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Multifactor Productivity and Idea Transmission Channels in the Malaysian Economy

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MULTIFACTOR PRODUCTIVITY AND IDEA TRANSMISSION CHANNELS IN THE MALAYSIAN ECONOMY

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Abstract

This paper examines the contribution of multifactor productivity (MFP) growth to output per worker growth in Malaysia from 1961-2000. MFP growth is found to contribute about 74 percent to output per worker growth from 1987-2000, but has only minimal or negative contribution to growth in the earlier years.

This paper then attempts to explain why MFP growth has such a large contribution to output per worker growth in the period 1987-2000 by looking at international trade as channel of technology or idea transfer from the G5 countries into Malaysia. MFP grows because ideas from these advanced nations are transferred into the economy through this channel. Regressions using OLS are carried out on the log-linearized idea production function. The time frame for the regressions is from 1980 to 2000. The empirical results suggest that trade is an important channel through which technology or ideas are transferred into Malaysia, even when other possible channels - foreign direct investment and tertiary education of workers - are controlled for.

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ACKNOWLEDGEMENTS

Except the LORD build the house, they labour in vain that build it: except the LORD keep the city, the watchman waketh but in vain.

(Psalm 127:1)

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For my parents

1.0. INTRODUCTION

In his 1957 paper Robert M. Solow finds that about 87 percent of of U.S. output per man hour growth from 1909-1949 is attributed to technical change. Over the years, although technical change has been given different names like Technology, Total Factor Productivity (TFP) and multifactor productivity (MFP), the basic meaning remains the same. Jesus Felipe (1999) defines it as the measure of the efficiency of the usage of all the factors of production or an index of all of the factors affecting output production other than physical and human capital. In this paper, technical change will be referred to as multifactor productivity.

The focus of this paper will be on the contribution of multifactor productivity towards economic growth in Malaysia from 1961-2000. A question one might ask is: why conduct this study? The growth in multifactor productivity is important for the economic progress of a country like Malaysia and has been emphasized in its development strategies. One of the future development challenges for Malaysia outlined in the 7th Malaysia Plan (1996-2000) includes the goal of transforming the economy from investment-driven output growth towards productivity and quality-driven growth. The growth in multifactor productivity is one of the ways stated to achieve that goal. In the light of globalization and increasing global competition, the increase in multifactor productivity is vital in order to stay competitive, to keep abreast with technological advancements worldwide and to have sustainable long term growth.

This leads to the next question which is: how to increase multifactor productivity? To answer this question, one needs to know what the sources or determinants of multifactor productivity are. Because of the nature of multifactor productivity – which is in essence the residual of the rate of growth in output after deducting the weighted average of the rates of growth of the inputs of production, its determinants are not clear.

This paper is an effort to study the growth of multifactor productivity in Malaysia and to look further into explaining its determinants by exploring previous studies as well as to carry out a separate study based on the growth model with an idea production function employed by Jones (2002) and Ho and Hoon (2009). In this growth model, technology or ideas are created by research and development activities in the G5 countries. A developing country like Malaysia would then be able to benefit from these R&D through several channels that enable technology transfer or spillovers. Subsequently, it is these technology spillovers that will increase multifactor productivity in Malaysia.

This paper is organized as follows: Section 2 reviews the related literature; Section 3 studies the basic growth accounting for Malaysia from 1961- 2000, Section 4 explores the growth of multifactor productivity as a result of technology spillovers from more advanced countries and Section 5 concludes this paper.

2.0. LITERATURE REVIEW

What are the methods used in obtaining estimates of MFP growth for Malaysia? In finding these, most studies reviewed here employ the neoclassical growth model with Cobb-Douglas production technology. However, there are some differences in terms of the inputs of production used. For example, Menon (1998) includes intermediate inputs alongside the traditional capital and labor inputs. Tham (1995) also includes two types of intermediate inputs which are non-energy intermediate inputs and energy intermediate inputs. Both of these studies are conducted on the manufacturing sector, which is why intermediate inputs are important.

Furthermore, most of the studies use a similar measurement for labor. However, Ghani and Suri (1999) and Collins and Bosworth (1996) adjust labor for educational attainment. In the study by Collins and Bosworth (1996), a labor quality index is employed, which weights the percentage of a country's population that has attained a certain level of schooling with the corresponding return to that level of schooling. This labor quality index, H is used to measure educational attainment and is multiplied with the amount of labor to give a production function of the form: $Q = AK^{\alpha}(HL)^{(1-\alpha)}$. In my study, different from Collins and Bosworth (1996), I will look at a measure of human capital which depends on the value of the rate of return to schooling obtained from Mincer (1974) and the average years of schooling.

Mahadevan (2004) also employs the neoclassical Cobb-Douglas form, but her model differs substantially from the simpler models that other studies have used. Mahadevan (2004) employs a different method of measurement of MFP growth. Nevertheless, other studies not mentioned here have also used similar methods to hers. In her study, she uses parametric and non-parametric approaches to produce the measure of MFP. The parametric approach employs stochastic production frontier models underlying the Cobb-Douglas production technology and the generalized least squares estimation technique. The non-parametric approach uses the Data Envelope Analysis (DEA) technique and decomposes the Malmquist TFP growth index into MFP growth as the product of technical efficiency change (catching up effect) and technical change (frontier effect). Technical efficiency measures the distance that the industry has covered in reaching the efficient frontier when it uses better technology and equipment while technical change measures the distance the efficient frontier itself has moved from its usage of better technology and equipment (Mahadevan, 2002a).

Kim and Lau (1996) make use of the meta-production function model. Their meta-production function is not of the Cobb-Douglas form to allow for the possibility of non-neutral returns of scale and technical progress (Boskin and Lau, 1990). Instead, they utilize the transcendental logarithmic (translog) functional form introduced by Christensen, Jorgenson and Lau (1973). They find that capital accumulation accounts for most of the growth in the Asian Pacific Countries including Malaysia.

The estimates of MFP growth and contribution to growth in these studies vary between one to another due to the usage of different data, time periods, methodology and models specified. Some studies look at the contribution of MFP to output growth, while others look at its contribution to output per capita or output per worker growth. In addition, some studies only focus on the manufacturing sector in Malaysia. Nevertheless, most of them tend to find that output growth is predominantly driven by increases in the inputs of production rather than increases in MFP. (Mahadevan, 2004; Menon, 1998; Raja Nazrin, 2000; Ghani and Suri, 1999; Kawai, 1994; Kim and Lau, 1996; Drysdale and Huang, 1997 and Collins and Bosworth, 1996). Furthermore, Mahadevan (2004) finds that the technical change portion contributes to MFP growth while the technical inefficiency leads to poor economic growth in her study on the manufacturing sector in Malaysia from 1981-1996.

To explain the growth in MFP, some studies have performed regressions operating on several explanatory variables depending on the focus of their study. Ghani and Suri's (1999) study is focused on the impact of the banking sector, trade policies and institutions on the economic growth in Malaysia. They conduct regressions to examine how these factors influenced growth – whether it was through capital accumulation or MFP growth. In the regressions with MFP growth as the dependent variable, the independent variables are growth in bank lending to GDP, growth in FDI to GDP and budget balance to GDP. They employ time series data from 1971 to 1997. The regressions are done using Ordinary Least Squares.

They find that all three variables have significant relationships with MFP growth. Both the budget and FDI variables are found to have positive relationships with MFP growth while the bank lending variable is found to have a negative relationship. In testing the relationship between trade policies and productivity growth, they employ several variables among which are: 1) imported capital goods to GDP, 2) growth in exports plus imports to GDP and 3) import revenue as a ratio of total imports. The first two variables are found to have positive and significant relationships with TFP growth. They also point out that the coefficient on imported capital goods is larger compared to the coefficient on FDI.

Collins and Bosworth (1996) explore the relationship between macroeconomic and outward-oriented trade policies and growth. They use the components of growth – capital accumulation and MFP growth as dependent variables so that they are able to find out whether capital accumulation or MFP growth is the better channel for these policies to function. To measure fiscal policy, they utilize the average budget balance as a share of GDP. The international price of consumption goods from the Penn World Tables is used to measure the real exchange rate. For trade policies, they only focus on one measure which is the Sachs-Warner openness index.

Their findings show that both the macroeconomic measures and Sachs-Warner index are strongly associated with growth. However, they find that budget surpluses are connected to the increase in capital accumulation per worker while more stable exchange rates are related to higher MFP growth. Concerning the Sachs-Warner index measuring openness to trade, Sachs and Warner had proposed that the more open a poor country is, the faster it would catch up with richer countries. Moreover, when it is more open, it is able to import capital and technology from richer and more advanced countries. Therefore openness would be associated with productivity growth. In this study, contrary to theory, the effect of the Sachs-Warner index is found to work through the channel of capital accumulation rather than the growth in MFP. Collins and Bosworth suggest that the Sachs-Warner index is not a very accurate measure of trade policies since it uses and allocates more importance to the black market premium measure which is not a direct measure of trade policies.

In other studies, with regard to trade policies, Kawai (1994) and Raja Nazrin (2000) use regressions to determine their relationship with productivity growth. Kawai's (1994) measures of trade policies - import substitution effects, export promotion effects and the ratio of foreign direct investment to domestic capital formation – are not found to have any significant relationship with MFP growth. On the other hand, Raja Nazrin (2000) finds that export expansion has a positive and significant impact on MFP growth for the period of his study which is from 1975-1997.

Another widely used measure of trade openness is the sum of imports and exports as a ratio to GDP. The literature above have used various measures of trade policies or openness, but none of these studies have looked at how this openness indicator would affect productivity growth. Ghani and Suri's (1999) measure is similar, but is in growth rate form. In my study later on, this measure will be employed to examine its relationship with MFP growth.

So far, all these literature have used the neoclassical way of defining MFP – that it is exogenous. In order to explain why it grows, some of these studies have used either regressions or theories. However, to the best of my knowledge, no study on Malaysia has employed an endogenous growth model where the growth of MFP has an explicit production function which then is incorporated into the larger output production function.

Of late, research and development (R&D)-based endogenous growth models for example Romer (1990), Grossman and Helpman (1991a, 1991b and 1991c) and Aghion and Howitt (1992) have been garnering attention in the literature. In these models, R&D activities are undertaken by profit-maximizing agents. As a result, technology grows and thus output grows. These models also imply that policy changes such as subsidies to R&D or subsidies to capital accumulation will affect long run growth. Thus, growth is endogenous because of these policy implementations and R&D activities.

Jones (1995) has taken a step further in creating an idea production function for the R&D-based model eliminating the "scale effects" implication of other R&D-based models including those mentioned above. He does this because these scale effects cannot be proven in reality. Because scale effects have been eliminated, his model now differs from the other models in that it is more "semi-endogenous". It is endogenous because research and development activities initiated by profit-maximizing agents result in technology which then drives long-run growth. But it is also not endogenous in the sense that policy changes do not lead to long run growth as in the Romer/Grossman-Helpman/Aghion-Howitt models.

In Jones (2002), he then tests a similar model to the one in his 1995 paper empirically for the case of the United States. In this model, ideas are produced through R&D activities in the G5 economies which the US is a member of. In addition, the number of ideas produced also depends on the existing stock of ideas. The technology resulting from these ideas are immediately spilled over to the US. Subsequently, it will lead to output growth. Therefore "the engine of growth is the creation of ideas throughout the world" (Jones, 2002). His growth accounting exercise indicates that a large portion of economic growth in the US from 1950-1993 is due to transition dynamics driving constant growth rates. Two factors influence these transition dynamics which are educational attainment and the rise in research intensity in the G5 countries. The increase in educational attainment contributes more than 33 percent to growth while the increase in research intensity contributes about 50 percent to growth.

Can Jones' (2002) also be applied to developing economies? Ho and Hoon (2009) answer this question by extending Jones' model to suit a developing economy. In Jones (2002), ideas can be discovered anywhere in the world and can be used by any developed country at the same instant. In contrast, Ho and Hoon (2009) argue that this scenario does not occur in developing countries. These countries obtain ideas or technology from developed countries through certain idea absorption channels. In their paper, they extend

Jones' (2002) model to include three channels of technology absorption which are educational quality, imports of machinery and transport equipment, and foreign direct investment from leader-economies. The latter two channels aid in bringing technology from leader-economies into the follower-economy, while the channel of educational quality – specifically the tertiary qualifications of workers, enable them to efficiently learn and apply the technology which has been brought into their country.

Furthermore, in Jones' (2002) model of ideas, there is no trade between countries and no mobility of capital and labor. The only link between economies is ideas. Conversely, following Coe, Helpman and Hoffmaister (1997), Ho and Hoon (2009) introduce trade into Jones' model of ideas, where trade takes the form of imports of machinery and transport equipment. This is one of the channels which will then influence the absorption of ideas into a developing country.

Ho and Hoon (2009)'s choice of the worker - education ratio and imports of machinery of transport equipment channels for their model is based on similar variables used by Coe, Helpman and Hoffmaister (1997). However, they use the tertiary enrolment ratio instead of the secondary school enrolment ratio employed in Coe et al. (1997)'s model. Tertiary education is a better indicator of workers' skills and knowledge. Moreover, with tertiary qualifications, workers would be better equipped to apply and absorb ideas and technology embodied in the technology-intensive and complicated equipment and machinery that are imported into the country. Besides these two channels, the channel of foreign direct investment is also employed based on Hejazi and Safarian (1999).

Ho and Hoon (2009)'s findings indicate that between 52.9 percent and 54.0 percent of output per worker growth in Singapore from 1970-2002 is due to the combined effect of the three channels of idea spillovers employed. Therefore, they suggest that an improvement in these channels would lead to a more effective absorption of ideas from abroad and thus propelling the growth of the Singaporean economy.

If the ideas or technologies from leader-economies have played an important role in the economic growth of Singapore, could they also explain the growth of multifactor productivity and the economic growth of Malaysia? In Chapter 4, this paper will address this question by applying the model by Ho and Hoon (2009) for Malaysia.

3.0. GROWTH ACCOUNTING FOR THE MALAYSIAN AGGREGATE ECONOMY, 1961-2000

Growth accounting for Malaysia enables us to determine the contribution of each factor of production, i.e., physical capital, human capital and multifactor productivity towards the growth rate of the economy. In this case, the growth rate of the economy is represented by the growth rate of real GDP per worker or otherwise referred to as output per worker.

Following Ho and Hoon (2009), the method used for growth accounting for the Malaysian aggregate economy is presented below. Beginning with equation (1):

$$Y_t = A_t^{\sigma} K_t^{\alpha} H_{Yt}^{1-\alpha} \tag{1}$$

In the Cobb-Douglas production function above, an increase in output is determined by the increase in multifactor productivity A_t^{σ}, the capital stock K_t^{α} of the economy and the effective workforce $H_{Yt}^{1-\alpha}$. Here, $\sigma = 1 - \alpha$, thus A_t will be labor-augmenting or Harrod-neutral.

The production function in output per worker terms is:

$$y_t \equiv \frac{Y_t}{L_t} = \left(\frac{K_t}{Y_t} \right)^{\frac{\alpha}{1-\alpha}} l_{Yt} h_t A_t^{\frac{\sigma}{1-\alpha}} \tag{2}$$

K_t, Y_t, and h_t are all observable from the data where K_t is capital stock, Y_t is real GDP, L_t is employed labor force and $h_t = e^{0.07 l_{ht}}$, where l_{ht} is average years of schooling. l_{Yt} is assumed to be equal to one.

First, by taking logs and differentiating equation (2) with respect to time we are able to decompose the production function into the contributions of each factor of production to growth in output per worker:

After taking logs we obtain:

$$\log y_t = \left(\frac{\alpha}{1-\alpha}\right)\log k_t + \log h_t + \left(\frac{\sigma}{1-\alpha}\right)\log A_t$$

And after differentiating the equation with respect to time we obtain:

$$\frac{\dot{y}_t}{y_t} = \left(\frac{\alpha}{1-\alpha}\right)\frac{\dot{k}_t}{k_t} + \frac{\dot{h}_t}{h_t} + \frac{\dot{A}_t}{A_t} \qquad (3)$$

where $\frac{\sigma}{1-\alpha} = \frac{1-\alpha}{1-\alpha} = 1$ and $\frac{K_t}{Y_t}$ is denoted as k_t

Equation (3) states that the growth rate in output per worker is made up of contributions from the growth rate of the capital-output ratio multiplied by its factor share which is $\left(\frac{\alpha}{1-\alpha}\right)$, the growth rate of the human capital measure and the growth rate of multifactor productivity (MFP).

The growth rate of multifactor productivity can then be obtained as a residual from equation (3):

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{y}_t}{y_t} - \left(\frac{\alpha}{1-\alpha}\right)\frac{\dot{k}_t}{k_t} - \frac{\dot{h}_t}{h_t} \tag{4}$$

Following Raja Nazrin (2000), the study on the contribution of MFP growth to output per worker growth will be divided into three distinct economic growth phases in Malaysia: (1) 1961-1970, (2) 1971-1986 and (3) 1987-2000.

The first period of 1961-1970 was a time of immense political instability in the country. The Emergency occurred from 1948-1960, followed by the confrontation with Indonesia (1963-1966), the split with Singapore in 1965 and the May 13, 1969 racial riots. During the same period of time in the 1960s, Malaysia's economic policies were towards the fostering of import substitution industrialization.

The second period of 1971-1986 coincides with the New Economic Policy (NEP) era (1970-1990), established as a result of the 1969 racial riots with the hopes of promoting greater economic equity amongst the races, eradicating poverty and boosting the economic growth of the country. Industrialization became export oriented from 1970-1980. The public sector became greatly involved in the economy, especially during the early 1980s when heavy industries were protected with high import duties and import restrictions. (Leete, 2007).

In the years 1985-1986 the economy of Malaysia went into recession after the drop in prices of all major export commodities in 1985. As a result of that, a series of policy reforms was initiated. Fundamentally, beginning from 1985 onwards, there was a policy shift from public-sector-led growth to private-sector-led growth. (Tham, 1995).

After 1986, Malaysia began to recover from the recession and economic growth picked up speed from 1987-1997. In 1997, the Asian financial crisis hit the region, and the economy of Malaysia went into another recession. The Malaysian government responded by executing capital controls, fixing the currency exchange rate at RM 3.80 per US Dollar and implementing expansionary macroeconomic policies (Menon, 2009). The economy then started to recover from the financial crisis beginning from the second quarter of 1999 onwards.

3.1. Growth Accounting Results

Using data from 1960 to 2000, the average growth rates of the capital-output ratio, human capital and multifactor productivity are calculated and are presented in the tables below. The capital-output ratio growth rates here have been multiplied with the factor $\left(\frac{\alpha}{1-\alpha}\right)$.

The value of α will be equal to 1/3 as adopted by several others like Ghani and Suri (1999) and Klenow and Rodriguez-Clare (1997)[1]. Since the earliest observation available is from 1960, after adjusting for end points, the total annual observations will be 40.

Growth Accounting Breakdown of Sources of Growth, 1961-2000							
Period	**Average Rate of Growth (%)**				**Contribution to Real GDP per worker growth (%)**		
	Real GDP per worker	Capital-Output ratio	Human Capital	**MFP**	Capital-Output ratio	Human Capital	**MFP**
1961-2000	3.77	1.55	0.98	**1.24**	41.04	25.95	**33.01**
1961-1970	2.65	2.06	0.50	**0.09**	77.83	18.82	**3.35**
1971-1986	3.28	2.68	0.86	**-0.26**	81.69	26.32	**-8.01**
1987-2000	5.13	-0.11	1.45	**3.79**	-2.22	28.31	**73.91**
1961-1986	3.03	2.44	0.72	**-0.13**	80.39	23.80	**-4.20**
1987-1998	5.00	0.32	1.64	**3.04**	6.48	32.79	**60.73**
1999-2000	5.89	-2.74	0.32	**8.31**	-46.49	5.48	**141.01**

From 1961-2000, the average growth rate of multifactor productivity was 1.24 percent. It fluctuated throughout the entire period. MFP grew at a very low rate of 0.09 percent in the decade of 1961-1970 and saw a decrease to an average growth rate of -0.26 percent in the following fifteen years.

1

The value of α is usually similar to the capital share of income of countries. It is obtained by estimating the factor share of labor by dividing employee compensation with GDP. The capital share is then taken as *(1- labor share)* following the Cobb-Douglas production function which allocates α as the capital share and $1-\alpha$ as the labor share. Gollin (2002) finds that labor shares across the cross section of rich and poor countries in his study range between 0.60 to 0.85. Therefore the value of $\alpha=1/3$ assumed here is quite reasonable. Furthermore, Sarel (1997) finds that the value of α is approximately 0.32 for Malaysia from 1978-1996.

From 1987, the growth rate of MFP rebounded and rose to an average of 3.79 percent from 1987-2000. It was during this period that its contribution to the growth rate of the economy was at its highest among the three economic growth phases. About 73.9 percent of growth in output per worker was attributed to the growth in multifactor productivity. This is a large contrast in comparison to the earlier two periods when growth in output per worker was predominantly driven by growth in physical capital and human capital while the contribution of MFP growth was very minimal or even negative from 1971-1986.

When observing the further breakdown of the period into 1987-1998 and 1999-2000, we are able to observe that the negative contribution of the capital-output ratio from 1987-2000 was partly due to the negative growth of the capital-output ratio in 1999-2000. In the year 1999, the country was only beginning to recover from the Asian financial crisis that occurred from 1997-1998. In 1998, the capital-output ratio grew at 4.31 percent. In 1999, it decreased to -0.46 percent and in 2000, it was even lower at -5.01 percent.

Studies on the contribution of MFP to output growth in Malaysia for example Mahadevan (2004), Menon (1998), Raja Nazrin (2000), Tham (1995) and Kim and Lau (1996) find that output growth is predominantly input driven – driven by the growth in physical and human capital - and not driven by MFP growth for all their time periods of study, be it for the aggregate economy or for the manufacturing sector.

The growth accounting results for my study from 1961-1970 and 1971-1986 agree with the findings of the studies above – that output per worker growth was largely input driven. In contrast, different from the findings of the studies above, I observe that in the period 1987-2000, output per worker growth was chiefly productivity driven. Sarel's (1997) numbers tend to agree more with my results for the later period. He finds strong MFP growth from 1978-1996 and 1991-1996 in Malaysia. In addition, he finds that MFP grew at 2 percent during these time periods. Its contribution to output per person growth was also quite significant in the two time periods – at 44.1 percent and 37.4 percent respectively.

Nevertheless, the methods, assumptions and time periods used for the calculation of MFP growth in the studies mentioned above are different. One difference is the measure of human capital that I have employed which is based on Jones (2002) and Ho and Hoon (2009). Human capital is measured using the Mincer (1974) rates of return to schooling and the average years of schooling in Malaysia. Therefore I am not able to exactly compare their results with mine. Some of the findings of these studies can be found in Table 1 in the appendix.

3.2. Explanations for MFP Results

Why did MFP grow at such a low rate from 1961-1986 but increased so rapidly in the years after that up until the year 2000? In the following are some possible explanations for these patterns in MFP growth.

Domestic Research and Development (R&D)

There are several reasons that Kim and Lau (1995) give to explain poor MFP growth in the East Asian Newly Industrialized Countries (NICs) - Hong Kong, Singapore, South Korea and Taiwan. One of these is the lack of domestic R&D. Kim and Lau (1995) argue that MFP growth was low in the NICs because R&D was not a priority in these countries. This was shown by the lack of investments allocated to R&D, as well as the deficiency in domestic technological improvements. This situation also applies to Malaysia.

In 1982, the national R&D expenditure was only 0.5 percent of the Gross National Product (GNP). In comparison, South Korea's and Japan's expenditures were 0.95 percent and 2.78 percent of their GNP in 1982. In that year, R&D expenditure in Malaysia was focused more on agricultural production compared to other areas. More than a decade later, in 1998, R&D expenditure was still very low at only 0.4 percent of GDP. In the same year, the number of R&D personnel was recorded at 7.0 researchers per 10,000 labor force which was also a small number compared to the ratio in the OECD countries (5^{th} and 8^{th} Malaysia Plans). Lall (2001) points out that the problem of the R&D gap in Malaysia will hinder it from keeping up with other nations such as South Korea and Taiwan which industrial and export structures were at similar levels of technology with Malaysia at the time of his study. Furthermore, not only does Malaysia lack domestic R&D, it is leaving much of the R&D work to the multinational companies in Malaysia (Athukorala and Menon, 1999).

Human Resource Endowment

Poor human resource endowment in the Newly Industrialized Countries might have restricted their chances from benefiting from technical progress (Kim and Lau, 1995). This explanation applies to any country as well, especially a developing economy like Malaysia. The less educated and less skilled the workforce in Malaysia, the less equipped they are to learn and apply new skills and technologies and perhaps even create new technologies on their own. Moreover, the lack of qualified scientists and engineers could lead to the deficiency in R&D personnel mentioned above.

From 1971-1980, the Malaysian government increased development expenditures for education. Consequently, the move achieved a 100 percent gross enrolment ratio at the primary level in 1987. At the secondary level, the enrolment ratio was twice the 1965 ratio by 1987 while the enrolment ratio more than tripled at the tertiary level. Still, the percentage of those enrolled in tertiary education was very low – only 7 percent. In the same year, the Philippines, Singapore and Thailand had tertiary enrolment rates of 38 percent, 12 percent and 20 percent respectively (Tham, 1995).

The government was successful in developing basic education, which was sufficient to train workers to work in the manufacturing sector. In fact, that was one of the reasons why foreign firms were attracted to invest in Malaysia in the early seventies. Labor was educated, cheap and plentiful (Tham, 1995).

However, an improvement in basic education is insufficient, especially when the country seeks to be more productivity-driven in the long run. It is documented that there were significant skilled labor shortages from 1957-1985. These labor shortages were due to the huge demand for high and middle-level manpower in the scientific, technical and managerial fields (2nd, 4th, and 5th Malaysia Plans).

Before the 1970s, the skilled labor shortages were caused by the bias in degree programmes in universities toward the arts and humanities instead of science and other technical fields. Later, there was an improvement in the enrolment ratio in science and technical programmes from 36.5 percent in 1970 to 52.2 percent in 1980. Still, from 1976-1980, the percentage of graduates from these programmes at 39 percent failed to achieve the desired graduate target of 60 percent. The shortage of skilled manpower was also seen in the first half of the 1980s despite the slower growth in the economy from 1981-85 (2nd, 4th, and 5th Malaysia Plans).

The problem of poor human resource endowment continued in the 1990s. Lucas and Verry (1999) find a decline in enrolment in science and technology streams at all levels from 1980 – 1991. Instead, there was a higher level of enrolment in arts and social sciences. In 1992, the overall primary level enrolment was close to the universal level, while overall enrolment at secondary level was only about a third of the enrolment in the US. Enrolment at tertiary level was the lowest – at only 4 percent, when the US tertiary level enrolment was 56 percent. (Lucas and Verry, 1999) The trend in enrolment for this period which continues until the mid-1990s seems to indicate that enrolment, especially tertiary enrolment in Malaysia was not in the position to aid in technology absorption. In fact, it led to a shortage of technicians in engineering and other skilled technical occupations (Leete, 2007).

In sum, poor human resource endowment is seen to have a negative influence on MFP growth from the 1960s to the 1990s. Therefore it could be one of the reasons why MFP growth in my study is low from 1960-86. Because there was poor human resource endowment even up to the 1990s, it is possible that human resource endowment was not one of the factors influencing the high growth of MFP from 1987-2000.

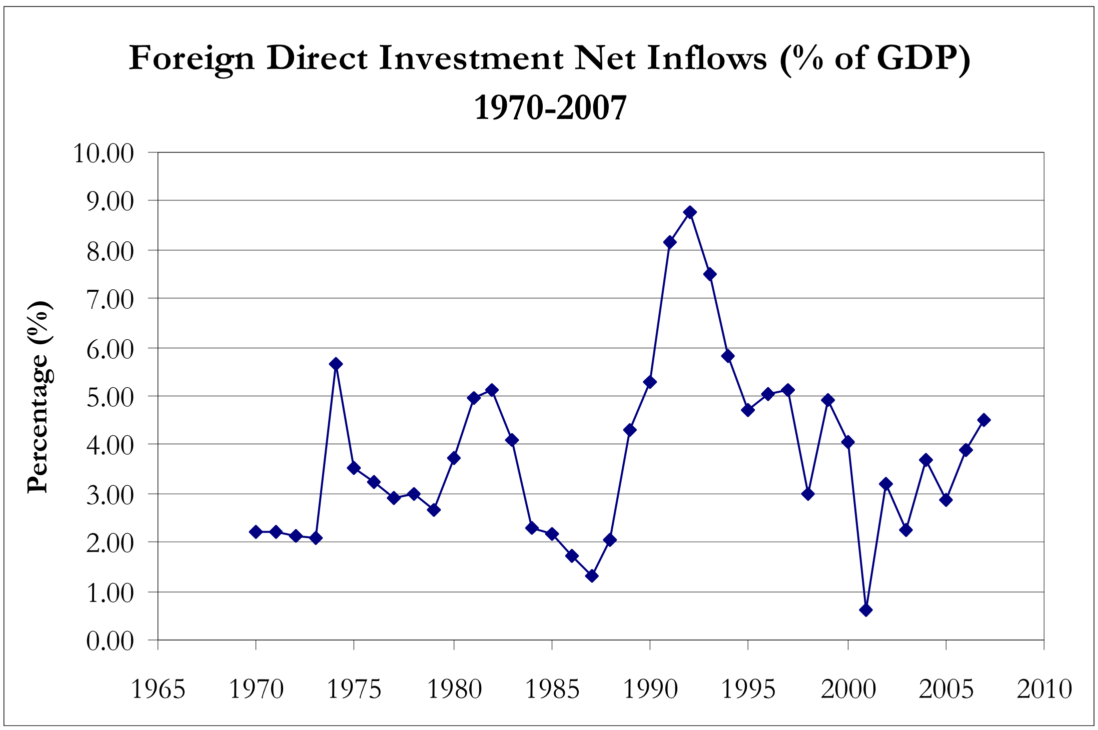
Foreign Direct Investment

Another factor that might affect the growth of multifactor productivity is the flow of foreign direct investment (FDI) into a country. Romer (1993) states that foreign direct investment is one of the channels through which technology or ideas can be transmitted from one country to another in order that the idea gap between countries can be diminished.

In testing for the relationship between FDI and MFP growth, Raja Nazrin (2000) finds only a small, positive influence of FDI on MFP growth for the period 1975-1997. An increase in the growth rate of FDI by 1 percent increases the growth rate of MFP by only

0.032 percent. Similarly, Nadiri and Son (1999) find that only 0.95 percent of aggregate Malaysian MFP growth is attributed to foreign capital. On the other hand, Mahadevan (2002b) finds a negative relationship between FDI and MFP growth in the manufacturing sector of Malaysia. Figure 1 below shows the pattern of FDI inflows into Malaysia from 1970 to 2007:

Figure 1:



Source: World Development Indicators Database

FDI inflows into Malaysia began very early in the 20th century. From the time of independence in 1957 to 1968 FDI was channeled into consumer goods production, especially in the electrical and electronics sector which products were low-tech and labor –intensive (Sieh Lee, 2006).

The growth in FDI inflows in the early 1970s was due to the Investment Incentives Act of 1968, and growth in the electronics sector, particularly in the rising number of Free Trade Zones (FTZs) (OECD, 1999). The Free Trade Zones were designed especially for export-oriented industries where they could enjoy benefits like minimum formalities in the export of their products, duty-free import of raw materials, and machinery and equipment needed for production and others (Driffield et al., 2004). The decline in the 2nd half of the 1970s was due to the establishment of the Industrial Coordination Act (ICA), 1975 which made it compulsory for foreign companies to apply for a licence to operate as well as to comply with only a 30 percent equity ownership in line with the New Economic Policy. (Sieh Lee, 2006).

In the early 1980s, there was also a decline in the inflows of FDI because of the recession that occurred from 1985-1986. But beginning from 1988 onwards, there was a rapid increase of FDI inflows into Malaysia. This was largely due to the Promotion of Investment Act introduced in 1986 through which the government of Malaysia relaxed the equity requirements of the 1975 ICA and also coincided with the recovery from the recession. There was an increase of FDI from Japanese and Taiwanese firm during this period (OECD, 1999).

Therefore, the rapid increase of FDI after 1987 could be one of the reasons for the rapid growth of MFP from 1987-2000. In the empirical exercise that I will be conducting later on in Section 4, I will also be testing the effectiveness of FDI as a channel of technology transfer into Malaysia.

Investment in Machinery and Equipment

De Long and Summers (1991, 1992, 1993) find that investment in machinery and equipment has a stronger relationship with economic growth compared to other types of investment. Why is this so? Through this particular investment, new technologies can be brought in and applied in the production process, thus leading to greater output growth. (Raja Nazrin, 2000).

Raja Nazrin (2000) finds that private investment growth rates have a positive and significant relationship with the growth rate of MFP. He then goes further to examine the De Long and Summers' hypothesis.

His finding for Malaysia for the period 1975-1997 is that investment in machinery and equipment has a positive and significant relationship with MFP growth. However, investment in construction and investment in perennial crops do not have any significant relationship.

From the 1960s to the mid 1980s, Raja Nazrin (2000) observes a drop in investment in machinery and equipment. From 1962-70, the growth rate of investment in machinery and equipment was 14.3 percent and it dropped to only 5.7 percent in the 1975-86 period. From 1987-1997 the growth rate investment in machinery and equipment then escalated to 15 percent.

In a similar fashion, the growth rate of MFP in my study is seen to dip from 1960-86 and rise rapidly from 1987-2000.

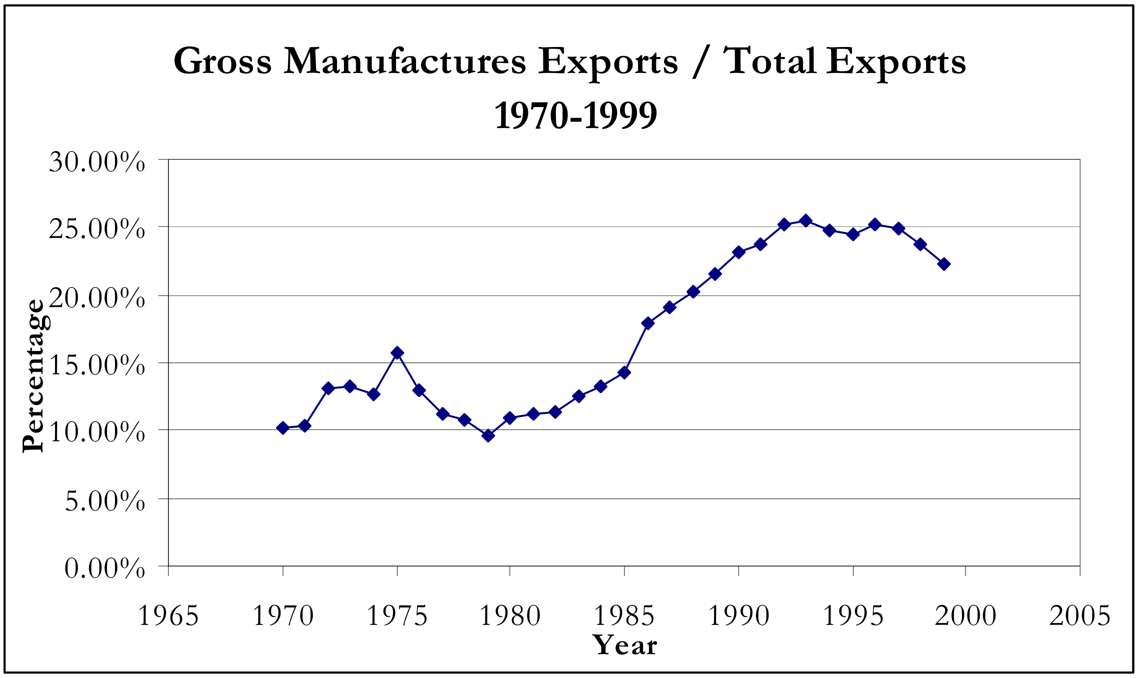
Trade policies

Raja Nazrin (2000) finds that the change in exports growth rates has a positive and significant relationship with the MFP growth rate from 1975-1997. In another study by Kawai (1994), opposing results are found. Kawai (1994) uses three proxies for trade policies in his study on the effect of trade policies on the growth of MFP in Malaysia from 1970-1990. His proxies are import substitution effects, export promotion effects and the ratio of foreign direct investment to domestic capital formation. None of these are found to have any significant impact on MFP growth.

These findings are inconclusive as to whether trade policies, particularly export expansion have an impact on MFP growth. Notwithstanding, there is still much to gain from studying the actual exports statistics for the country.

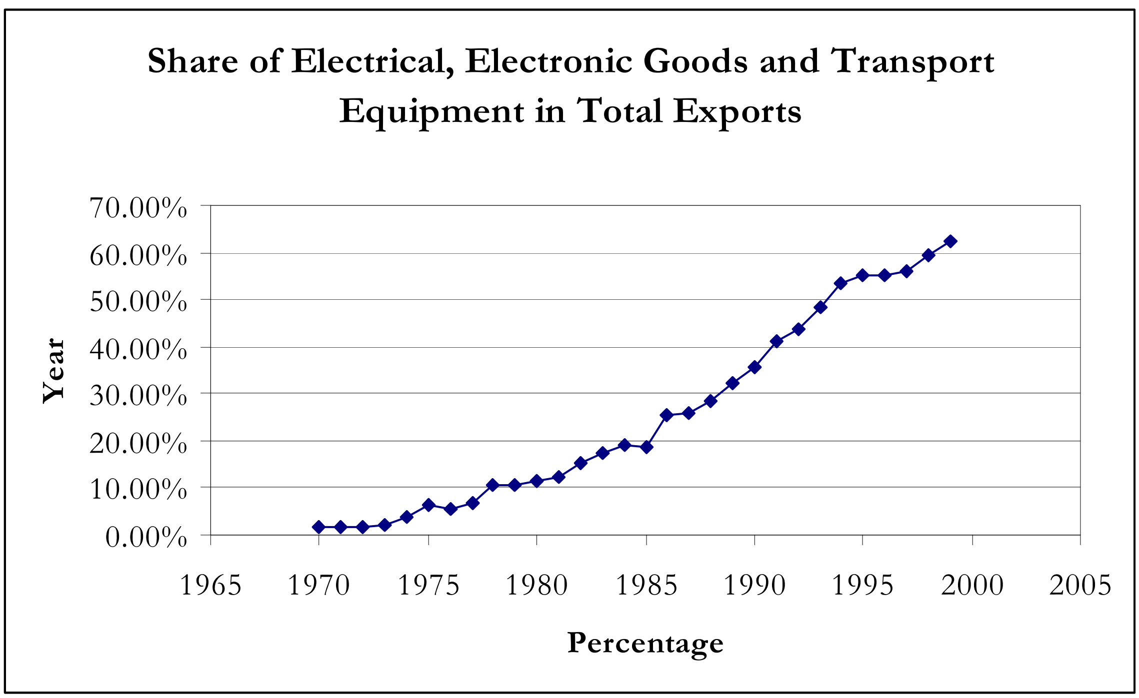
From 1962-70 and 1971-86 exports grew at 5.8 percent and 8.5 percent respectively. In 1975-86 the real exports growth rate was at 9.1 percent, but it increased even more rapidly from 1987-97 at 12.8 percent. The growth rate of manufactured exports was more significant. The average growth rate of manufactured exports from 1986-90 was 30 percent and from 1991-95 it was 26 percent (Raja Nazrin, 2000).

Figure 2:



Source: Economic Planning Unit, Malaysia

Figure 3:



Source: Economic Planning Unit, Malaysia

Figure 2 above shows the percentage of exports attributed to manufactured goods. A growing percentage of manufactures in exports is seen from the 1970s to the 1990s. In 1970, the percentage of exports of manufactured goods was only 10.3 percent. In these 30 years, the percentage of manufactured goods was at its highest in 1993 at 25.5 percent. In 1999, its percentage decreased a little to 22.3 percent of exports. From Figure 3, of all the manufactured goods, electrical and electronic goods as well as transport equipment made up only 1.6 percent of total exports in 1970, but their percentage rose to 62.3 percent of total exports in 1999.

The Business Cycle

The fluctuations in business cycle may explain the fluctuations in MFP growth because the latter tends to follow the former. This is because when a cyclical downturn occurs, production operations tend to be cut back and this leads to a fall in MFP. The converse happens during a cyclical upturn. (Raja Nazrin, 2000).

In his regression analysis, Raja Nazrin (2000) uses a dummy variable to represent the recession years of 1985 and 1986 in Malaysia. It is found significant in explaining negative MFP growth.

The "Stage of Development" Hypothesis

It is possible that Malaysia was still in an early stage of development from 1961-1986 which might explain the reason for low MFP growth rates from 1961-1986. This "stage of development" hypothesis has been studied in early economic development literature for example Rostow (1960) and revisited in recent studies, for example Azariadis and Drazen (1990). The hypothesis states that a country goes through several developmental stages. In the early stages, growth is mainly attributed to physical and human capital accumulation. After fulfilling some preconditions or crossing some developmental threshold, the country will be more able to adopt technology and knowledge from overseas through catchup. Therefore, growth in the later stages will be more driven by technological advancements (Collins and Bosworth, 1996).

To test this hypothesis, Collins and Bosworth (1996) compare development indicators between East Asian countries (including Malaysia) and six industrial countries. The indicators for the year 1975 for the East Asian countries are compared with the 1965 indicators for the six industrial countries. The indicators include years of schooling, capital per worker and fraction of the labor force employed in agriculture.

They find that the East Asian countries are less-developed compared to the industrial countries. Their results suggest that the East Asian countries might have been at an earlier stage of development when they experienced low MFP growth from 1960-1994 (or 1973-1994). Furthermore, after 1984, MFP growth rose rapidly in many of these countries, possibly indicating that the countries have entered another stage of development. The findings of Collins and Bosworth (1996) suggest that the stage of development hypothesis is applicable to Malaysia.

3.3. Conclusion

So far the study has focused on the growth rate of multifactor productivity and how much it has contributed to the growth rate of output per worker from 1961-2000. We see that MFP growth's contribution to output per worker growth is very minimal or even negative from years 1961-1986. However, the results take an about turn in the following 14 years (1987-2000) when the growth rate of MFP plays a major part in accounting for output per worker growth.

We have seen that there are several factors affecting MFP growth and its trends over the years. However, there is another possibility – another line of theory that offers to explain why MFP grows. In this line of theory, MFP represents ideas, and these ideas are created through research and development (R&D). As a result of R&D, new innovations and technologies emerge to make production more efficient. In developed countries, where the R&D sector is well-established and thriving, ideas can be created and disseminated almost immediately (Jones, 2002). MFP grows because there are more and more ideas being created and put to productive use in the economies.

However, for developing countries, it is a different story. And this is where the rest of the paper is heading toward in Section 4 – can the growth of MFP from 1987-2000 be explained as a result of ideas disseminated or transferred from developed nations? How then are these ideas transferred into a developing country like Malaysia?

4.0. MULTIFACTOR PRODUCTIVITY, TECHNOLOGY SPILLOVERS AND CHANNELS OF TECHNOLOGY ABSORPTION

Recent studies like Jones (2002) and Ho and Hoon (2009) have explored the factors influencing the residual of the goods production function of an economy. In Neoclassical models of economic growth, the residual known as the Total Factor Productivity (TFP), Multifactor Productivity (MFP) , technology or technical change is treated as an unknown, exogenous phenomenon.

Benhabib and Spiegel (2005) discuss the theory that this technology originates from countries which have developed new ideas and technology from research and development activities, and it can subsequently diffuse to other countries. Furthermore, Coe, Helpman and Hoffmaister (1997) suggest that technology can be transferred or spilled over via international trade or foreign direct investment. They also state that the multifactor productivity of a country depends on the quality of the country's human capital. To add to that, Xu (2000) finds that technology transfer from FDI may not increase productivity growth in the host country when there is insufficient human capital present to adopt the new technology.

Spillovers have benefited **developed** countries which are trade partners of other developed countries engaged in R&D (Coe, Helpman and Hoffmaister, 1997), but can **developing** or less - developed countries benefit in the same way or even more?

In this paper, a type of an endogenous growth model – the R&D-based growth model - will be employed. Instead of being an unknown, exogenous factor in the economic growth of a country as treated in neoclassical growth models, MFP growth will be driven by factors that can be quantified - through channels which enable the absorption of technology into a developing country.

I will employ the R&D – based growth model employed by Ho and Hoon (2006), which is an extension of Jones (2002). Jones (2002) introduces an ideas production function, which depends on the number of research scientists and engineers in the G5 nations. Ho and Hoon (2006) extend Jones' ideas production function to include channels of technology absorption.

The reason for the need for channels of technology absorption is that Jones' model is based on the theory that ideas can immediately be utilized in any economy at the instant they are produced. This theory is relevant for his study because it is conducted on the United States. Since the United States is one of the world leaders in research and development, it is capable of producing its own ideas from its own pool of research scientists and engineers. This is on top of the fact that it is a developed country. Furthermore, the country is also a member of the G5 nations.

On the other hand, Ho and Hoon (2006) modify the model to suit a developing country – Singapore – which accumulates ideas through the process of technology absorption compared to immediate consumption of technology, as in the case of a developed country like the US. Hence, for Singapore, there must be channels to aid in that process. Therefore, in their paper, Ho and Hoon (2009) bring in three channels of technology absorption which are educational quality of the employed labor force, machinery and transport equipment imports from the G5 countries and foreign direct investment from the G5 countries.

In this paper, I will conduct a similar study on a developing country – Malaysia. The purpose of this study is to examine whether the channel of international trade has a positive impact on technology absorption from developed countries into Malaysia. In addition to international trade, the channels of G5 foreign direct investment and quality of learning of workers will also be examined. These channels have been highlighted in recent literature to be possible channels of technology absorption. In addition, I will also look at the contributions of the growth rates of these channels to the growth rate of real income per worker in Malaysia.

The time period of the study is from 1980 to 2000. The data employed will be annual data. Empirical testing of the ideas production function will be conducted to ascertain the impact of the channels on the change in the multifactor productivity. Multifactor productivity is also referred to as the stock of ideas or technology in this paper.

To make it suitable for empirical testing, the ideas production function will be log-linearized. Multifactor productivity is obtained as a residual from the production function. The remaining variables can be obtained from the data on Malaysia and the G5 nations. The regressions will be conducted using the method of Ordinary Least Squares. Following that, using the coefficients from the regressions, calculations of the growth rates for the purpose of growth accounting will be done.

This section is organized as follows: The following sub-section discusses the methodology employed for the study, followed by the regression and growth accounting results.

4.1. METHODOLOGY

4.1.1. Theoretical Framework

In this paper, I will apply the theoretical framework for a follower economy employed by Ho and Hoon (2009). They utilize the Jones (2002) growth accounting framework and modify it to include technology spillover channels by Coe, Helpman and Hoffmaister (1997) and Hejazi and Safarian (1999).

The production function of an economy is given by:

$$Y_t = A_t^{\sigma} K_t^{\alpha} H_{Yt}^{1-\alpha} \tag{1}$$

where Y_t is total output produced, K_t is physical capital, H_{Yt} is total quantity of human capital employed to produce output and A_t is the total stock of ideas available to this economy. All of these have their measurements at a particular time, *t*. In addition, as before, $\sigma = 1 - \alpha$ in order that multifactor productivity or the stock of ideas is measured in Harrod-neutral terms.

Physical capital accumulates according to:

$$\dot{K}_t = s_{Kt} Y_t - dK_t \ , \quad K_0 > 0 \tag{2}$$

where s_{Kt} is the function of output invested and (1-s_{Kt}) is the remainder which is consumed, while $d > 0$ is the exogenous, constant rate of depreciation.

Effective workforce H_{Yt} is given by

$$H_{Yt} = h_t L_{Yt} , \tag{3}$$

where h_t is human capital per worker, and L_{Yt} is labor that is employed and involved in producing output.

Human capital per worker is then affected by the amount of time a worker spends in accumulating human capital, l_{ht} :

$$h_t = e^{\psi l_{ht}} , \psi > 0. \tag{4}$$

The parameter ψ is obtained from the return to schooling estimated by Mincer (1974) from regressions of the log of wages on years of schooling. ψ takes on the value of the coefficient of years of schooling which is estimated to be 0.07.

The labor resource constraint in the economy is

$$L_{At} + L_{Yt} = L_t = (1 - l_{ht}) N_t , \tag{5}$$

where total employment, L_t, is the sum of labor employed in research activities, L_{At} , and labor employed in production, L_{Y_t}. It is also the portion of labor force (N_t) not involved in accumulating human capital. $l_A \equiv \frac{L_A}{L}$ is defined to be research intensity while $l_Y = \frac{L_Y}{L}$.

The labor force of the economy is assumed to be growing at the rate of n:

$$N_t = N_0 e^{nt} , \quad N_0 > 0. \tag{6}$$

Equations (1) to (6) apply both to the leader-economy and the follower-economy. In this paper, the leader-economy is represented by the G5 nations, while the follower-economy is Malaysia. In subsequent equations, any variables associated with the leader-economy will be capped with a ~ while those without ~ will be associated with the follower-economy.

Output per effective worker is defined as:

$$y_t^E \equiv \frac{Y_t}{A_t H_{Yt}}.$$

and steady-state output per effective worker can be derived to be:

$$y^{E*} = \left[\frac{s_k}{g(AH_y) + d}\right]^{\frac{\alpha}{1-\alpha}},$$

where the growth rate of $A_t H_{Yt}$ is written as

$$g(A_t H_{Yt}) = g(A_t) + g(H_{Yt}) = \frac{\dot{A}_t}{A_t} + \psi \frac{dl_{ht}}{dt} + n .$$

Next, we obtain the growth of output per effective worker:

$$g(y_t^E) \equiv \frac{\dot{y}_t^E}{y_t^E} = \alpha v \left[\left(\frac{y^{E*}}{y_t^E}\right)^{\frac{1}{\alpha}} - 1\right]$$

where the speed of convergence $v \equiv (1-\alpha)(g(AH_Y) + d)$. A first order Taylor series expansion around $\frac{y^{E*}}{y_t^E} = 1$ gives

$$g(y_t^E) = v\left(\frac{y^{E*}}{y_t^E} - 1\right).$$

From (1) and (3) they get $y_t = \frac{Y_t}{L_t} = A_t h_t y_t^E$ and using the four equations above, we arrive at the growth rate of y_t:

$$g(y_t) = \alpha\left[g(A_t) + \psi \frac{dl_{ht}}{dt}\right] - (1-\alpha)[n-d] + \frac{(1-\alpha)s_K^{\frac{\alpha}{1-\alpha}}\left[n + g(A_t) + \psi \frac{dl_{ht}}{dt} + d\right]^{1-\frac{\alpha}{1-\alpha}}}{\frac{y_t}{A_t h_t}} \tag{7}$$

There are several ceteris paribus observations that Ho and Hoon (2009) make from equation (7): most notably that increases in the state variables A_t and h_t will increase $g(y_t)$. They also point out a sufficient but not a necessary condition for an increase in $g(A_t)$ and/or $\frac{dl_{ht}}{dt}$ to increase $g(y_t)$ is that $\alpha \le 0.5$.

From here we proceed to the production function of A_t and its determinants:

Effective world research effort $\tilde{H}_{At}$ is defined as

$$\tilde{H}_{At} = \sum_{i=1}^{M} L_{Ait} \tag{8}$$

where i indexes each of the G5 economies. L_{Ai} is the number of research scientists and engineers in country i.

The rate at which a follower-economy absorbs the stock of ideas from a leader-economy is as follows:

$$\dot{A}_t = \delta \tilde{H}_{At}^{\lambda} A_t^{\phi} Trade_t^{\omega}, \qquad A_0 > 0 \ , \tag{9}$$

where $\tilde{H}_{At}$ is the sum of research scientists and engineers in the G5 countries, A_0 is the initial level of technology and $Trade_t$ which is the ratio of imports plus exports to GDP *[(Imports$_t$ + Exports$_t$ /) GDP$_t$]*. $\delta > 0, \ \ 0 < \lambda < 1, \ \ \phi < 1,$ and $\omega > 0$.

Dividing both sides of the ideas production function in (9) by A_t and rewriting in terms of γ, where $\gamma \equiv \frac{\sigma}{(1-\alpha)} \cdot \frac{\lambda}{1-\phi}$ and $\sigma = 1 - \alpha$ we get:

$$\frac{\dot{A}_t}{A_t} = \delta \left(\frac{\tilde{H}_{At}}{A_t^{\frac{1}{\gamma}}} \right)^{\lambda} Trade_t^{\omega} \tag{10}$$

This equation states that productivity growth depends on the ratio the quantity of human capital used in producing ideas to the level of productivity, and the economy's openness to international trade.

How then does the follower-economy absorb technology or ideas from the leader-economies at the frontier of world technology? The equations below describe the process:

The frontier stock of ideas evolves according to

$$\dot{T}_t = \delta \tilde{H}_{At}^{\lambda} T_t^{\phi} \ , \qquad T_0 > 0 \ ,$$

while the growth rate of ideas at the frontier is

$$g(T_t) \equiv \frac{\dot{T}_t}{T_t} = \delta H_{At}^{\lambda} T_t^{\phi - 1} \tag{11}$$

Plugging (11) into the growth-rate form of (9), it follows that

$$g(A_t) \equiv \frac{\dot{A}_t}{A_t} = g(T_t)\left(\frac{T_t}{A_t}\right)^{1-\phi} Trade_t^{\omega} \ , \qquad A_0 > 0 \, . \tag{12}$$

This relationship demonstrates three factors corresponding to the three terms on the right hand side of the equation above that bring an increase to the growth rate of the stock of ideas in the follower-economy:

Firstly, a faster growth rate of the stock of ideas in the leader-economies will increase the growth rate of the stock of ideas in the follower-economy. Secondly, the further away the follower-economy is from the technology frontier, the faster its stock of ideas will grow.

This second property seems to disagree with the stage of development hypothesis studied by Collins and Bosworth (1996). Their findings suggest that the further away a country is from the frontier, the slower its stock of ideas or MFP will grow. But, as we will see later on, it is a country's openness to ideas that influences the growth in its stock of ideas. A country may be a long distance away from the technology frontier, but its stock of ideas will grow faster because its channels of ideas transfer - which reflect the country's openness to ideas from abroad – actually aid in facilitating the transfer of ideas, and therefore the increasing growth of ideas. Therefore, the low rate of growth of MFP observed in Malaysia could possibly indicate that the country was less open to the transfer of ideas from 1961-1986 and the high MFP growth rate from 1987 onwards could indicate a greater degree of openness to ideas.

Correspondingly, this leads us to the third property observed in equation (12) above which is: stronger channels of technology transfer in the follower-economy will increase its growth rate of ideas. In this case, there is only one channel which is international trade.

Rewriting (1) in terms of output per worker, we obtain

$$y_t \equiv \frac{Y_t}{L_t} = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} l_{Yt} h_t A_t^{\frac{\sigma}{1-\alpha}} \tag{13}$$

and using (2) and (9), (13) becomes

$$y_t = \left(\frac{s_{Kt}}{n_t + g(k_t) + d}\right)^{\frac{\alpha}{1-\alpha}} l_{Yt} h_t \left(\frac{\delta}{g(A_t)}\right)^{\frac{\gamma}{\lambda}} \tilde{H}_{At}^{\gamma} \left(Trade_t^{\omega}\right)^{\frac{\gamma}{\lambda}} \quad , \tag{14}$$

where $k = \dfrac{K}{L}$, and $\gamma \equiv \dfrac{\sigma}{(1-\alpha)} \cdot \dfrac{\lambda}{1-\phi}$.

This equation fully describes output per worker in terms of all the factors of production including the factors that influence the stock of ideas or multifactor productivity.

In the econometric estimations and growth accounting implementations to follow, the methods employed are also based on Ho and Hoon (2009):

4.1.2. Econometric Estimation of the Idea Production Function

I will empirically estimate equation (10), which coefficients will then be used in the growth accounting exercises. Following Jones (2002), let A be the actual, unobserved stock of ideas and B be the measured stock of ideas or multifactor productivity. The relationship between A and B is assumed to be:

$$\ln B_t = \ln A_t + \varepsilon_t , \tag{i}$$

where ε_t is the stationary error term.

Equation (10) is then converted to its discrete form which is:

$$\frac{\Delta A_{t+1}}{A_t} = \delta \left(\frac{\tilde{H}_{At}}{A_t^{\frac{1}{\gamma}}} \right)^{\lambda} Trade_t^{\omega} . \tag{ii}$$

Using the above equations, (ii) is log-linearized around a path where B_t and $\tilde{H}_{At}$ are growing at constant rates and the result is written in terms of the measured multifactor productivity:

$$\Delta \ln B_{t+1} \approx \beta_0 + \lambda g(B) \left[\ln \tilde{H}_{At} + \frac{\omega}{\lambda} \ln Trade_t - \frac{1}{\gamma} \ln B_t \right] + \pi_{t+1} \quad , \tag{iii}$$

where $\beta_0 \equiv g(B)\left(1 - \ln\left(\frac{g(B)}{\delta}\right)\right)$ is a constant, and $\pi_{t+1} \equiv \Delta \varepsilon_{t+1} + \frac{\lambda g(B)}{\gamma} \varepsilon_t$ is an error term.

Other Channels of Idea Transmission

In Ho and Hoon (2009), foreign direct investment and tertiary education of workers are also found to be important channels of idea transmission. Therefore, in this paper, in addition to trade, the effectiveness of these channels will also be tested according to the idea production functions below. E_t is the ratio of tertiary enrolment to employment and $\left(\frac{G5FDI_t}{K_t}\right)$ is the stock of foreign direct investment from the G5 countries weighted by capital stock. $\beta > 0$ and $\eta > 0$.

There are two specifications which will be used:

a) Trade, FDI and tertiary education of workers entering separately:

$$\dot{A}_t = \delta \widetilde{H}_{At}^{\lambda} A_t^{\phi} E_t^{\beta}\, Trade_t^{\omega} \left(\frac{G5FDI_t}{K_t}\right)^{\eta}, \qquad A_0 > 0,\ \omega > 0 \quad \text{and} \tag{15}$$

b) Trade interacted with FDI:

$$\dot{A}_t = \delta \widetilde{H}_{At}^{\lambda} A_t^{\phi} E_t^{\beta} \left(Trade_t \times \frac{G5FDI_t}{K_t}\right)^{\rho}, \qquad A_0 > 0,\ \rho > 0. \tag{16}$$

In equation (16) the trade variable – also known as "trade intensity" or the level of openness in trade literature - is interacted with FDI to reflect the link between trade and FDI in reality. A country's level of openness is related to the amount of foreign direct investment flowing into the country. Hejazi and Safarian (1999) state that a large portion of international trade in fact is attributed to trade between Multinational Enterprises (MNE) and their subsidiaries or affiliates.

In Malaysia, for example, foreign companies invested in the electrical and electronics industry for the purpose of exports rather than to produce for the domestic market. For instance, US and European affiliates mainly exported their output to their home country through intrafirm channels (Sieh Lee and Yew, 1997).

In many studies, such as Kreinin et al. (1998) a country's level of openness is used as one of the factors influencing the amount of foreign direct investment flowing into the country. Kreinin et al. (1998) find a positive relationship between trade openness in the East Asian countries and inflows of foreign direct investment from Japanese MNCs.

Since there is an association between trade openness and foreign direct investment it makes sense to interact these two variables rather than study them separately as a larger level of openness would amplify the level of FDI and vice versa.

As in equation (10), the same log-linearizations will be performed on the discrete versions of equations (15) and (16) to obtain the following:

$$\Delta \ln B_{t+1} \approx \beta_0 + \lambda g(B)\left[\ln \tilde{H}_{At} + \frac{\beta}{\lambda}\ln E_t + \frac{\omega}{\lambda}\ln Trade_t + \frac{\eta}{\lambda}\ln\left(\frac{G5FDI_t}{K_t}\right) - \frac{1}{\gamma}\ln B_t\right] + \pi_{t+1} \qquad \text{(iv)}$$

and

$$\Delta \ln B_{t+1} \approx \beta_0 + \lambda g(B)\left[\ln \tilde{H}_{At} + \frac{\beta}{\lambda}\ln E_t + \frac{\rho}{\lambda}\ln\left(Trade_t \times \frac{G5FDI_t}{K_t}\right) - \frac{1}{\gamma}\ln B_t\right] + \pi_{t+1} \qquad \text{(v)}$$

4.1.3. Regressions

In order to econometrically estimate equations (iii), (iv) and (v) I will first obtain the values of multifactor productivity from equation (13).

The values of the observed multifactor productivity are calculated as the residual of (13) which is

$$A_t = \frac{y_t}{\left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} h_t}$$

where the annual numerical values of y_t, $\frac{K_t}{Y_t}$, and h_t are obtained from the data on Malaysia. l_{Yt} is considered as equal to 1 since the percentage of research scientists and engineers in Malaysia is very low. In the year 2000, the number of researchers engaged in science, technology and innovation in Malaysia is 15, 022, which is only about 0.16 percent of total labor force (Ninth Malaysia Plan). Therefore, the amount is very small, and l_{At} is considered zero to simplify calculations.

After log-linearization, equation (iii) can now be estimated using the method of Ordinary Least Squares. The OLS method can be used because although they are nonstationary, the explanatory variables are cointegrated. The tests for unit roots, optimum number of lags and cointegration are reported in the appendix.

There will be 4 different regressions for each of the log-linearized equations – the first, in which λ is not fixed, followed by $\lambda = 1$, $\lambda = 0.5$ and $\lambda = 0.25$. In the equations where λ is not fixed, the dependent variable will be $\Delta \ln B_{t+1}$ and independent variables will be $\ln \tilde{H}_{At}$, $\ln E_t$, $\ln Trade_t$, $\ln\left(\frac{G5FDI_t}{K_t}\right)$ and $\ln B_t$, when trade is not interacted with FDI and $\ln \tilde{H}_{At}$, $\ln E_t$, $\ln\left(Trade_t \times \frac{G5FDI_t}{K_t}\right)$ and $\ln B_t$ when trade is interacted with FDI.

When λ has fixed values, it is brought over to the left hand side of the equation and the new dependent variable becomes $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$. With the new dependent variable, the right hand side variables are now $\ln E_t$, $\ln Trade_t$, $\ln\left(\frac{G5FDI_t}{K_t}\right)$ and $\ln B_t$ for the specification without interaction, and they are $\ln E_t$, $\ln\left(Trade_t \times \frac{G5FDI_t}{K_t}\right)$ and $\ln B_t$ for the specification with interaction.

4.1.4. Growth Accounting

Growth accounting in this section is to determine the contributions of the growth rate of each factor in the production function towards the growth rate of income per worker, especially focusing on the contributions of the growth rate of each channel of technology absorption.

To conduct the growth accounting, equation (14) will be converted into its growth rate form. First, using (2) and (4) to rewrite (14) we have

$$y_t = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} l_{Yt} e^{\psi l_{ht}} \left(\frac{\delta}{g(A_t)}\right)^{\frac{\gamma}{\lambda}} H_{At}^{\gamma} \left(Trade_t^{\omega}\right)^{\frac{\gamma}{\lambda}} \tag{17}$$

This also applies to the case when $G5FDI_t / K_t$ and E_t enter into the equation as additional technology absorption channels. Therefore equation (17) would look like:

$$y_t = \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} l_{Yt} e^{\psi l_{ht}} \left(\frac{\delta}{g(A_t)}\right)^{\frac{\gamma}{\lambda}} H_{At}^{\gamma} \left[E_t^{\beta} \left(Trade_t \times \frac{G5FDI_t}{K_t}\right)^{\rho}\right]$$

(All three channels and interaction)

Next, applying the natural logarithm and differentiating it with respect to time, and using (8) it becomes

$$g(y)=\frac{\alpha}{1-\alpha}g\left(\frac{K_t}{Y_t}\right)+g(l_{Yt})-\frac{\gamma}{\lambda}g(g(A_t))+\psi\Delta l_{ht}+\gamma\tilde{n}$$
$$+\gamma g\left(\tilde{l}_{At}\right)+\frac{\omega}{1-\phi}g\left(Trade_t\right) \qquad \textit{(Only trade)} \qquad (18)$$

Or,

$$g(y)=\frac{\alpha}{1-\alpha}g\left(\frac{K_t}{Y_t}\right)+g(l_{Yt})-\frac{\gamma}{\lambda}g(g(A_t))+\psi\Delta l_{ht}+\gamma\tilde{n}$$
$$+\gamma g\left(\tilde{l}_{At}\right)+\frac{\beta}{1-\phi}g(E_t)+\frac{\rho}{1-\phi}g\left(Trade\times\frac{G5FDI_t}{K_t}\right)$$

(All three channels and interaction)

As mentioned before, the number of researchers out of the number of employed workers (l_A) in Malaysia is very low – about 0.16 percent. Hence, l_Y = 1- l_A = 0.9984 which is very close to 1. Therefore, in this paper, I will assume that l_Y =1 and l_A = 0. Since l_Y is a constant, its growth rate is zero and can be cancelled out from equation (21) above.

Furthermore, the t-test is carried out to determine whether $g(A_t)$ is a constant. The results, which are in the appendix of this paper, indicate that $g(A_t)$ is constant and stationary and that $g(g(A_t))$ is not statistically different from zero. Therefore the term involving $g(g(A_t))$ above can also be cancelled out and the equation is simplified to become

$$g(y) = \frac{\alpha}{1-\alpha} g\left(\frac{K_t}{Y_t}\right) + \psi \Delta l_{ht} + \gamma \tilde{n} + \gamma g\left(\tilde{l}_{At}\right) + \frac{\beta}{1-\phi} g(E_t) + \frac{\rho}{1-\phi} g\left(Trade_t \times \frac{G5FDI_t}{K_t}\right)$$

(All three channels and interactions) (19)

The same applies to the other similar equation in (18) above.

The values of the growth rates are calculated from the data on Malaysia and the G5 nations. Besides, the parameter values of γ, $\frac{\beta}{1-\phi}$, $\frac{\rho}{1-\phi}$, $\frac{\eta}{1-\phi}$, and $\frac{\omega}{1-\phi}$ are calculated from the coefficients of the regressions on equations (iii), (iv) and (v), and also by taking note of the definitions that $\gamma \equiv \frac{\sigma}{(1-\alpha)} \cdot \frac{\lambda}{1-\phi}$ and $\sigma = 1-\alpha$. The value of α used here is 1/3.

4.2. Regression Results

The regressions are divided into three main categories according to equations (iii), (iv) and (v). Equation (iii) has only trade as a channel of technology absorption. Equation (iv) has the additional channels of G5 foreign direct investment and tertiary enrolment per worker and Equation (v) includes all three channels with trade interacting with G5 FDI.

The value of the rate of return to capital α is equal to 1/3 and the depreciation rate of capital stock is assumed to be 5 percent since there is no available data to calculate the exact depreciation rate for Malaysia.

All of the above equations are estimated using Ordinary Least Squares on data from 1980-2000. The number of observations tested for each variable is only 19, since differencing removes one year from the dependent variable $\Delta \ln B_{t+1}$, and the regressions are done on the first lag of the explanatory variables.

In all regressions, leaving λ free results in none of the coefficients being significant except for $\ln B_t$. However, the coefficient for $\ln Trade_t$ is found significant at the 5 percent level in the regression where it enters alone and the regression without interactions. The ideal value for λ should be between 0 and 1 since it represents the importance of decreasing returns to research at a point in time in Jones (2002), Ho and Hoon (2009) and in this paper. For example, as Jones (2002) states, if the number of researchers is doubled today, the stock of ideas produced by them today would increase by 2^{λ}. However, the values of λ calculated from the regressions here are very large – ranging from -27.65 to 27.1.

The values of λ used here are the same as those used in Jones (2002) and Ho and Hoon (2009) where they are assumed to be somewhere between a maximum of 1 and a minimum of 0.25. Therefore, in this paper, I will focus more on the regressions where the values of λ are fixed. In particular, I will focus on the regressions where $\lambda = 1$ which coefficients shall be used in the calculations of γ, β, η, ω, ϕ, and ρ later on.

Overall, from the results, I find that the coefficient of the log of the stock of ideas - $\ln B_t$ is significant at at least the 10 percent significance level in all the regressions.

I find that the coefficient on $\ln Trade_t$ is significant at at least the 5 percent level in the regressions where it enters alone as a channel of technology absorption. When $\ln\left(\frac{G5FDI_t}{K_t}\right)$ and $\ln E_t$ are included to test its robustness, it still remains significant. However, this only occurs in regressions where the trade variable is not interacted with G5 foreign direct investment variable.

Conversely, the coefficient of the log of foreign direct investment from the G5 nations, $\ln\left(\frac{G5FDI_t}{K_t}\right)$ is not significant in any of the regressions whether it enters alone or when it interacts with trade. Similarly, the coefficient for the log of tertiary education to employment ratio, $\ln E$ is not significant in any of the regressions. Furthermore, in the regressions where trade is not interacted with G5 FDI, both the channels of G5 FDI and tertiary enrolment per worker are not only insignificant but their estimates have the wrong sign.

In sum, I find that among all the channels of technology transfer tested only trade seems to be an important channel of technology transfer for this period of study.

International Trade and Technology Transfer

In the studies of international trade as a channel of technology transfer, trade is represented either by imports or exports individually. In the studies on imports, the focus is on imports of intermediate goods particularly imports of machinery and equipment. Coe, Helpman and Hoffmaister (1997) and Keller (2000) both utilize this measure of imports to represent trade.

The theory behind this is that through these imports, a country, especially a developing country can have greater access to a larger variety of capital equipment and machinery which are of a higher level of technology than that which the country can acquire. Furthermore, through trade the country is able to attain better information on production methods, product design, organizational methods and market conditions. (Coe, Helpman and Hoffmaister, 1997).

Technology is then transferred or diffused through the process of utilizing these capital equipment and machinery, where the country is then able to increase productivity and efficiency and at the same time learn the new technology. Moreover, the knowledge gained could lead to efforts in imitating the technology which could further increase productivity.

Coe, Helpman and Hoffmaister (1997) in their study on 77 developing countries use imports of machinery and transport equipment to measure trade openness as well as to be used as the bilateral import shares measure between industrial and less developed countries. They find results suggesting that total factor productivity is larger when there is more openness to imports of machinery and equipment from industrial countries. Likewise, Ho and Hoon (2009) have also found that the channel of imports of machinery and transport equipment is an important means through which technology is transferred from the G5 nations to Singapore.

Keller and Acharya's (2007) study focuses on 17 industrial countries. In contrast to Coe, Helpman and Hoffmaister (1997), they use total import shares instead of machinery and equipment imports shares in their study. Their findings show that for some countries, the main channel of technology transfer is through technology embodied in imports, while for others non-trade channels play a more important role.

Through these studies, some empirical evidence has been found to support the theory that trade through imports is an important channel of technology transfer, whether it occurs through imports of machinery and equipment or total imports. This gives some support to my measure of trade which uses total imports.

From Table 2 in the appendix we can observe that Malaysia's imports have been increasing from 1960 to 2005. Through the years, imports of machinery and transport equipment were becoming a more significant portion of total imports. In 1960, imports of machinery and transport equipment constituted only 15.4 percent of total imports. In 2000, imports of machinery and transport equipment rose to 62.8 percent of total imports. Almost two thirds of total imports were made up of imports of machinery and transport equipment in that year.

Furthermore, from Table 3 we can see that bulk of the imports of machinery and transport equipment come from the G5 nations which are developed countries. A significant portion also comes from the four countries formerly known as the Newly Industrializing Economies (NIEs) – Singapore, Taiwan, South Korea and Hong Kong. These countries were known as the Asian Tigers and had experienced rapid growth and industrialization from the 1960s to the 1990s. These countries are now advanced and developed economies.

The next question is whether exports play any role in the transfer of technology from one country to another. One of the most cited means through which exports can aid in the transfer of technology is through the potential to benefit from the technical expertise of buyers. Some studies cited below give some illustrations on this:

"Participating in export markets brings firms into contact with international best practice and fosters learning and productivity growth" (World Bank, 1997).

"…a good deal of the information needed to augment basic capabilities has come from the buyers of exports who freely provided product designs and offered technical assistance to improve process technology in the context of their sourcing activities. Some part of the efficiency of export-led development must therefore be attributed to externalities derived from exporting."(Evenson and Westphal, 1995)

"Buyers want low-cost, better-quality products from major suppliers. To obtain this, they transmit tacit and occasionally proprietary knowledge from their other, often OECD economy suppliers." (World Bank, 1993, p. 320)

Studies on the effects of learning-by-exporting have found mixed evidence for the relationship between exports and productivity growth. Some indicate a positive association between exports and productivity growth, but their causal directions indicate that it is productivity that increases exports. For example, Clerides, Lach and Tybout (1998) find that productivity does not increase when firms enter the export market. Rather, it is the firms with high productivity that self-select to enter the export market. Therefore, the positive association between exports and productivity is not due to learning-by-exporting.

Correspondingly, Bernard and Jensen (1999) also find that the firms in their study were already high performers before they entered the export market, while there is ambiguous evidence on how exporting would benefit firms.

On the contrary, some studies do find that exports do influence productivity change. For example, Pack and Page (1994) demonstrate from their cross-country study and detailed study of Korea and Taiwan that the rapidly increasing growth in manufactured exports of these countries resulted in a higher productivity change although there was some portion of productivity growth that was still unexplained.

To sum, the findings of previous literature agree that there is a positive relationship between exports and productivity growth although in some cases the causal direction might be the other way around.

Therefore, for Malaysia, there is a possibility that trade through exports by way of learning-by-exporting might be aiding in the transfer of technological expertise and therefore multifactor productivity growth. This could be reflected in the exports portion of the trade variable employed here.

4.3. Growth Accounting Results

After obtaining the coefficients from the regressions on the log-linearized equations, we can now proceed to conduct growth accounting. This section presents the growth accounting calculations for the contribution of the three channels of technology absorption towards output per worker growth. In the growth accounting tables shown in the appendix, Table 8 presents the growth accounting with the single idea transmission channel of trade. Next, Table 9 presents the growth accounting with three channels of idea transmission – G5 FDI weighted by capital stock, tertiary enrolment of workers and trade.

As mentioned before in the method for growth accounting, these channels actually explain the residual or multifactor productivity. Therefore, collectively, they will represent the contribution of multifactor productivity to Real GDP per worker growth.

The values of the parameters γ, $\frac{\beta}{1-\phi}$, $\frac{\rho}{1-\phi}$, and $\frac{\omega}{1-\phi}$ are used to calculate the growth rates of the channels. They are taken from the regressions where $\lambda = 1$. The accounting is done for the years 1980 to 2000.

From 1980 to 2000 the growth rate of real GDP per worker is about 3.38 percent. The contribution of capital intensity to growth is about 42 percent and the educational attainment effect contributes about 6 percent to growth. Together, the inputs of production account for about 48 percent of output per worker growth.

In the specification with only trade as a channel of MFP growth, the growth in trade is found to contribute about 50.1 percent to output per worker growth. There is a portion of growth attributed to MFP which is still unexplained, but the value is very small at only 0.58 percent. Therefore to correct for this under-explanation, the contribution of trade is about 50.1 + 0.58 = 50.68 percent.

For the specification with all three channels of idea spillovers and the interaction between trade and FDI, although the estimated coefficients from the regressions are found to be insignificant, they still enter with the correct sign. Therefore growth accounting for these channels will also be carried out as it is still interesting to examine their contributions toward Real GDP per worker growth. Accordingly, for the specification with FDI, trade and tertiary education of workers I find that the total contributions of the channels of technology absorption is similar to the first specification without trade. The contribution of all three channels of technology absorption to output per worker growth is 48.72% + 25.66% - 24.82% = 49.56%.

In sum, when taking the two tables into account, I find that for the period of study, trade alone as a channel is better than trade interacted with FDI. This is because the coefficient of trade is found to be significant in the regressions. Moreover, for the specification with trade alone there is less of contribution to output per worker growth that is unexplained. Therefore, the results here suggest that trade is a better channel of technology absorption.

5.0 CONCLUSION

There are two main studies conducted in this paper. Firstly, the paper conducts a growth accounting exercise to find the contribution of multifactor productivity (MFP) to Real GDP per worker growth from 1961-2000. Multifactor productivity growth contributes about 33 percent to Real GDP per worker growth for the entire period. From 1961-1986, its contribution was negative, at -4.2 percent, while in the following 14 years – from 1987-2000, it grew rapidly and about 74 percent of Real GDP per worker growth was attributed to the growth in MFP.

Secondly, the paper then proceeds to explain the rapid growth of MFP and its great contribution to Real GDP per worker growth. Following Jones (2002) and Ho and Hoon (2009), an idea production function is constructed where the growth of MFP is theorized to depend on idea spillovers from research and development activities in the G5 nations through the channel of international trade. The idea production function in its discrete form is then log-linearized and an empirical study using annual data from 1980 – 2000 is carried out.

The method of OLS is used on the log- linearized idea production function with the log of change in multifactor productivity or stock of ideas as the dependent variable and the log of total research scientists and engineers, log of the stock of ideas and the log of trade as the independent variables. The results indicate that trade is a significant channel of idea spillovers from the G5 nations.

Next, regressions employing other possible channels of idea spillovers which are foreign direct investment and tertiary education of workers are conducted for robustness tests on trade. The outcome of the regressions show that trade still has a positive and significant effect on the change in the stock of ideas even when FDI and tertiary education of workers are controlled for. Incidentally, both of these channels are found to be insignificant.

Growth accounting for the idea transmission channels indicate that from 1980-2000, the contribution of multifactor productivity growth from the trade channel to Real GDP per worker growth is about 50 percent, while the sum of the contributions of physical and human capital to Real GDP per worker growth is approximately 48 percent.

Therefore, from the results of this study it can be concluded that the growth of multifactor productivity from idea spillovers occurs primarily through the channel of international trade from 1980-2000. Thus, the openness of Malaysia to international trade could have facilitated idea transfers from abroad and subsequently led to the rapid growth in multifactor productivity from 1987 – 2000.

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APPENDIX

Table 1: Results of other MFP Estimates for Malaysia

		Other MFP Estimates for Malaysia		
Author	**Period**	**Growth of Output per worker**	**Growth of MFP**	**Contribution to Output per worker growth**
Collins & Bosworth (1996)	1960-94	3.8	0.9	23.7
	1960-73	4.0	1.0	25.0
	1973-94	3.7	0.9	24.3
	1973-84	3.6	0.4	11.1
	1984-94	3.8	1.4	36.8
		Growth of GDP	**Growth of MFP**	**Contribution to GDP growth**
Raja Nazrin (2000)	1962-99	6.6	1.8	27.3
	1962-70	6.4	2.4	37.4
	1971-86	6.5	1.4	21.6
	1987-97	8.3	3.2	38.6
		Growth of Output per person	**Growth of MFP**	**Contribution to Output per person growth**
Sarel (1997)	1978-96	4.5	2.0	44.1
	1991-96	5.4	2.0	37.4
		Growth of GDP	**Growth of MFP**	**Contribution to GDP growth**
Tham (1995)	1971-75	6.7	-1.4	-0.21
	1976-80	8.5	0.3	0.03
	1981-87	4.6	-2.7	-0.58
	1971-87	6.3	-1.4	-0.23
		Growth of GDP	**Growth of MFP**	**Contribution to GDP growth**
6th and 7th Malaysia Plans	1991-95	9.5	2.5	25.9
	1996-00	4.7	1.2	24.8

Table 2: Imports by Commodity Section, 1960 - 2005

Imports by Commodity Section, 1960-2005, Malaysia
RM (Million)

Year	Food	Beverages and Tobacco	Crude materials, Inedible	Mineral Fuels, Lubricants, etc	Animal and Vegetable Oils and Fats	Chemicals	Manufactured Goods (includes tin)	Machinery and Transport Equipment	Misc. Manufactured Articles	Miscellaneous Transactions & Commodities	Total
1960	559.9	82.4	339.3	149.2	13.1	143.2	356.9	330.7	131.8	44.1	2,150.6
1965	749.6	123.5	237.7	388.5	18.2	233.9	597.6	728.6	206.3	72.3	3,356.2
1970	786.7	92.9	322.1	517.5	23.8	312.5	770.2	1,197.3	199.9	65.5	4,288.4
1975	1,401.5	119.4	554.9	1,021.1	26.0	711.8	1,389.4	2,774.1	465.3	66.9	8,530.4
1980	2,444.3	221.3	1,052.8	3,554.4	29.7	2,022.4	3,849.2	9,105.3	975.0	196.6	23,451.0
1985	3,064.0	228.9	1,035.8	3,722.0	80.6	2,639.8	4,419.0	13,262.1	1,673.8	311.9	30,437.8
1990	4,582.5	292.9	2,551.2	4,021.0	218.0	6,716.8	12,499.1	39,740.5	4,496.8	3,999.6	79,118.6
1995	7,884.7	558.2	4,651.2	4,351.0	380.1	13,759.2	26,956.6	116,722.1	9,508.4	9,573.2	194,344.5
2000	11,393.1	708.7	7,095.7	14,973.1	604.0	22,371.5	32,596.4	195,728.0	17,658.9	8,329.5	311,458.9
2005	17,780.2	1,463.3	10,496.3	34,938.2	2,094.6	33,895.6	47,964.0	248,767.5	22,601.5	12,869.7	432,870.8

Source: Economic Planning Unit, Malaysia

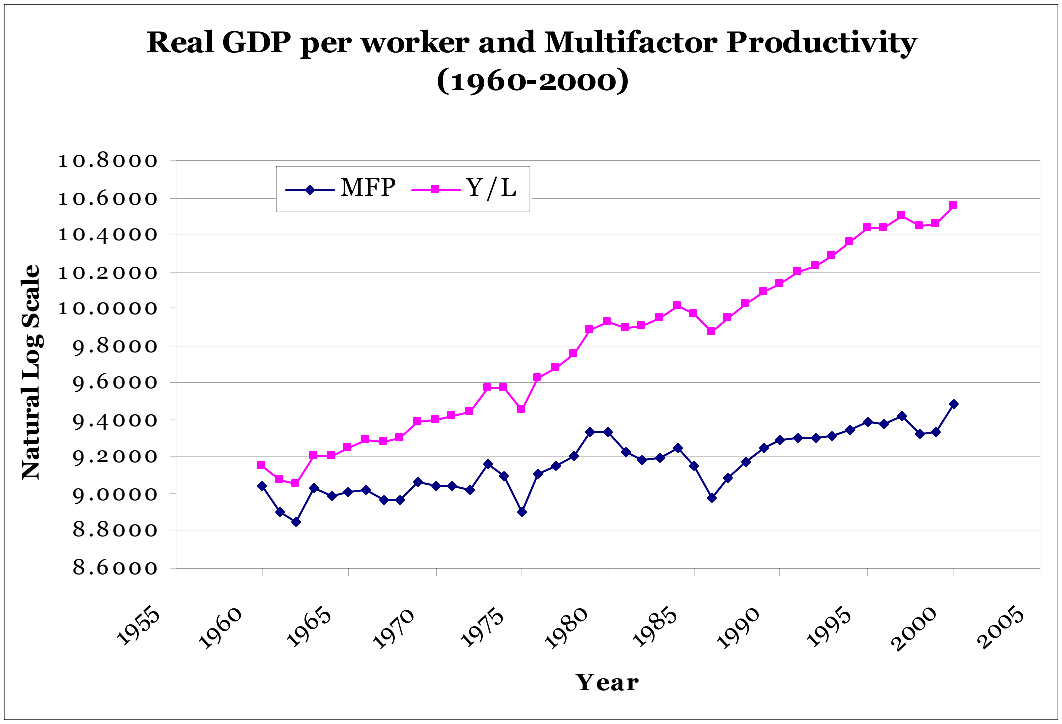
Table 3: Imports of Machinery and Transport Equipment from the G5 and NIE countries

Imports of Machinery and Transport Equipment

	TOTAL (RM Million)	G5 Countries	NIE Countries	G5+NIE Countries
1990	39,773.9	68%	22%	90%
1991	54,241.7	65%	24%	89%
1992	55,818.8	63%	26%	89%
1993	65,709.7	65%	25%	90%
1994	94,081.6	63%	24%	88%
1995	117,102.2	64%	23%	87%
1996	118,808.9	58%	26%	84%
1997	133,442.7	56%	26%	82%
1998	144,123.8	53%	29%	82%
1999	154,554.4	52%	29%	81%
2000	196,547.5	51%	28%	79%
2001	169,785.8	50%	25%	75%
2002	188,217.3	47%	27%	74%
2003	195,539.5	47%	25%	72%
2004	232,916.6	45%	25%	70%
2005	248,818.7	42%	8%	50%
2006	265,451.1	40%	28%	68%
2007	268,170.7	38%	28%	66%

Source: Department of Statistics, Malaysia

Figure 4: Real GDP per worker and Multifactor Productivity from 1960-2000



Source: Department of Statistics, Malaysia

Data Sources

Consumer Price Index (CPI)

Data on CPI was obtained from the Department of Statistics. CPI was only available from 1967 onwards; therefore CPI for years 1960-1966 is taken as equal to 1967's value. The year 2000 is the base year.

Educational Attainment

Data on average years of schooling for years 1980 – 2000 at five-year intervals are obtained from Barro and Lee (2000). The remaining years in between i.e. 1981-1984, 1991-1994 and so on are linearly interpolated. Data on average years of schooling is not available for years 2001 – 2007. Therefore, the time period of study has to be shortened to 1980 – 2000.

Labour Force and Employment

Data on labour force and employment for years 1960, 1965, 1970, 1975, and 1980 were obtained from the 1^{st}, 2^{nd} and 4^{th} Malaysia Plans, while data for years 1982-2007 were obtained from the Department of Statistics, Malaysia. The remaining years were linearly interpolated.

Construction of Capital Stock Series

Data on Gross Fixed Capital Formation (GFCF) and Changes in Stocks (CIS) from years 1960 – 2007 are obtained from the Department of Statistics, Malaysia. Gross investment is equal to the sum of GFCF and CIS. Since the figures are in current values, they are converted to their real values using the Consumer Price Index (CPI) at 2000=100.

The gross investment figures are flow values. Therefore, the capital stock series is constructed from gross investment following the perpetual inventory method.

To construct the capital stock series, I follow the method of Ho and Hoon (2006) which is stated in the following steps:

1. The growth rate of gross investment (*g*) is obtained from the regression of the natural logarithm of real gross investment on an intercept and trend term. The coefficient of the trend term is taken to be the growth rate of gross investment, which is 6.8 percent.

2. An initial capital stock figure is computed using the formula: $K(0) = \frac{I(0)(1+g)}{g+d}$,

where I is real gross investment (GFCF+CIS), g is the growth rate of real gross investment, and d is the depreciation rate of capital stock. Ho and Hoon (2006) compute the depreciation rate from data on the average service lives of several asset classes, i.e. Residential Buildings, Non-Residential Buildings, Other Construction and Works, Transport Equipment and Machinery and Equipment. In this paper, since data on average service lives of similar asset classes in Malaysia are not available, three separate capital stock series based on assumed depreciation rates of 5 percent, 10 percent and 15 percent are calculated and used later on.

3. Subsequent net real capital stock figures are computed using the following formula: $K(t) = (1-d)K(t-1) + I(t)$, where all are in real values.

4. This method for computing net real capital stock is based on Ho and Hoon (2006) who base their method on Park (1995, page 590) and Gong, Greiner and Semmler (2004, pages 158-159)

Foreign Direct Investment

Data on foreign direct investment is obtained from the Malaysian Industrial Development Authority (MIDA). The data series from MIDA only involves the manufacturing sector. In addition, it only involves FDI that has been approved by MIDA.

Tertiary Enrollment

Data on enrollment in tertiary institutions of education for the years 1980 to 2000 are obtained from the Statistics Department of Malaysia.

Trade

The data on trade is obtained from the World Development Indicators Database, where trade is defined as (Total Imports + Total Exports)/ GDP. Data on Imports of machinery and transports equipment are not available for years 1980-1990, and therefore are not included in the empirical study. Instead, data on trade would be used as a proxy.

Test for Unit Root (Augmented Dickey-Fuller Test)

λ *not fixed:*

The Augmented Dickey Fuller (ADF) test on the dependent variable $\Delta \ln B_{t+1}$ find that it is stationary up to the 5% critical level.

λ *fixed:*

The ADF tests on the dependent variable $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$ at all values of λ find that it is stationary up to the 5% critical level.

On the other hand, all the explanatory variables are found to have unit roots.

Tests for Optimum Number of Lags in Explanatory Variables

The Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Schwarz' Bayesian Information Criterion (SBIC), and the Hannan Quinn Information Criterion (HQIC) tests are conducted to find the appropriate number of lags for the explanatory variables.

λ not fixed:

For the specification with trade without interactions, FPE and SBIC suggest an appropriate lag order of 1 and AIC and HQIC suggest an appropriate lag order of 4. For the specification with trade and interaction with FDI, the suggestions for lag order are the same as above.

λ fixed:

The FPE, SBIC, AIC and HQIC tests all suggest an appropriate lag order of 1 for the regressions without interactions.

For the regressions with interactions, the FPE and SBIC suggest an appropriate lag order of 1 while the AIC and HQIC suggest and appropriate lag order of 4.

Due to the already short time period employed in the study (1980-2000), it is not possible to test the variables with very long lags hence further reducing the number of time periods involved. Therefore this study I shall just impose one lag on each of the explanatory variables.

Cointegration Tests (Johansen Cointegration Test)

The Johansen Tests are conducted using the Eviews Software. The results are presented as follows:

i) Five Variables - $\ln B_t$, $\ln E_t$, $\ln \tilde{H}_{At}$, $\ln\left(\frac{G5FDI_t}{K_t}\right)$ and $\ln Trade_t$

Johansen Cointegration Test

Date: 07/16/09 Time: 19:02
Sample: 1980 2000
Included observations: 19
Test assumption: Linear deterministic trend in the data
Series: LNA_33_D05 LNE LNHAT LNG5FDIK_05 LNTRADE
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.950989	111.4053	68.52	76.07	None **
0.753268	54.10696	47.21	54.46	At most 1 *
0.664948	27.51736	29.68	35.65	At most 2
0.290196	6.741458	15.41	20.04	At most 3
0.011974	0.228884	3.76	6.65	At most 4

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 2 cointegrating equation(s) at 5% significance level

The Johansen test is conducted on the explanatory variables for the specifications without interactions and with interactions. For the first specification seen in the table above, the trace statistic rejects the null hypothesis that there is no cointegration at the 1% significance level and rejects the null hypothesis that there is one cointegrating relation at the 5% significance level. However, it fails to reject the null hypotheses that there are two, three or four cointegrating relations. Therefore, we can conclude that there is a possibility that all the five explanatory variables are cointegrated.

ii) Four Variables - $\ln B_t$, $\ln E_t$, $\ln \widetilde{H}_{At}$ and $\ln\left(Trade_t \times \frac{G5FDI_t}{K_t}\right)$

Johansen Cointegration Test

Date: 07/16/09 Time: 20:45
Sample: 1980 2000
Included observations: 19
Test assumption: Linear deterministic trend in the data
Series: LNA_33_D05 LNE LNHAT LNG5FDI_05TRADE
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.783322	57.33012	47.21	54.46	None **
0.676538	28.27263	29.68	35.65	At most 1
0.285415	6.827827	15.41	20.04	At most 2
0.023037	0.442826	3.76	6.65	At most 3

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

The table above describes the results for the test on the second specification with interactions. The trace statistic rejects the null hypothesis that there is no cointegration. This is at the 1% significance level. However, it fails to reject the hypotheses that there is one, two or three cointegrating equations. Therefore, we can also conclude that the four explanatory variables are possibly cointegrated.

Since, the explanatory variables are cointegrated, the OLS regression can be performed because the estimators will be consistent and will have a normal distribution.

Test of Constancy of *g(A)*– (student t-test)

Depreciation Rate: 5 percent

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
ggA_d05	21	1.343313	1.860519	8.52597	-2.537662	5.224288

mean = mean(ggA_d05) t = 0.7220

Ho: mean = 0 degrees of freedom = 20

Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
Pr(T < t) = 0.7607	Pr(|T| > |t|) = 0.4786	Pr(T > t) = 0.2393

Depreciation rate: 10 percent

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
ggA_d10	21	-.0028369	.8838494	4.050307	-1.846515	1.840841

mean = mean(ggA_d10) t = -0.0032

Ho: mean = 0 degrees of freedom = 20

Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
Pr(T < t) = 0.4987	Pr(|T| > |t|) = 0.9975	Pr(T > t) = 0.5013

Depreciation Rate : 15 Percent

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
ggA_d15	21	-.3584357	.6820734	3.125653	-1.781216	1.064344

mean = mean(ggA_d15) t = -0.5255

Ho: mean = 0 degrees of freedom = 20

Ha: mean < 0	Ha: mean != 0	Ha: mean > 0
Pr(T < t) = 0.3025	Pr(|T| > |t|) = 0.6050	Pr(T > t) = 0.6975

The tests above are to check for constancy of $g(A)$ with α =0.33 and depreciation rate = 5 percent. The small t statistic 0.7220 and large p-value of 0.4786 for the test on $g(A)$ where the depreciation rate is 5 percent indicate that we cannot reject the null hypothesis that the mean of $g(gA\_d05)$ is 0. These results suggest that $g(A)$ is a constant.

In the case where depreciation rate is 10 percent, $g(A)$ can be inferred to be a constant, since the p-value is very large. This result also applies to the test on $g(g(A)$ where depreciation rate is 15 percent. Overall, it can be inferred that $g(A)$ is a constant.

Regression Result Tables

Below are the results of the econometric estimations using OLS. The standard errors are obtained from the OLS regression while ***, ** and * denote p-values at the 1%, 5% and 10% levels respectively. The depreciation rate for capital stock is 5 percent.

Regression Results and Growth Accounting : Trade

<u>Regression Results</u>
(***, ** and * denote p-values at the 1%, 5% and 10% significance levels respectively)

Table 4: With Trade Alone
Regressions:

1 When λ not set, Dependent variable: dlnBt_3305

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.9009	***0.2631	λ	-27.650
lnTrade	0.5476	**0.2360	γ	-0.314
$\ln H_{At}$	-0.2825	0.2468	ω	53.595
			Φ	-87.172

2 λ = 1 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.7001	***0.2038	γ	0.015
lnTrade	0.2899	***0.0927	ω	28.373
			Φ	-67.516

3 λ = 0.5 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.7036	***0.2036	γ	0.007
lnTrade	0.2943	***0.0925	ω	28.799
			Φ	-67.861

4 λ = 0.25 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.7053	***0.2034	γ	0.004
lnTrade	0.2964	***0.0925	ω	29.012
			Φ	-68.033

Table 5: Without Trade

1 λ not set, Dependent variable: $\Delta \ln B_{t+1}$

	Reg. Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.36	*0.19	λ	27.10
lnE	0.06	0.22	γ	0.77
ln(G5FDI/K)	-0.02	0.07	β	5.99
$\ln H_{At}$	0.28	0.72	η	-1.98
			Φ	-34.10

2 λ = 1 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.36	*0.18	γ	0.03
lnE	0.13	0.13	β	12.52
ln(G5FDI/K)	0.00	0.04	η	0.01
			Φ	-34.11

3 λ = 0.5 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.36	*0.18	γ	0.01
lnE	0.13	0.13	β	12.65
ln(G5FDI/K)	0.00	0.04	η	0.05
			Φ	-34.11

4 λ = 0.25 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.36	*0.18	γ	0.01
lnE	0.13	0.13	β	12.71
ln(G5FDI/K)	0.00	0.04	η	0.07
			Φ	-34.11

Table 6: With Trade, No Interactions

Regressions:

1 λ not set, Dependent variable: $\Delta \ln B_{t+1}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.92	**0.30	λ	14.96
lnE	-0.10	0.22	γ	0.17
Ln(G5FDI/K)	-0.04	0.07	β	-9.82
lnTrade	0.57	**0.26	η	-4.16
$\ln H_{At}$	0.15	0.74	ω	55.78
			Φ	-88.59

2 λ = 1 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.92	***0.29	γ	0.01
lnE	-0.07	0.14	β	-6.72
Ln(G5FDI/K)	-0.03	0.03	η	-3.02
lnTrade	0.58	**0.25	ω	56.52
			Φ	-89.10

3 λ = 0.5 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.92	***0.29	γ	0.01
lnE	-0.07	0.14	β	-6.61
Ln(G5FDI/K)	-0.03	0.03	η	-2.98
lnTrade	0.58	**0.25	ω	56.55
			Φ	-89.13

4 λ = 0.25 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.92	***0.29	γ	0.00
lnE	-0.07	0.14	β	-6.55
Ln(G5FDI/K)	-0.03	0.03	η	-2.96
lnTrade	0.58	**0.25	ω	56.57
			Φ	-89.14

Table 7: With Trade and Interactions

Regressions:

1 λ not set, Dependent variable: $\Delta \ln B_{t+1}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.38	*0.21	λ	2.85
lnE	0.09	0.23	γ	0.08
ln[(G5FDI/K)*Trade]	0.01	0.08	β	9.24
$\ln H_{At}$	0.03	0.84	ρ	0.63
			Φ	-36.64

2 λ = 1 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
lnBt	-0.39	*0.20	γ	0.03
lnE	0.10	0.14	β	9.63
ln[(G5FDI/K)*Trade]	0.01	0.03	ρ	0.79
			Φ	-36.74

3 λ = 0.5 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.39	*0.20	γ	0.01
lnE	0.10	0.14	β	9.74
ln[(G5FDI/K)*Trade]	0.01	0.03	ρ	0.82
			Φ	-36.78

4 λ = 0.25 Dependent variable: $\Delta \ln B_{t+1} - \lambda g_B \ln \tilde{H}_{At}$

	Reg Coeff	Std. Error	Parameters	Calculated Values
$\ln B_t$	-0.39	*0.20	γ	0.01
lnE	0.10	0.14	β	9.80
ln[(G5FDI/K)*Trade]	0.01	0.03	ρ	0.84
			Φ	-36.80

Formulas used in calculating parameters:

$$\lambda = \frac{Coeff.\ln H_{At}}{g(B)}$$

$$\phi = 1 - \left(\frac{\lambda}{\gamma}\right)$$

$$\rho = \frac{Coeff.\ln\left(Trade_t \times (G5FDI_t / K_t)\right)}{g(B)}$$

$$\omega = \frac{Coeff.\ln Trade}{g(B)}$$

$$\gamma = -\lambda \times \frac{g(B)}{Coeff.\ln B_t}$$

$$\eta = \frac{Coeff.\ln\left(G5FDI_t / K_t\right)}{g(B)}$$

$$\beta = \frac{Coeff.\ln E_t}{g(B)}$$

$$g(B) = 0.010218$$

Growth Accounting Tables

Table 8:
α= 1/3, d=0.05 , 1 Channel: Trade

Description	Variable	1980-2000 average	Percentage
Growth rate of real GDP per worker	$g(y)$	0.033847	100%
Capital Intensity Effect	$\frac{\alpha}{1-\alpha} g\left(\frac{K}{Y}\right)$	0.014227	42.03%
Educational Attainment Effect	$\psi \Delta lh$	0.002004	5.92%
G5 R&D Intensity Effect	$\gamma g(\tilde{l}_A)$	0.000286	0.85%
Scale Effect of Labor Force	$\gamma \tilde{n}$	0.000177	0.52%
Trade Effect	$\frac{\omega}{1-\phi} g(Trade)$	0.016958	50.10%
Unexplained			0.58%

Table 9:
α= 1/3, d=0.05 , Trade, FDI and Educational Attainment

Description	Variable	1980-2000 average	Percentage
Growth rate of real GDP per worker	$g(y)$	0.033847	100%
Capital Intensity Effect	$\frac{\alpha}{1-\alpha} g\left(\frac{K}{Y}\right)$	0.014227	42.03%
Educational Attainment Effect	$\psi \Delta lh$	0.002004	5.92%
G5 R&D Intensity Effect	$\gamma g(\tilde{l}_A)$	0.000520	1.54%
Scale Effect of Labor Force	$\gamma \tilde{n}$	0.000321	0.95%
Tertiary Enrollment to Employment Ratio learning effect	$\frac{\beta}{1-\phi} g(E)$	0.016492	48.72%
G5 FDI and Total Trade Transmission Effect	$\frac{\rho}{1-\phi} g\left(Trade \times \frac{G5FDI}{K}\right)$	0.008686	25.66%
Unexplained			-24.82%