Estimates of the steady state growth rates for the Scandinavian countries: a knowledge economy approach

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Abstract

This paper estimates the steady state growth rate for Scandinavian countries with a "knowledge economy" approach. We shall use an extended version of the Solow (1956) growth model, in which total factor productivity is assumed to be a function of human capital (measured by average years of education), trade openness and investment ratio. Using this framework we show that these factors, and in particular the education variable, have played an important role to determine the long run growth rates of the Scandinavian countries. Some policy measures are identified to improve the long-run growth rates for these countries.

Keywords: Endogenous growth models, Trade openness, human capital, investment ratio, Steady state growth rate, Scandinavian countries

JEL Classification: C22, O52, O40

1. Introduction

During the second half of the 1990s the Scandinavian countries (Sweden, Finland, and Norway) were one of the most successful economies in the OECD countries. These Scandinavian countries had relatively high average GDP growth from 1995 to 2010 (2.5% in Norway, 2.6% in Sweden, and 2.9% in Finland) in comparison to the average growth rate of 1.8% in the 15 EU countries. These high growth rates seem to have been caused by the openness, education, and investment ratio and these variables are some of the key drivers of competitiveness and growth in a knowledge based economy. All the three Scandinavian countries are near the top of the Knowledge Economic Index (KEI) of the World Bank and suggest that these three variables have played an important role in explaining the long-term growth rates of Sweden, Finland and Norway. We investigate this aspect with an extended version of the Solow (1956) growth model by incorporating education, trade openness, and investment ratio as key determinants of the long-run growth rate. Our approach broadly follows the specification and methodology in Rao (2010) and Paradiso and Rao (2011).

The paper is organized as follows. In Section 2 we illustrate the characteristics of Scandinavian model in the light of the knowledge economy framework. Section 3 presents the specification of the model and the implications for the estimates of the long run growth rate, which is the same as steady state growth rate (SSGR) in the Solow growth model. Section 4 presents our empirical results and Section 5 concludes.

2. Scandinavian Countries as Knowledge Economies

In the past few decades where countries have experienced the effects of globalization and technical innovations, knowledge has become the key driver of competitiveness and economic growth. Dahlman and Anderson (2000) define knowledge economy as "one that encourages its organization and people to acquire, create, disseminate and use (codified and tacit) knowledge more effectively for greater economic and social development". Dereck *et al.* (2004) postulated that knowledge economy is based on four pillars: educated and skilled workers; effective innovation system of firms, research centers, universities, and other organizations; modern and adequate information of infrastructure to facilitate the information dissemination; economic and institutional regimes to provide incentives for the efficient use of knowledge. In essence, these authors postulated that the amount of knowledge and how it is used are key determinants of total factor productivity (TFP). Strengthening the above four pillars will lead to an increase in the pool of knowledge available for economic production.

The three Scandinavian countries can be defined as knowledge economies according to these characteristics. Basing on the work of Dereck *et al.* (2004), World Bank developed an index called Knowledge Economy Index (KEI). The KEI is an economic indicator to measure a country's ability to generate, adopt and diffuse knowledge. KEI summarizes each country's performance on 12 variables corresponding to the four knowledge economy pillars introduced above. Variables are normalized on a scale of 0 (worst) and 10 (best). In Figure 1 we make an over-time comparison of KEI of some countries in terms of their relative performance for two points in time viz., 1995 and 2009. Countries above the diagonal line have made an improvement in the KEI in 2009 compared to 1995, whereas countries below the line experienced a decline. As we can see, Finland, Sweden, and Norway show very high value of KEI although Finland's KEI in 2009 is a bit smaller than in 1995. Table 1 presents the most recent KEI (2009) and its four components for the best 5 countries, out of a total of 146 countries. Finland, Sweden, and Norway are between Denmark, which tops the list, and Norway at the end of the list.

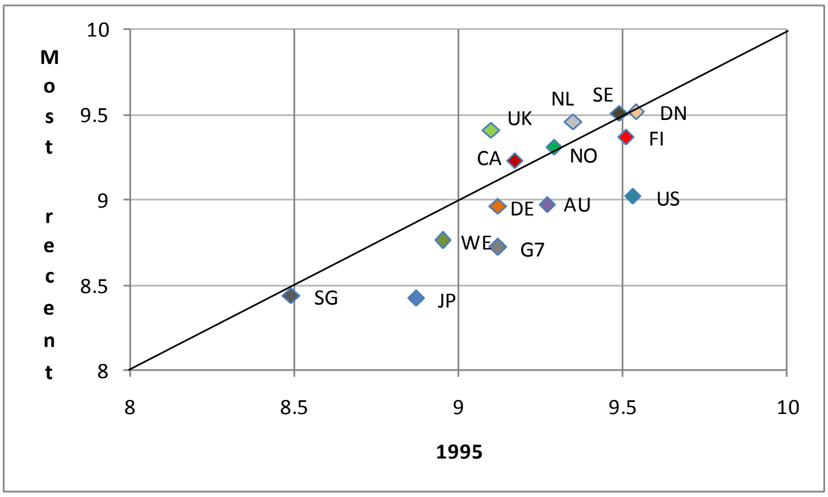
The empirical indicators used for the estimations for the four components are the following. *Economic and institutional regime*: To proxy for the innovation system, we used trade openness index as indicator of the level of economic and institutional regime operating in the country. An open country is a country with (a) low tariff and non-tariff barriers on trade, (b) low barriers to technology transfers and (c) low power of national monopolies in the area such as telecommunications, air transport, and the finance and insurances industries (Houghton and Sheehan (2000)). *Innovation system*: Trade openness is perceived by many authors to have a positive impact on efficiency and innovation in the economy[1]. The idea is that the international trade leads to faster diffusion of technology, and hence higher productivity growth. In addition there are also spillover effects due to "learning by doing" gains and better management practices triggered by the new technology leading the firms to the best practice technology (Krugman (1987)). *Human capital and education*: One commonly used measure of human capital is the average years of schooling of the adult population. Average years of schooling is clearly a stock measure and reflects the accumulated educational investment embodied in the current labour force. *Information infrastructure*: Empirical assessments of the effects of ICTs on aggregate output and economic growth typically entail the use of ICT investment. However, due to the non availability of this series for a long time span and the importance also of non-ICT investments in economic growth, we use the aggregate series of investment (as a ratio of GDP) in our estimations.

[1] See for example Jenkins (1995), Baldwin and Gu (2004), and Greenway and Kneller (2004).

Figure 1

Knowledge Economic Index by Countries:

1995 and the most Recent Year (2009)



Source: World Bank-Knowledge Assessment Methodology (KAM), www.worldbank.org/kam. Notes: Countries above the diagonal line have made an improvement in the KEI compared to 1995, whereas countries below the line experienced a regression. Legend: DN = Denmark; SE = Sweden; FI = Finland; NL = Netherland; US = U.S.A.; No = Norway; UK = United Kingdom; CA = Canada; AU = Australia; DE = Germany; G7 = Group of seven viz., France, Germany, Italy, Japan, United Kingdom, U.S.A., Canada; WE = Western Europe; JP = Japan; SG = Singapore.

Table 1: KEI and its Four Component Values for the Best 5 Countries (2009)

Rank	Country	KEI	Economic Incentive Regime	Innovation	Education	ICT
1	Denmark	9.52	9.61	9.49	9.78	9.21
2	Sweden	9.51	9.33	9.76	9.29	9.66
3	Finland	9.37	9.31	9.67	9.77	8.73
4	Netherlands	9.35	9.22	9.45	9.21	9.52
5	Norway	9.31	9.47	9.06	9.6	9.1

Source: World Bank-Knowledge Assessment Methodology (KAM), www.worldbank.org/kam.

3. Specification of the Model

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

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

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

$$\Delta \ln y^* = SSGR = \Delta \ln A = TFP \tag{2}$$

However, since the determinants of TFP are not known and are exogenous to 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, Johnson and Temple (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:

$$Y_t = A_t K^{\alpha} L_t^{(1-\alpha)} \tag{3}$$

Following Rao (2010) and Paradiso and Rao (2011) we assume the following general evolution for the stock of knowledge A, where for simplicity the vector Z may consist of more than one variable, whereas S and W are assumed to consist of one variable each.

$$A_t = A_0 e^{\left(\gamma_i Z_{it} \cdot T + \phi_1 S_t + \phi_2 S_t^2 + \varphi_1 W_t\right)} \tag{4}$$

Transforming (3) into its intensive form, substituting (4), and taking the logs we have:

$$\ln y_t = \ln A_0 + \gamma_i Z_{it} \cdot T + \phi_1 S_t + \phi_2 S_t^2 + \varphi_1 W_t + \alpha \ln k_t \tag{5}$$

where $y = (Y / L)$ and $k = (K / L)$. Equation (5) captures the actual level of output due to two types of variables viz., factor accumulation and due to variables other than factor accumulation such as Z, S and W. Specification of these other variables may affect output is an empirical issue. Their effects may be trended (Z) or nonlinear (S) or simply linear (W). What variables should be included in these three vectors is also an empirical matter. We have experimented with various alternatives but to conserve space report only the best and plausible results.

In the steady state, when $\Delta \ln k \rightarrow 0$, the Steady State Growth Rate (SSGR) is equal to the growth rate of the stock of knowledge ($\Delta \ln A$). There are two ways to measure the SSGR. One restrictive method considers all the changes in the variables as zero; whereas a less restrictive one considers only $\Delta \ln k = 0$. We call the first SSGR as *SSGR1*, and the second as *SSGR2* and are as follows. SSGR1 and SSGR2 can also be interpreted as the medium run and long run estimates of the growth rate and they are:

$$SSGR1 = \gamma_i Z_{it} \tag{6}$$

$$SSGR2 = \gamma_i \Delta Z_{it} \times T + \gamma_i Z_{it} + \phi_1 \Delta S_t + 2\phi_2 \Delta S_t \times S_t + \varphi_1 \Delta W_t \tag{7}$$

We make use of both of these measures of SSGR and we try to understand the potential factors influencing the SSGR and which policy can improve it.

4. Empirical Estimates

Data from 1960 to 2010 are used to estimate SSGR, which is the long run growth rate. Since we have to estimate the long run relationships, equitation (2) is estimated with the standard time series methods of cointegration. Our selected growth-enhancing variables are: trade openness (TRADE), ratio of investment to GDP (IRAT), and human capital index (HKI). Definitions of variables and sources of data are in the appendix. We expect that all variables enter in the estimation of countries but multi-collinearity problem between variables may arise and some of these variables could be not statistically significant. In the paper we report only the estimations showing plausible, economically and statistically results. Three estimations techniques are implemented viz., Fully Modified OLS (FMOLS), Canonical Cointegrating Regression (CCR) and Dynamic OLS (DOLS). These estimators deal with the problem of second-order asymptotic bias arising from serial correlation and endogeneity and they are asymptotically equivalent and efficient. Dummies are added in the estimations and are discussed in Appendix.

Our estimation strategy is the following. We estimate the long-run relationship with these three methods and if all the results are similar and plausible, we pass to verify the existence of the cointegrating relationship with the Engle-Granger (EG) residual test. If the test confirms the existence of the long-run relationship we construct an Error Correction Model (ECM). Then we study the factor loading and tests for correct specifications i.e., we test for the normality, absence of autocorrelation, and no heteroskedasticity in the residuals.

4.1 Sweden

In Sweden model, trade openness and average years of schooling enter as long-run growth determinant variables. This is because Sweden is one of the best countries in education according to Global Competitiveness Report (2011) of World Economic Forum and Barro and Lee (2010) education dataset, and has historically supported the trade liberalization in the interest of its industrial firms (The access to foreign access is a need to growth). According to equation (3) we have $Z_1 = \ln HKI, Z_2 = TRADE, S = \ln HKI$:

$$\ln y_t = Interc. + \alpha \ln k_t + \phi_1 \ln HKI_t + \phi_2 \left(\ln HKI_t\right)^2 + \gamma_1 \ln HKI_t \cdot T + \gamma_2 TRADE_t \cdot T \quad (8)$$

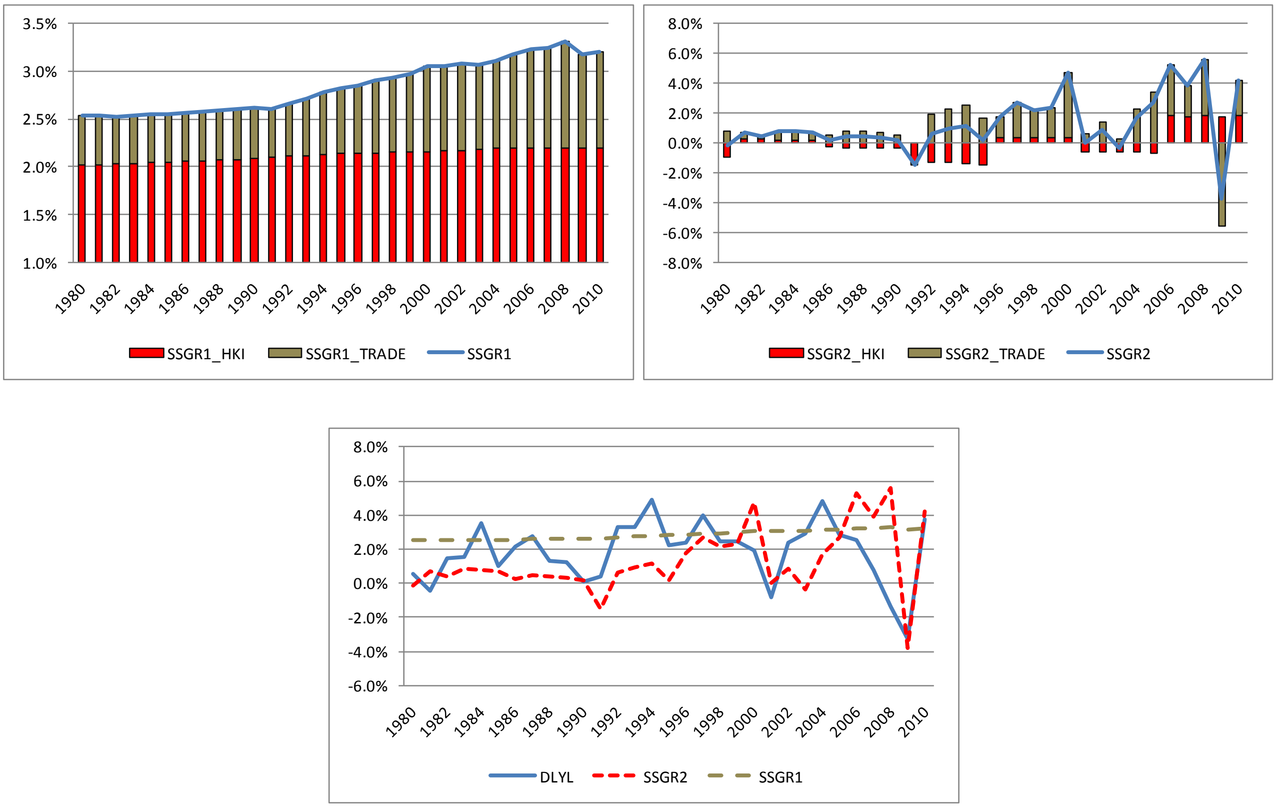
According to equation (8) HKI has two components: one non-linear component and one long-run component multiplied for the trend. This is because education may have non-linear effects as discussed by Rao et. al (2010). The estimation results of equation (8) are reported in Table 2. The estimate of equation (8) is satisfactory in that all of its coefficients are correctly signed and statistically significant. The EG residual test shows that a cointegration exists at 5% level of statistically significance. The ECM shows a factor loading (λ) significance and with the expected negative sign. The diagnostic tests show that the model is correctly specified.

Table 2: Results for Swedish Model: 1960-2010			
$\ln y_t = Interc. + \alpha \ln k_t + \phi_1 \ln HKI_t + \phi_2 (\ln HKI_t)^2 + \gamma_1 \ln HKI_t \cdot T + \gamma_2 TRADE_t \cdot T$			
	FMOLS	**DOLS**	**CCR**
$Intercept$	-15.720 (1.817) [8.650]	-9.312 (2.029) [4.589]	-15.572 (1.749) [8.902]
$\ln k$	0.633 (0.077) [8.262]	0.521 (0.140) [3.727]	0.636 (0.073) [8.730]
$TRADE \cdot T$	0.011 (0.001) [9.639]	0.003 (0.001) [2.243]	0.011 (0.001) [7.928]
$\ln HKI \cdot T$	0.010 (0.001) [5.416]	0.016 (0.004) [3.892]	0.009 (0.002) [5.522]
$\ln HKI$	15.122 (1.800) [8.416]	10.293 (2.173) [4.737]	15.035 (1.707) [8.809]
$\ln(HKI)^2$	-3.945 (0.456) [8.657]	-2.811 (0.642) [4.381]	-3.938 (0.4300) [9.165]
λ	-0.359 (0.139) [2.580]		
EG residual test	-5.243**		
LM(1) test (p-value)	0.932		
LM(2) test (p-value)	0.768		
LM(4) test (p-value)	0.905		
JB test (p-value)	0.441		
BPG test (p-value)	0.159		

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; CCR = Canonical Cointegrating Relationship. EG = Engle-Granger *t*-test for cointegration. λ, factor loading in the ECM. BPG, Breusch-Pagan-Godfrey heteroskedasticiy 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 2008-2010 financial crisis is added in ECM formulation.

SSGR1 and SSGR2 for Sweden are reported in Figure 2. In both versions the trade openness plays an important and positive role in TFP growth. HKI is always positive in SSGR1, and in SSGR2 is negative in some periods (late of 1980s, first of 1990s, and first of 2000s) even if it is highly positive in last years. This is due to high non-linearity effect in education. Finally, we plot the per worker GDP growth (DLYL) with SSGR1 and SSGR2. SSGR2 shows a more adherent pattern respect to DLYL, whereas SSGR1 has a more smoothed pattern with a slightly upward trend towards 3.3%.

Figure 2: SSGR1 and SSGR2 for Sweden



4.2 Finland

Two models are compatible with Finland. The first model considers average years of schooling and investment ratio as long-run growth determinants variables. HKI enters with non-linearity effect. Investment enters only as multiplied for trend. That is, according to equation (3) we have

$Z_1 = TRADE, Z_2 = IRAT, S = HKI$:

$$\ln y_t = Interc. + \alpha \ln k_t + \phi_1 HKI_t + \phi_2 HKI_t^2 + \gamma_1 TRADE_t \cdot T + \gamma_2 IRAT_t \cdot T \qquad (9)$$

The results for equation (9) are reported in Table 3. All the coefficients are statistically significant and with expected signs. EG residual cointegration test confirms the existence of the long-run equation. ECM shows a factor loading highly statistically significant and with the expected negative sign. The residual diagnostic tests show that model is correctly specified.

Table 3: Results for Finnish Model 1: 1960-2010

$$\ln y_t = Interc. + \alpha \ln k_t + \phi_1 HKI_t + \phi_2 HKI_t^2 + \gamma_1 TRADE_t \cdot T + \gamma_2 IRAT_t \cdot T$$

	FMOLS	DOLS	CCR
$Intercept$	-3.368 (0.201) [16.776]	-3.00 (0.096) [31.323]	-3.390 (0.203) [16.664]
$\ln k$	0.608 (0.020) [30.843]	0.614 (0.007) [87.900]	0.608 (0.020) [30.630]
$IRAT \cdot T$	0.027 (0.003) [9.594]	0.033 (0.002) [20.512]	0.027 (0.003) [7.873]
$TRADE \cdot T$	0.010 (0.000) [18.207]	0.008 (0.000) [22.834]	0.010 (0.000) [14.498]
HKI	0.291 (0.041) [7.170]	0.186 (0.020) [9.420]	0.297 (0.043) [6.925]
HKI^2	-0.018 (0.002) [7.539]	-0.011 (0.001) [9.173]	-0.019 (0.003) [7.122]
λ	-0.346 (0.131) [2.638]		
EG residual test	-5.630**		
LM(1) test (p-value)	0.738		
LM(2) test (p-value)	0.813		
LM(4) test (p-value)	0.930		
JB test (p-value)	0.900		
BPG test (p-value)	0.215		

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; CCR = Canonical Cointegrating Relationship. EG = Engle-Granger *t*-test for cointegration. λ, factor loading in the ECM. BPG, Breusch-Pagan-Godfrey heteroskedasticiy 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 2008-2009 financial crisis is added in ECM formulation.

Another version that produces good results considers HKI instead of TREND as one of the two variables multiplied for trend. In this version HKI enters with a double effect: with non-linearity and multiplied for trend. In this case, we have $Z_1 = HKI, Z_2 = IRAT, S = HKI$:

$$\ln y_t = Interc. + \alpha \ln k_t + \phi_1 HKI_t + \phi_2 HKI_t^2 + \gamma_1 HKI_t \cdot T + \gamma_2 IRAT_t \cdot T \qquad (10)$$

The results appear satisfactory for coefficients signs, EG residual test, ECM, and diagnostic tests on ECM. These results are reported in Table 4 below.

Table 4: Results for Finnish Model 2: 1960-2010			
$\ln y_t = Interc. + \alpha \ln k_t + \phi_1 HKI_t + \phi_2 HKI_t^2 + \gamma_1 HKI_t \cdot T + \gamma_2 IRAT_t \cdot T$			
	FMOLS	**DOLS**	**CCR**
$Intercept$	-6.420 (0.564) [11.382]	-4.997 (1.016) [4.916]	-6.192 (0.650) [9.532]
$\ln k$	0.182 (0.057) [3.175]	0.327 (0.095) [3.443]	0.206 (0.067) [3.092]
$IRAT \cdot T$	0.009 (0.006) [1.518]	0.023 (0.015) [1.607]	0.012 (0.008) [1.543]
$HKI \cdot T$	0.003 (0.000) [10.539]	0.002 (0.000) [3.744]	0.002 (0.000) [7.770]
HKI	0.785 (0.108) [7.288]	0.533 (0.200) [2.669]	0.743 (0.125) [5.941]
HKI^2	-0.052 (0.007) [7.494]	-0.035 (0.013) [2.710]	-0.049 (0.008) [6.039]
λ	-0.393 (0.106) [3.706]		
EG residual test	-5.219**		
LM(1) test (p-value)	0.946		
LM(2) test (p-value)	0.844		
LM(4) test (p-value)	0.892		
JB test (p-value)	0.744		
BPG test (p-value)	0.602		

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; CCR = Canonical Cointegrating Relationship. EG = Engle-Granger *t*-test for cointegration. λ , factor loading in the ECM. BPG, Breusch-Pagan-Godfrey heteroskedasticiy 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 2008-2009 financial crisis is added in ECM formulation.

The SSGR1 and SSGR2 for both models are presented in Figure 3 and 4 respectively. In model 1, TRADE and IRAT play a highly positive and significant role in determining SSGR1. The same appears to hold for determining SSGR2. However, the contribution of HKI becomes negative after 1990s. In model 2, instead, the contribution of HKI is highly positive to both SSGR1 and SSGR2. The contribution of TRADE is positive to SSGR1 and SSGR2, especially during 1980-2010 to SSGR2. Since a negative effect of education on SSGRs is not very plausible, we prefer model 2 for Finland.

Figure 3: SSGR1 and SSGR2 for Finland model 1

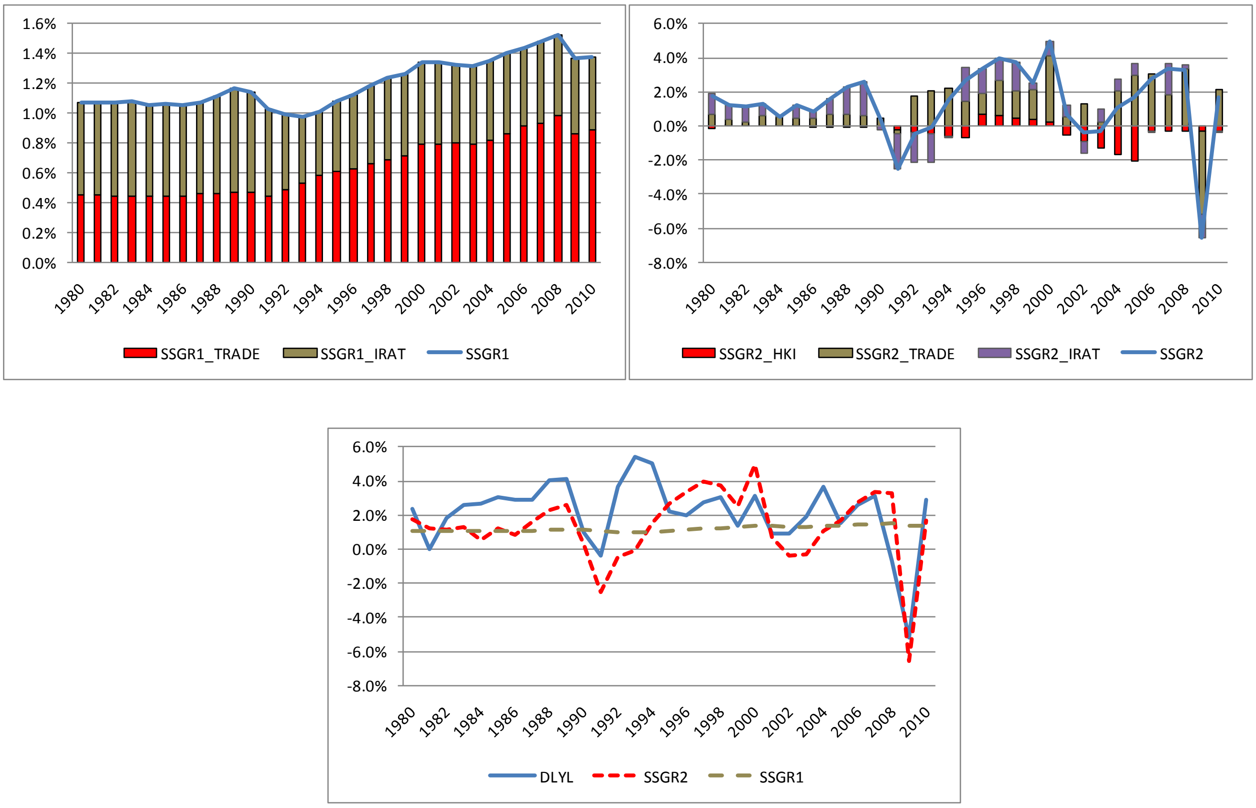
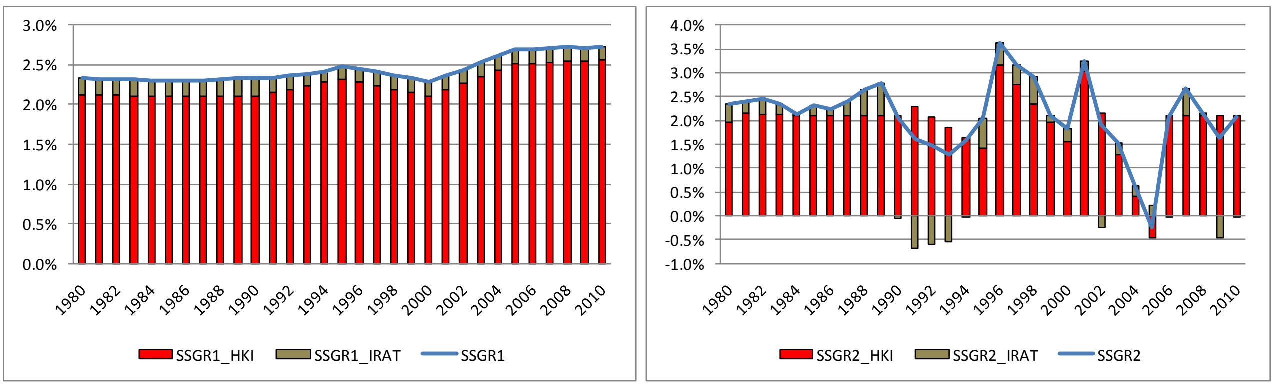
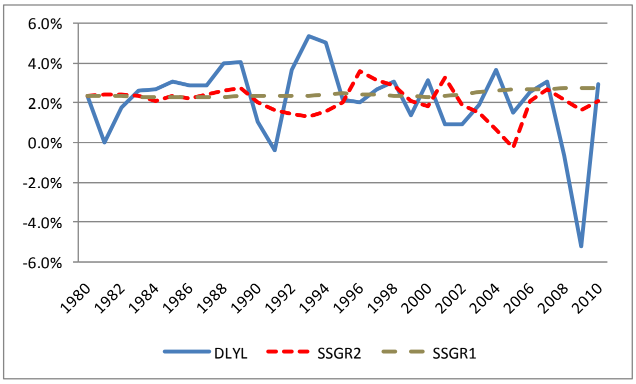


Figure 4: SSGR1 and SSGR2 for Finland model 2





4.3 Norway

Norway's long-run growth is determined by trade openness and average years of schooling. Norway showed historically a higher value of education (according to Barro-Lee (2010) dataset and to Global competitiveness report (2011)) and has evolved into a very open economy with some exceptions. Measured as a share of GDP, gross trade flows (exports and imports of goods and services) are higher than in most other countries. Accordingly we assume that in equation (3) $Z_1 = HHKI$ and $W = TRADE$, so that:

$$\ln y_t = Interc. + \alpha \ln k_t + \gamma_1 HKI_t \cdot T + \varphi TRADE_t \qquad (11)$$

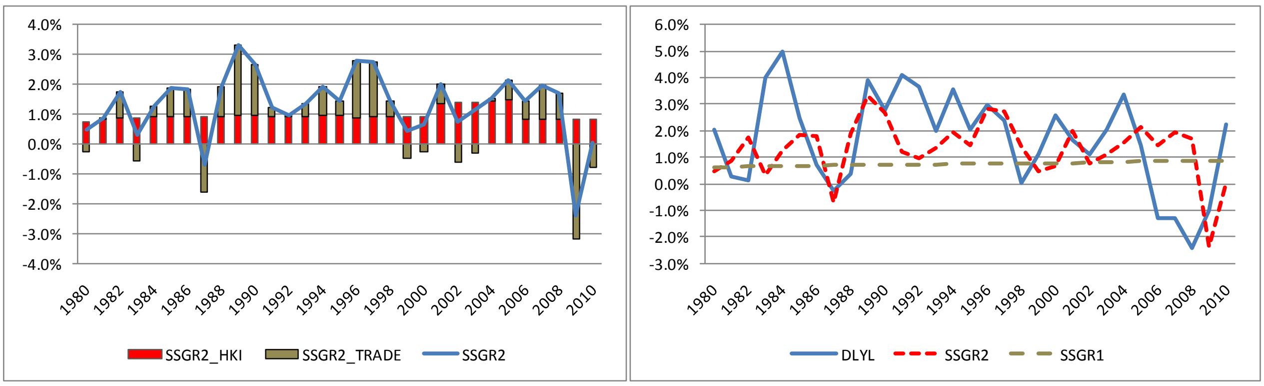
Estimates of this equation are reported in Table 5. All results appear satisfactory in terms of statistically significance of coefficients, EG residual test, ECM, and residual diagnostic tests.

Table 5: Results for Norwegian Model: 1960-2010			
$\ln y_t = Interc. + \alpha \ln k_t + \gamma_1 HKI_t \cdot T + \varphi TRADE_t$			
	FMOLS	**DOLS**	**CCR**
Intercept	-1.561 (0.031) [49.806]	-1.617 (0.045) [2.623]	-1.557 (0.031) [49.402]
$\ln k$	0.586 (0.019) [31.062]	0.559 (0.015) [36.806]	0.591 (0.018) [32.737]
TRADE	0.644 (0.060) [10.744]	0.758 (0.075) [10.149]	0.639 (0.060) [10.586]
$HKI \cdot T$	0.001 (0.000) [15.689]	0.001 (0.000) [7.456]	0.001 (0.000) [16.032]
λ	-0.354 (0.154) [2.291]		
EG residual test	-6.337***		
LM(1) test (p-value)	0.448		
LM(2) test (p-value)	0.259		
LM(4) test (p-value)	0.456		
JB test (p-value)	0.827		
BPG test (p-value)	0.107		

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; CCR = Canonical Cointegrating Relationship. EG = Engle-Granger *t*-test for cointegration. λ , factor loading in the ECM. BPG, Breusch-Pagan-Godfrey heteroskedasticiy 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.

The contributions of TRADE and HKI to SSGR2 are shown in Figure 5. However, their contribution to SSGR1 is trivial and is not reported to conserve space. SSGR2 shows the most dynamic pattern and is closely linked to the actual growth rater of per worker GDP.

Figure 5: SSGR1 and SSGR2 for Norway



5. Conclusions

In this paper we showed that the Solow (1956) model can be extended and used to estimate the SSGRs for the Scandinavian countries, which may be treated as "Knowledge Economies", where trade openness, human capital (proxied with years of education) and investment-GDP-ratio play key roles in determining their productivity and the long run growth rate (SSGR). Our results showed that these "Knowledge factors" are significant in the Scandinavian countries with some differences. We have computed the SSGRs for these countries and showed that the human capital index (*HKI)* and trade openness (*TRADE)* explain much of the dynamics of the SSGRs in of Sweden. Similarly, we fond that *HKI* and the investment ratio (*IRAT)* explain the dynamics of SSGR in Finland version 2, our preferred model, and only *HKI* is the key determinant of SSGR in Norway.

A noteworthy feature of our estimates is the non-liner effects of HKI in Sweden and Finland where as in Norway HKI has liner effects. DOLS estimates for these countries imply that while HKI has its maximum growth effects in Sweden and Finland (Model 2) when it is between seven and nine respectively, but it has increasing growth effects over time in Norway. Such increasing effects of HKI in Norway may due to lower starting values but are unlikely to persist as HKI increases over time and Norway's HKI catches up with the high values of HKI in Sweden and Finland. Therefore, our estimates for Norway should be treated with some caution.

Appendix

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* = Ratio of imports plus exports to GDP.

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

Dummy variables

Sweden. Two dummies are added in estimation. One spike dummy for 2001 recession, and the other for 2008-2010 financial crisis.

Finland. A dummy for years 1966-1968 is added in estimation. This period was characterized by some important policy changes: income policies limiting wage increases to growth in productivity, abolition of all index clauses, markka devaluation by 24% in 1967 (Kouri (1975)).

Norway. **.** Two dummies are added in estimation. One dummy for period 1989-1991 (Nordic crises; see Honkapohja (2009)), and other for 2008-2010 financial crisis.

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