Malaysian Journal of Economic Studies 51(2): 231-247, 2014 ISSN 1511-4554

Reopening the Debate on Globalisation and Economic Growth Through Technology Transfer

Mina Sabbaghpour Fard[a]
Kee-Cheok Cheong[b]
Su-Fei Yap[c]
University of Malaya

Abstract: The main question posed by this research is whether globalisation is capable of increasing the growth rate of low-income, as well as middle-income or high income countries. This paper provides empirical evidence that there are two roles for globalisation. One is the direct effect of globalisation on economic growth, and the other is the indirect effect – through technology transfer as the facilitator and accelerator of accumulation of human capital (absorptive capacity). In this research, the KOF index and FDI have been chosen as proxies for globalisation. By modeling knowledge transfer through globalisation factors, it is possible to study the impact of new aspects of growth in the traditional Solow model. The results showed that the KOF index is most effective compared to traditional proxies for human capital, such as the education factor. This is true especially in low-income countries as it turns out most of the economic growth is explained by the KOF index and physical capital accumulation, since there is a place for exchange of knowledge compared to only exchange of goods. It can be concluded that the exchange of ideas can have stronger effects on economic growth compared to exchange of goods, and can better improve the growth in low-income countries. Therefore, government policies should aim towards improving the absorption capacity of countries, so as to enable the absorption of technology from leaders.

Key words: Economic growth, globalisation, human capital, technology transfer,
JEL classification: O10, O40, F63, F60

1. Introduction

This paper provides empirical evidence that there are two roles for globalisation. One is the direct effect of globalisation on economic growth. There is increasing recognition that globalisation plays an important role in explaining the different growth rates across countries (Dollar and Kraay 2001; Bhagwati and Srinivasan 2002; Agénor 2004; Ganuza 2005; Heshmati 2006). The other role is indirect – via technology transfer as a facilitator and accelerator of accumulation of human capital (absorptive capacity). This is because globalisation is not limited to flows of goods, but extends to flows of ideas. So, if globalisation brings about international technology spillovers across countries, by increasing FDI and access to the Internet and more infrastructure in an economy, a

[a,b,c] Department of Economics, Faculty of Economics & Administration, University of Malaya, 50603 Kuala Lumpur, Malaysia. [a]Email: *sabaghpour@gmail.com;* [b]Email: *cheongkeecheok@um.edu.my;* [c]Email: *g2yss@um.edu.my* (Corresponding author).

country with limited R&D can take advantage of new ideas as well. Therefore, globalisation can indirectly affect economic growth via the channel of technology spillovers.

A large number of theoretical models and much econometric work have been undertaken for testing the direct effect of globalisation on economic growth. However, based on our knowledge, there has been almost no work on the effects of globalisation through technology transfer. This paper investigates a panel of 106 countries over 1996-2010. Strong evidence emerges regarding globalisation factors as new variables of human capital having stronger effects on economic growth in low-income countries compared to traditional variables such as school education are presented. Also, globalisation can help accelerate the growth rate of countries with a low level of income and help them escape the poverty trap.

In order to do so, this study is extending the Solow-Swan model by applying globalisation indicators as new exogenous factors that increase the accumulation of human capital, besides traditional factors like education, physical capital, population growth rate, and this drives a regression, which can be empirically tested.

This paper seeks to answer two specific questions. First, does globalisation affect growth in low-income countries, as well as middle and high-income countries? Second, are the effects of globalisation, through a new human capital variable, stronger than traditional variables like school education?

2. Extending the Solow Model in Terms of Knowledge Transfer

Looking back, we can see that the role of technology became very important during World Wars I and II, and even more important after the emergence of the three tigers in Asia (Singapore, Taiwan and Korea). Economists have done a lot of research to understand what is going on, and try to explain this massive growth rate through different channels. A large portion of literature in this field is allocated to the investigation of the role of technology, and how it can affect growth in different countries. However, most of the studies, which have been done in this field, adhere to the school of thought that they believe in. For example, the neoclassical adherents attempt to prove that capital accumulation is the main source of growth, without considering the role of technology. They believe that technology is important, but do not look into the role of other factors apart from the accumulation of capital in their model. Therefore, this research attempts to reopen the role of technology in the neoclassical growth model (Solow model) by focusing on the role of globalisation through technology transfer on growth.

In line with new aspects of growth theories, we want to reconcile the Solow model by incorporating the essence of globalisation and technology transfer. Starting from the augmented Solow production function (Mankiw *et al.* 1992), equation 1 is given as:

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \qquad \alpha+\beta<1 \tag{1}$$

where *Y* is output, *K* is physical capital, *A* is technology, *L* is labour, *H* is human capital, α and β represent capital share and according to NCG assumptions, there is diminishing returns to capital. Labour force and technology are assumed to grow at exogenous rates, according to the following functions:

$L_t = L_0 e^{nt}$ (we simply normalised L_0 to unity) (*n*=exogenous growth of labour force)

$A_t = A_0 e^{gt}$ (g= exogenous growth of technology) (2)

According to the assumption of constant returns to scale, the intensive form of production function is as follows:

$$\hat{y}_t = \hat{k}_t^{\alpha} \hat{h}_t^{\beta} \quad (3)$$

where $\hat{k} = K/AL$, $\hat{h} = H/AL$ and $\hat{y} = Y/AL$. In the Solow-Swan model, the saving rate is exogenously determined according to the decision of savers or government policy.

Therefore, the capital accumulation equation is written in terms of per effective worker like this:

$$\frac{d\hat{k}_t}{dt} = s_k \hat{y}_t - (n + g + \delta)\hat{k}_t \quad (4)$$

And Mankiw *et al.* (1992) accumulated human capital through investing in education in the model:

$$\frac{d\hat{h}_t}{dt} = s_h \hat{y}_t - (n + g + \delta)\hat{h}_t \quad (5)$$

In the two equations above, S_k and S_h represent the capital and human capital share respectively. Here, we want to contribute to literature by accumulating human capital through other channels that are important in recent growth literature: globalisation and technology transfer. In recent literature, the role of R&D activities is highlighted as an important source of growth. Countries that spend more money on R&D can innovate more, and can therefore accelerate their growth rate. Although empirical evidence shows that other countries which are not involved in R&D activities can take advantage of these new ideas by the diffusion of technology, this research focuses on accumulating human capital through technology spillovers, and absorbing new technologies (imitation), which need a certain level of human capital. However, there are several difficulties in absorbing technology (imitation) from advanced countries. This research considers globalisation as a way of technology spillovers. Globalisation, in a sense of openness, international trade and infrastructure, all of which criteria are in the KOF index. These concepts are incorporated into the model by considering this fact from a new growth theory - that the absorptive capacity of a country can present a possibility for accelerated human capital accumulation (Paakkonen 2010). Therefore, we rewrite equation (5) as:

$$\frac{d\hat{h}_t}{dt} = s_h(1 + GLOB)^{\pi}\hat{y}_t - (n + g + \delta)\hat{h}_t \quad 0 < \text{GLOB} < 1 \quad (6)$$

2.1 The Steady State

In the steady state, the levels of physical and human capital per effective worker are constant (Knight 1993). The steady states values are given in the following equations:

$$\hat{k}^* = \left(\frac{s_h^{\beta} * (1+GLOB)^{\pi\beta} * s_k^{\alpha}}{n+g+\delta}\right)^{\frac{1}{\alpha+\beta}} \quad (7)$$

$$\hat{h}^* = \left(\frac{s_h^{1-\alpha} * (1+GLOB)^{\pi(1-\alpha)} * s_k^{\alpha}}{n+g+\delta}\right)^{\frac{1}{\alpha+\beta}} \quad (8)$$

Substituting these equations into Equation (3), we have:

$$\hat{y}^* = \left(\frac{s_h^{\beta} * (1+GLOB)^{\pi\beta}}{(n+g+\delta)^{\alpha+\beta}}\right)^{\frac{1}{\alpha+\beta}} \quad (9)$$

And for the purpose of estimating the econometric equation, it should be written in logarithmic form:

$$Ln(\hat{y}_t) = \frac{\beta}{1-\alpha-\beta} lns_h + \frac{\alpha}{1-\alpha-\beta} lns_k + \frac{\pi\beta}{1-\alpha-\beta} \ln(1+GLOB) - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+\delta) \quad (10)$$

Following Knight *et al.* (1993), the linearisation of the transition path around the steady state is given as:

$$\frac{dLn(\hat{y}_t)}{dt} = \lambda(\ln(\hat{y}^*) - Ln(\hat{y}_t)) \quad (11)$$

Or integrating equation (2-9) from $T=t-1$ to $T=t$:

$$Ln(\hat{y}_t) - \ln(\hat{y}^*) = e^{-\lambda t}\ln(\hat{y}^*) - e^{-\lambda t} Ln(\hat{y}_{t-1}) \quad (12)$$

This can be re-written as:

$$Ln(\hat{y}_t) = 1 - e^{-\lambda t}\ln(\hat{y}^*) + e^{-\lambda t} Ln(\hat{y}_{t-1}) \quad (13)$$

where *ë= (n+g+ä)(1-á-â)* is the speed of convergence.

Substituting for $Ln(\hat{y}_t)$ in equation (13) we have:

$$Ln(\hat{y}_t) = (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta} lns_h + (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta} lns_k + (1-e^{-\lambda t})\frac{\pi\beta}{1-\alpha-\beta}\ln(1+GLOB) + -(1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + e^{-\lambda t} Ln(\hat{y}_{t-1}) \quad (14)$$

Since the format of equation (14) is in per effective worker, we have to transform it to per worker for the purpose of estimation. So, as we had $A_t=A_0 e^{gt}$, adding on logarithm, we have:

$$LnA_t = LnA_0 + gt \quad (15)$$

And we have, $\hat{y}$ *Y/AL*, which can be written for per worker as $\hat{y}=y/A$, $\ln \hat{y} = \ln y - \ln A$

Therefore, we have:

$$\ln \hat{y} = \ln y - LnA_0 - gt \quad (16)$$

$$Ln(y_t) = LnA_0 + gt + (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta} lns_h + (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta} lns_k + (1-e^{-\lambda t})\frac{\pi\beta}{1-\alpha-\beta}\ln(1+GLOB) - (1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + e^{-\lambda t} Ln(y_{t-1}) \quad (17)$$

To estimate the growth regression, we subtracted $Ln(y_{t-1})$ from both sides:

$$\Delta Ln(y_t) = LnA_0 + gt + (1 - e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}lns_h + (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}lns_k - (1 - e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n + g + \delta) + (1 - e^{-\lambda t})\frac{\pi\beta}{1-\alpha-\beta}\ln(1 + GLOB) + (e^{-\lambda t} - 1)Ln(y_{t-1}) \quad (18)$$

Equation (18) provides us with a good specification for empirical research; however, it will not be used literally. This equation shows the effect of different factors on the GDP per capita growth rate. The first two terms LnA_0 and *gt* represent the cross-specific effect and time specific effect, respectively. A_0 represents all the unobserved factors that affect efficiency. These two items might be correlated to the other explanatory variables on the model. The third and fourth coefficients show that the greater the savings and investment on human and physical capital, the more rapid the growth. The fifth term is about the role of population growth on economic growth. With a given β, α, δ and g, population growth rate has a negative effect on GDP per capita growth. The coefficient of GLOB shows that if λ is positive, opening up the borders and being globalised can help hasten the rate of GDP per capita growth. And for the last term, if π is positive, it means that there is a negative relationship between the initial level of GDP per capita and the growth rate. According to Barro and Sala-i-Martin (1992),"Countries below their steady state growth path, can grow faster: conditional convergence."

3. Measuring Globalisation

In previous studies on measuring globalisation, most researchers focused just on the economic aspects of globalisation, and used variables like trade, capital flows and openness as proxies for globalisation, and also usually relied on neoclassical growth theory and its assumptions. Furthermore, most of these studies used cross-sectional analysis, which does not consider time, and also does not solve the problem of endogeneity (Alesina 1994; Chanda 2005; Rodrik 1999; Blomström *et al.* 1997); Garrett 2000; Dollar and Edward 1993; Frankel and Romer 1999) . However, becoming aware of the shortcomings of this method, economists have started using new methods like time series and sophisticated panel data which consider both time and unit, such as the fixed effect, random effect and first difference GMM and so on. But the focus was still on economic aspects of globalisation, and with some results still inconsistent with theories. According to Dreher (2006), what is important to highlight in this area is examining the results of globalisation on growth in "greater detail". These inconsistent results might be due to the omission of other important aspects of globalisation from regressions (Dreher 2006). Since the different dimensions of globalisation are strongly related to each other, putting them separately in the model might cause collinearity problems, while omitting these dimensions could bias the results. Therefore, since what is important is the overall effect of globalisation on growth, this study will contribute to literature by using a new proxy for globalisation introduced by Dreher (2006). According to him, globalisation is not only concerned with economic aspects but also with two other dimensions of globalisation: social integration, and political integration. He introduced an index, known as the KOF index, that was calculated for 158 countries in the world, and based on which, countries were ranked. This index is updated every year and was available on the website as"KOF Index of globalisation" until 2008. Details of the index are available in the Appendix.

4. Estimation Method

To overcome the limitations of cross-section data used in earlier studies, panel methods were used in this study. Panel data have advantages over both cross-section data and time series data. For the panel database, the dynamic system generalised method of moments (DSGMM) is used because of its many advantages (Arellano and Bover 1995; Blundell and Bond, 1998; Windmeijer 2005). First, in comparison to other methods like fixed and random effects, instrumental variables, standard GMM or first difference GMM, DSGMM is unbiased as the number of countries exceeds the number of time periods (Baltagi 2008; Bond *et al.* 2001). Second, the problem of endogeneity which has not been resolved using static techniques like ordinary least squares, generalised least squares, and feasible generalised least squares is resolved in DSGMM (Baltagi 2008).[1] Third, DSGMM allows for heteroskedasticity in data and in situations where the distribution of error terms is normal.

To solve the problem of endogeniety, scholars like Holtz-Eakin *et al.* (1988) and Arellano and Bond (1991) developed an estimator for dynamic panel data models, named first differenced generalised method of moments. Researchers such as Caselli *et al.* (1996) applied their method for the first time in growth literature. Subsequently several other scholars used similar methods (Benhabib and Spiegel 1997; 2000; Easterly and Levine (1997) and Forbes (2000) in their research. However, this method has its own shortcomings – it behaves poorly when time series are persistent, because the lagged levels of the variables which are used are weak instruments for subsequent first difference. They are still correlated with the error term. To solve this problem Arellano and Bover (1995) and Blundell and Bond (1998) developed an estimator system, the GMM, which estimates a system of equations at both first difference and levels; in the levels equations, the lagged first differences of the series are used as instruments, and for the difference equation, the lagged two period or more of the dependent variable and first differences of the series are used as instruments. So by using this GMM system, the estimates are no longer biased due to omitted variables with the problem of endogeniety being also overcome; further, by taking first differences, the problem of country specific effect is solved.

Pedroni (2008), in a IMF workshop, discussed the procedure for choosing the best estimator for the panel dataset. He argued that the proportion of number of individuals to length of time (N/T) could be a good way to choose the best method. He also stated that if the time series is short relatively to the number of individuals, fixed effect, generalised method of moments (GMM) and system generalised method of moments (sysGMM) are the best estimators to apply for estimation, amongst others. Using the instrument's variables is valid, including its own lags. However, in cases where the lagged dependent

[1] Despite their efforts, researchers like Islam (1995), Loayza (1994) and Knight *et al.* (1993) did not fully address the problem of endogeneity.

variables are included in the model, there is no place for fixed and random effects estimators; then GMM would be the best choice.

As Baltagi (2008) argued in his book, dynamic panel models do have problem with the heteroskedasticity of data; however, it can be controlled (Baltagi 2008: 144). In the dynamic system GMM, along with the application of the instruments the Sargan test is used for testing the correlation between error term and instruments; the null hypothesis in this case is whether the instruments are valid in the sense that they are not correlated with the error term in the first difference equation. If the Sargan test is rejected, it means that the over-identifiying restrictions are invalid and therefore the instruments are invalid as well. To test for residual serial correlation, there are AR(1) and AR(2) tests, where the null hypothesis of each test is that the test should reject the null of no first-order serial correlation, but should not reject the null if there is no second-order serial correlation (Baum *et al.* 2007; Roodman 2006).

4.1 Estimating the Solow Growth Model by System GMM

Equation (18) from Section 2 will serve as the guide for useful specification of empirical research. As said before, using a cross-sectional approach just assumes away the cross-country specific and time effects across countries; it also assumes that countries are homogenous. Since this assumption is far from reality, using panel estimators allows for reflecting country specific effects (ρ_i) and period specific intercepts ζ_t which capture aspects that are common to all countries. We indexed all of the variables by time to explore the changes of the variables over time in each country (*i*), rather than just across countries; this is the notion of panel data.

$$\Delta Ln(y_{i,t}) = (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}lns_{h,i,t} + (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}lns_{ki,t} + (1-e^{-\lambda t})\frac{\pi\beta}{1-\alpha-\beta}\ln(1+GLOB_{i,t}) - (1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n_{i,t}+g+\delta) + (e^{-\lambda t}-1)Ln(y_{i,t-1}) + \zeta_t + \rho_i + \varepsilon_{i,t} \quad (19)$$

And the general form of equation (19) is the following equation:

$$\Delta Ln(y_{i,t}) = \theta_1 lns_{h,i,t} + \theta_2 lns_{ki,t} + \theta_3\ln(1+GLOB_{i,t}) - \theta_4\ln(n_{i,t}+g+\delta) + \theta_5 Ln(y_{i,t-1}) + \zeta_t + \rho_i + \varepsilon_{i,t} \quad (20)$$

where

- $\Delta Ln(y_{i,t})$ is annual GDP per capita growth rate between 1996 and 2010.
- $Ln(s_h)$ is annual secondary school enrolment rate
- $Ln(s_k)$ is annual gross capital formation (%GDP)
- *lna (1+GLOB)* is annual KOF index and annual foreign direct investment (FDI %GDP net inflows)
- $Ln(n+g+\delta)$ is population growth rate plus 0.05, based on the assumption of Solow model (*n* is population growth rate, *g* is technology progress and δ is depreciation rate)
- $Ln(y_{t-1})$ is annual lagged level of GDP per capita (PPP, constant 2005 international $) between 1996 and 2010

ζ_t is time dummy

ρ_i is country dummy

To have a better understanding of the effects of globalisation factors on economic growth, we shall first examine equation (20) without globalisation indicators, and subsequently estimate it with globalisation indicators. Clearly, equation (20) can be written as:

$$Ln(y_{i,t}) = \theta_1 lns_{h,i,t} + \theta_2 lns_{ki,t} + \theta_3 \ln(1 + GLOB_{i,t}) - \theta_4 \ln(n_{i,t} + g + \delta) + (1 + \theta_5)Ln(y_{i,t-1}) + \zeta_t + \rho_i + \varepsilon_{i,t} \quad (21)$$

And according to Blundell and Bond (1998), by taking first difference from equation (21), the country specific effects will be removed from the equation, and so the assumption $E(\rho_i \Delta y_{i,t})=0$ is satisfied.

$$\Delta y_{i,t} = \theta_1 \Delta lns_{h,i,t} + \theta_2 \Delta lns_{ki,t} + \theta_3 \Delta\ln(1 + GLOB_{i,t}) - \theta_4 \Delta\ln(n_{i,t} + g + \delta) + (1 + \theta_5)\Delta Ln(y_{i,t-1}) + \zeta_t - \zeta_{t-1} + \varepsilon_{i,t} \quad (22)$$

It should be highlighted here that this assumption does not imply that the country-specific effect does not have any effect on growth, but these effects will be presented in the model by other steady state determinates like investment rate, physical capital and etc. This assumption means that there is no correlation between economic growth, and the country specific effect in the absence of other variables.

4.2 The Data

The dataset consists of a panel of observations for three groups of countries that are classified based on World Bank classification, that is, on income level. The first group consists of 29 countries while the second and third groups consists of 81 and 30 countries, respectively. The lists of countries are available in the Appendix. Annual data for GDP growth rate, initial GDP per capita, FDI, secondary school enrollment ratio and population growth rate were collected from World Development Indicators (WDI) 2012[2] of the World Bank. The data for KOF index was collected from the database of Dreher (2006).

5. Empirical Results

5.1 Panel Unit Root Tests

To analyse data and test the regression model, we first investigated the stationarity of the research variables. To reach this point and have a better understanding about variables characteristics, we use the LLC test[3] (Levin, Lin and Chu 2002).

[2] Using annual data may cause business cycle effects; hence in many studies, researchers use 5-year interval averages, but since in this case "T" is small, only annual data from 1996 to 2010 were used rather than a 5-year interval average.

[3] The reasons for the use of the LLC test (Levin *et al.* 2002) is because the data set is not balanced and this is the only method that deals with an unbalanced dataset.

Table 1. Panel unit root tests

Variables	Levin, Lin & Chu Low income	Levin, Lin & Chu Middle income	Levin, Lin & Chu High income	Levin, Lin & Chu Whole sample
ΔY	-12.45	-20.37	-6.31	-8.45
	(0.000)	(0.000)	(0.000)	(0.000)
Y_{t-1}	-1.52	-1.75	-1.71	-1.67
	(0.63)	(0.042)	(0.043)	(0.033)
S_h	-0.916	-10.35	-7.55	-8.76
	(0.17)	(0.000)	(0.000)	(0.000)
S_k	-5.395	-3.20	-1.27	-4.76
	(0.000)	(0.000)	(0.10)	(0.020)
FDI	-4.73	-9.63	-9.93	-8.65
	(0.000)	(0.000)	(0.000)	(0.010)
POP	-6.04	-4.05	-1.76	-3.78
	(0.000)	(0.000)	(0.038)	(0.000)
KOF	-1.2468	-4.67	-11.80	-6.87
	(0.1062)	(0.000)	(0.000)	(0.000)

Note: H_0: Assumes common unit root process; ΔY is GDP per capita growth rate; Y_{t-1} is initial GDP per capita; S_h is secondary school enrolments ratio; S_k is gross fixed capital formation; FDI is foreign direct investments; POP is population growth rate; KOF is globalisation indicators.

As indicated in Table 1, all of the variables are stationary at the initial level based on the test of Levin *et al.* (2002). Therefore, there is no need to undertake co-integration analysis.

Table 2 reports the results for Equation 2 without globalisation indicators for the whole, and split samples.

Table 1 reports the effects of investing in human capital, physical capital and population growth on economic growth across these groups of countries. As can be seen, the signs of investing in physical capital are positive and significant in all of the groups. However, it is less productive for low-income countries, compared to high-income and middle-income countries. Moreover, in comparing high-income and middle-income countries, it is stronger in middle-income countries.

Findings related to investments in education at secondary level show that it is less productive for low-income countries compared to middle-income countries. This means that by investing more in their secondary education, middle-income countries can accelerate their economic growth. The sign for this variable is positive, but not significant for high-income countries, meaning that they already have a sufficient level of human capital with secondary education, and investing in this section will not affect growth. This is consistent with the argument of Islam (2010), who said that "advanced countries are more likely to engage in innovating new technologies which require highly skilled human capital."

The growth rate of a population has a negative and significant effect on GDP growth, especially when we eliminate middle-income and high-income countries from the sample.

Table 2. Estimating growth regression without globalisation indicators by using dynamic system GMM panel data

VARIABLES	Whole sample	High-income	Low-income	Middle-income
$\Delta Ln(y_{i,t-1})$	0.139***	0.196***	-0.118**	0.0164*
	(0.00483)	(0.0278)	(0.0479)	(0.00994)
$Ln(y_{i,t-1})$	-0.00106***	-0.0139***	-0.0212	-0.478***
	(3.26e-05)	(0.369)	(0.415)	(0.0370)
$Ins_{h,i,t}$	0.158***	0.280	0.191**	1.198***
	(0.00448)	(0.388)	(0.841)	(0.0830)
$Ins_{ki,t}$	2.157***	3.484***	0.231***	4. 609*
	(1.00496)	(1.067)	(0.0806)	(1.0313)
$ln(n_{i,t} + 0.05)$	-1.208***	-0.115***	-0.218***	-0.022***
	(0.0817)	(0.0803)	(0.00989)	(0.00789
Implied λ	0.0000707	0.00107	...	0.0500
Observations	1,616	392	298	1231
Number of code	156	29	30	90
Sargan test,P-value	0.3435	1.0000	0.9987	1.0000
AR(1),P-value	0.0000	0.0042	0.3226	0.0003
AR(2),P-value	0.0768	0.2548	0.3654	0.9269

Note: Standard errors in parentheses; *** p<0.01; ** p<0.05, * p<0.1; time dummies are also included in estimated regression; however, results are not reported here.

Table 3 reports the effects of investing on human capital, physical capital, population growth, globalisation indicators, FDI and KOF index on the extended Solow-Swan model across these groups of countries. By including globalisation indicators, an attempt has been made to control for unobserved effects.

The estimated coefficients for investing in education are positive and significant for the whole sample, but eliminating middle-income and low-income countries from the sample, the coefficients become negative and significant. This result contradicts what Barro (1991), Mankiw *et al.* (1992) and others, who used cross-sectional data analyses, have found in their studies. The one explanation for this result is that when the time dimension is added to the education variable, in addition to cross-country difference, there is need to consider changes in human capital during that time in each country as well. But why are the coefficients negative in high-income countries, but remain positive for middle-income and low-income countries? It indicates that though there was increased investment in secondary education in high-income countries during 1996-2010, the output growth fell. However, this story is not true for middle-income, and especially for low-income countries, where a 1-point increase in investment in education increased GDP growth by 0.3 percentage points. The explanation could be that for middle-income and low-income countries, the cross-sectional effects are strong enough to overcome the time series relations.

Furthermore, the results show that the coefficients are stronger for low-income than for middle-income countries. This means that low-income countries, by investing more in secondary education, can accelerate their economic growth.

Table 3. Estimating growth regression by using dynamic system GMM panel data

Variables	Whole sample	High income	Middle income	Low income
	0.211***	0.349***	0.783***	0.0880**
	(0.00355)	(0.0363)	(0.0522)	(0.0518)
	-0.00084***	-0.72***	-0.4108***	-0.121*
	(1.305)	(0.0025)	(6.45)	(0.0065)
	0.0567***	0.123***	-0.0345***	0.315***
	(0.0325)	(0.0435)	(0.456)	(0.3450)
	6.118***	4.335***	5.070***	6.0766***
	(2.00313)	(0.0209)	(1.557)	(1.0296)
	0.0345***	0.134**	0.876***	0.0566**
	(0.0245)	(0.0456)	(0.245)	(0.678)
	-2.358***	0.789***	-0.256***	-4.345**
	(1.6787)	(0.456)	(0.567)	(3.455)
	4.345***	7.189***	3.567***	9.175***
	(3.145)	(2.763)	(2.789)	(2.456)
Observations	1,034	980	210	259
No. of code	149	90	29	30
Sargan test	13.756	45.21	12.43	11.34
AR2-p Value	.1543	-2.678	.137	.0432
AR1-p Value	.274	0.389	.295	.295

Note: $\Delta Ln(y_{i,t-1})$: lagged GDP per capita growth rate; $Ln(y_{i,t-1})$: lagged GDP per capita; $Ins_{h,i,t}$: secondary school enrolment ratio; $ln(n_{i,t} + 0.05)$: Population growth rate plus 0.05; $Ins_{ki,t}$: gross capital formation; KOF: globalisation indicators. The results for AR1 and AR2 show that there is no first and second serial correlation in the residuals which also give validity to the model. The Sargan statistics test the null hypothesis of correct model specification and validity of instruments. As the results show, we cannot reject the null hypothesis, which means that the instruments are valid. Time dummies are included as well but are not reported here.

The sign of investing in physical capital is positive and significant in the whole sample, and it is the strongest amongst the variables. A 1-point increase in the physical capital increases the GDP growth rate by 6 percentage points. When the middle-income and low-income countries are eliminated from the sample, the sign is still positive, and a 1- point increase in the formation of physical capital increases GDP growth rate by 4 percentage points. For middle-income and low-income countries, the observation is similar, with the sign being positive and significant; 5- and 6-point percentage variations in GDP growth can be explained by physical capital accumulation in these two groups of countries, respectively.

The next step is to investigate the globalisation phenomenon in the process of growth. As discussed earlier, economists have not drawn the same conclusions on the effect of globalisation indicators on growth. In earlier studies, globalisation indicators like trade, openness and FDI were used to estimate the direct effect of these variables on economic growth, but their findings were not consistent. While this study is based on the Solow model, it is possible to test the accumulation effects of globalisation factors on various types of capital. Also, in this research, we applied an alternative proxy named KOF index, introduced by Dreher (2006) to explore the different dimensions of globalisation on growth and the convergence process. We also applied the FDI index.

For high-income countries, the effect of the KOF index is positive and significant. This means that globalisation can increase economic growth across countries with high levels of income. The sign of FDI is also positive and significant in this group, but less powerful than when the KOF index was applied.

For middle-income countries, the results for both variables are positive and significant. These countries can also take advantage of international technology spill-overs through globalisation as they have a suficient level of human capital in their countries. Furthermore, we can see that the KOF index is more powerful than FDI.

The story is the same for low-income countries, with the difference being the effect of globalisation which is is very high in this group. This can be another reason for the significant sign of physical capital accumulation for this group of countries, as discussed earlier. This positive and strong sign means that opening up the borders and allowing for international technology transfer can make lots of difference to these countries. This is consistent with the argument of economists like Jones (1998), who argue that some countries do not have highly skilled workers to take advantage of R&D output; however, they still can grow. These economists argue that it is true that there is a low level of skilled human capital in these countries to take advantages of advanced technologies, but with the opening up of their borders to foreign investments which bring with them a skilled labour force, the labour force in the host country can be trained. In low-income countries, we can also see that the results of the KOF index are more powerful than the FDI.

In general we can conclude that this new KOF index is a better proxy for measuring globalisation, because it not only measures the flows of goods, but also the flow of technology and knowledge as well by incorporating infrastructure like internet users, telephone lines etc.

6. Conclusion

This research set out to see whether globalisation can increase the growth rate of low-income, middle-income and high-income countries. In the growth literature, a large proportion of articles is about the effect of opening up borders of countries, and reducing tariff rates to increase international trade across countries. This is hotly debated up to now. As discussed, some economists believe that globalisation is a malignant force that only helps developed countries to take advantage of this openness (Rodríguez and Rodrik 1999; Slaughter 1997). However, there are other groups that believe globalisation can help developing and undeveloped countries to catch up with the rich ones and accelerate their growth rate (Dollar and Kraay 2001; Garrett 2000; Greenaway and Torstensson 2000). In this research, KOF index and FDI were chosen as proxies for globalisation. The results of this research show that the KOF index and FDI can increase the economic growth rate in low-income countries, with the effect being even stronger than in high-income and middle-income countries. This effect is stronger for the KOF index where there is a place for the exchange of knowledge transfer compared to only the exchange of goods. This could also support the idea of convergence which argues that countries further from the steady state can grow faster. But how can we relate this result with technology transfer?

The other aim of this research was to investigate the role of technology transfer on economic growth by applying the Solow growth framework with the focus being on globalisation indicators, and to see whether these new aspects had stronger effects on growth. By modeling knowledge transfer through globalisation factors such as increased human capital, it is possible to study the impact of new aspects of growth in the traditional Solow model. The results show that the KOF index has the strongest effect compared to the traditional proxy for human capital, the education factor. Especially in low-income countries, it turns out that much of the economic growth can be explained by the KOF index and physical capital accumulation.

In the new growth literature, globalisation is not only about the trade of goods, but also about transferring technology across countries through communication and infrastructure. This explains the choice of the KOF index which covers two other aspects besides the economic aspect: political and social. The results of this study show that globalisation affects the growth of middle-income and high-income countries in the Solow model with the focus being on capital accumulation. Furthermore, this impact is more visible in low-income countries.

The conclusion derived from these findings is that the exchange of ideas can have stronger effects on economic growth than the exchange of goods, and can lead to enhanced growth in low-income countries. Therefore, government policies should aim towards improving the absorption capacity of countries to enable absorption of technology from leaders.

References

Agénor, P.-R. 2004. Does globalisation hurt the poor? *International Economics and Economic Policy* **1(1)**: 21-51.

Alesina, A., V. Grilli and G.M. Milesi-Ferretti. 1994. The political economy of capital controls. In: *Capital Mobility: The Impact on Consumption, Investment, and Growth* ed. Leonardo Leiderman and Assaf Razin. New York: Cambridge University Press.

Arellano, M. and S. Bond. 1991. Some tests of speciûcation for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* **58**: 277-297.

Arellano, M. and O. Bover. 1995. Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics* **68(1)**: 29-51.

Baltagi, B. 2008. *Econometric Analysis of Panel Data* (4th ed.). Wiltshire: Wiley.

Barro, R. 1991. Economic growth in a cross-section of countries. *The Quarterly Journal of Economics* **106(2)**: 407-443.

Barro, R. and X. Sala-i-Martin. 1992. Convergence. *Journal of Political Economy* **100**: 223-251.

Baum, C., M. Scha and S. Stillman. 2007. Enhanced routines for instrumental variables/generalised method of moments estimation and testing. *Stata Journal* **7(4)**: 465-506.

Benhabib, J. and M.M. Spiegel. 1997. Cross-country Growth Regressions. NYU Research Report, pp. 97-20. NYU: C.V. Starr Center for Applied Economics.

Benhabib, J. and M.M. Spiegel. 2000. The role of financial development in growth and investment. *Journal of Economic Growth* **5(4)**: 341-360.

Bhagwati, J. and T.N. Srinivasan. 2002. Trade and poverty in the poor countries. *American Economic Review Economic Studies* **92(2)**: 180-183.

Blomström, M., G. Fors and R.E. Lipsey. 1997. Foreign direct investment and employment: home country experience in the United States and Sweden. *Economic Journal* **107**: 1787 - 1797.

Blundell, R. and S. Bond. 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* **87(1)**: 115-143.

Bond, S., A. Hoefflern and J. Temple. 2001. GMM estimation of empirical growth models. Economics Papers, No. W21,Nuffield College, University of Oxford.

Caselli, F., G. Esquivel and F. Lefort. 1996. Reopening the convergence debate: A new look at cross-country growth empirics. *Journal of Economic Growth* **1(3)**: 363-389.

Chanda, A. 2005. The influence of capital controls on long run growth: where and how much. *Journal of Development Economics* **77(2)**:441- 466

Dollar, D. and N.W. Edward. 1993. *Competitiveness, Convergence, and International Specialization*. Cambridge: MIT Press.

Dollar, D. and A. Kraay. 2001. *Trade, Growth, and Poverty.* Development Research Group, The World Bank.

Dreher, A. 2006. Does globalisation affect growth? Evidence from a new index of globalisation. *Applied Economics* **38(10)**: 1091-1110.

Easterly, W. and R. Levine. 1997. Africa's growth tragedy: Policies and ethnic divisions. *Quarterly Journal of Economics* **112(4)**: 1203-1250

Forbes, K. 2000. A reassessment of the relationship between inequality and growth. *American Economic Review* **90(4)**: 869-887.

Frankel, J. A. and D. Romer. 1999. Does trade cause growth? *American Economic Review Economic Studies* **89(3)**: 379-399.

Ganuza, E., S.Morley, V. Pineiro, S. Robinson and R.Vos. 2005. Are Export Promotion and Trade Liberalisation Good for Latin America's Poor? *Development Policy Review* **23(3)**: 385-404.

Garrett, G. 2000. The causes of globalisation. *Comparative Political Studies* **33(6/7)**: 941-991.

Greenaway, D. and J. Torstensson. 2000. Economic geography, comparative advantage and trade within industries: Evidence from the OECD. *Journal of Economic Integration* **15(2)**: 260-280.

Heshmati, A. 2006. The relationship between income inequality, poverty and globalisation. In *The Impact of Globalisation on the World's Poor,* ed. M. Nissanke and E. Thorbecke, pp.59-93. Basingtoke: Palgrave Macmillan

Holtz-Eakin, D., W. Newey and H. Rosen. 1988. Estimating vector autoregressions with panel data. *Econometrica* **56**: 1371-1395.

Islam, M. R. 2010. Human Capital Composition, Proximity to Technology Frontier and Productivity Growth. Economics Working Papers No. 23-10, Monash University, Department of Economics.

Islam, N. 1995. Growth empirics: a panel data approach. *The Quarterly Journal of Economics* **110(4)**: 1127-1170.

Jones, C. 1998. *Introduction to Economic Growth*. New York: Norton & Company.

Knight, M., N. Loayza and D. Villanueva. 1993. Testing the neoclassical theory of economic growth: a panel data approach. *Staff Papers - International Monetary Fund* **40(3)**: 512-541.

Levin, A., C.F. Lin and C.S.J. Chu. 2002. Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics* **108**: 1–24.

Loayza, N. 1994. A Test of the International Convergence Hypothesis Using Panel Data. Policy Research Working Paper No 1333. The World Bank.

Mankiw, G., D. Romer, D. and D.N. Weil. 1992. A contribution to the empirics of economic growth. *Quarterly Journal of Economics* **107(2)**: 407-437.

Paakkonen, J. 2010. Economic freedom as a driver for growth in transition. *Economic Systems* **34(4)**: 469-479.

Pedroni, P. 2008. Nonstationary Panel Data. Notes for IMF Course.

Rodríguez, F. and D. Rodrik. 1999. Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence. NBER Working Paper No. 7081. National Bureau of Economic Research.

Rodrik, D. 1999. Where did all the growth go? External shocks, social conflict and growth collapses. *Journal of Economic Growth* **4(4)**: 385-412.

Roodman, D. 2006. How to Do xtabond2: An Introduction to "Difference" and "System". GMM in Stata. Working Paper No. 103. Centre for Global Development.

Slaughter, M. J. 1997. Per Capita Income Convergence and the Role of International Trade. NBER Working Paper No. 5897. National Bureau of Economic Research.

Windmeijer, F. 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics* **126(1)**: 25-51.

Appendix

List of Countries

High income		
Australia	Hungary	Poland
Austria	Iceland	Portugal
Belgium	Ireland	Slovak Republic
Canada	Italy	Slovenia
Czech Republic	Israel	Spain
Denmark	Japan	Sweden
Finland	Luxembourg	Switzerland
France	Netherlands	United Kingdom
Germany	New Zealand	United States
Greece	Norway	

Note: For high-income countries, OECD countries have been chosen; since data was not available for most of the variables in Estonia and Korea Rep., these two were dropped from the sample.

Low income		
Bangladesh	Gambia, The	Niger
Benin	Guinea	Rwanda
Burkina Faso	Haiti	Sierra Leone
Burundi	Kenya	Tajikistan
Cambodia	Kyrgyz Republic	Tanzania
Central African Republic	Liberia	Togo
Chad	Madagascar	Uganda
Comoros	Malawi	Myanmar
Congo, Dem. Rep	Mali	Nepal
Eritrea	Mozambique	Ethiopia

Note: For low income countries, Afghanistan, Somalia, Zimbabwe and Mauritania were dropped because there was no data for governance indicators and KOf index for these countries.

Middle income					
Angola	Ecuador	Seychelles	Cameroon	Papua New Guinea	Vietnam
Algeria	Jordan	South Africa	Cape Verde	Paraguay	Yemen, Rep.
Philippines	Kazakhstan	St. Lucia	Congo, Rep.	Zambia	Fiji
Antigua and Barbuda	Latvia	St. Vincent and the Grenadines	Côte d'Ivoire	Panama	Georgia
Honduras	Lebanon	Suriname	Djibouti	Peru	Ghana
Azerbaijan	Libya	Thailand	Egypt, Arab Rep.	Romania	Guatemala
Belarus Guyana	Lithuania	Tunisia	El Salvador	Russian Federation	
Bosnia and Herzegovina	Macedonia, FYR	Turkey	Albania	Mongolia	Syrian Arab Republic
Botswana	Malaysia	Uruguay	Armenia	Morocco	Tonga
Brazil	Maldives	Venezuela, RB	Belize	Nicaragua	Ukraine
Bulgaria	Mauritius	Samoa	Bhutan	Nigeria	Uzbekistan
Chile	Mexico	São Tomé and Principe	Bolivia	Pakistan	Vanuatu
China	Namibia	Senegal	Cuba	Iraq	Sri Lanka
Colombia	Indonesia	Solomon Islands	Dominica	Kiribati	Sudan
Costa Rica	India	South Sudan	Dominican Republic	Moldova	Swaziland

Note: This group is a combination of upper middle-income and lower middle-income countries. Across middle-income countries (108 countries), 90 countries were chosen and 18 countries dropped because of the lack of data for most of the variables. For these groups of countries, much of the data were available, and therefore could be evaluated from 1996-2010.