test (p-value)</td>
<td>0.288</td>
<td></td>
</tr>
<tr>
<td>BPG test (p-value)</td>
<td>0.716</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Standard errors are reported in ( ) brackets, whereas t-statistics in [ ] brackets. *, **, *** denotes significance at 10%, 5%, and 1%, respectively. FMOLS = Fully Modified Ordinary Least Squares; DOLS = Dynamic Ordinary Least Squares. EG = Engle–Granger t-test for cointegration. λ, factor loading in the ECM. BPG, Breusch–Pagan–Godfrey heteroskedasticity test; JB, Jarque–Bera normality test, LM, Breusch–Godfrey serial correlation LM test. FMOLS uses Newey–West automatic bandwidth selection in computing the long-run variance matrix. In the DOLS leads and lags are selected according to SIC criteria. The standard errors for the DOLS estimation are calculated using the Newey–West correction. A dummy for 2008 financial crisis is added in ECM formulation.

Appendix A. Data appendix

Y = Real GDP; L = Employment (Total economy); HKI = Human Capital Index measured as average years of education; IRAT = Ratio of investment to GDP; TRADE = Sum of imports and exports as a share of GDP.

All data, excluding HKI, are taken and constructed from AMECO-EUROSTAT database. HKI is taken from Barro and Lee (2010) database.

to 12 years. In UK, to increase the SSGR to a value above 1.6%, it is necessary to increase the investment ratio from its current value of 16% to 20% and also minimize fluctuations in this ratio. Although SSGR is still very high in Ireland, our estimates suggest that an increase of TRADE by 5% will increase its SSGR by 0.1%. Note that these are long run and permanent growth effects of implementing these policies in contrast to the well known estimates by Barro (1996, 1998), which are actually transient growth rates. Therefore, our estimates of these growth rates will be smaller than Barro’s estimates.

Fig. 4. Actual growth per worker and SSGR for Ireland.

Fig. 5. Actual growth per worker and SSGR for France.
A.1. Dummy variables

Spain. Three dummies are used for this country: two level shift dummies (1978 and 1994) and one dummy for the intensive economic crisis of 1992–1993.


References


