Foreword

This thesis is the conclusion to my master degree in economics at NTNU. Writing the thesis has been a trying process that has included both revelation and frustration. It has been very educational and, although at times it has been extremely frustrating, looking back I have enjoyed the process.

I want to thank my thesis adviser Hildegunn E. Stokke, for helping me find a topic that I have found interesting throughout this process and, for invaluable guidance and input that has helped me shape my thesis. I would also like to thank, my parents for continues support and assistance throughout my academic endeavors and, Elli for countless pep talks and coffee breaks through what, at times, has felt like some of the longest months of my life.

All mistakes and are my own.

Trondheim, 29. May 2013.

Camilla Vedeler

Contents

1. Introduction

Economic growth and what creates it has always been of great interest to economists and policymakers alike. However, with the recent events; the global financial crisis and the following economic crisis, debate surrounding economic growth has increasingly become a part of the public domain. The world is increasingly becoming divided between the haves and the have-nots'. This is evident within nations but also between them. Africa and Sub-Saharan Africa in particular, holds some of the poorest nations on earth, but after the economic crisis it has become clear that these are countries with great potential for growth. The question then becomes; how is this growth potential best utilized so that countries that seem to be stagnating and struggling can reach their economic potential?

A significant factor for increasing economic growth is the total factor productivity (TFP). Both Solow (1957) and Easterly and Levine (2001) amongst others finds strong positive effects of total factor productivity (TFP) on gross domestic product (GDP). The increased awareness of the vulnerability of the global economic systems has increased the interest in attracting investments as investment is assumed to be one of the key components to economic growth (investment increases the capital stock which, along with labor, is one of the main factors in the standard production function). Investment from abroad and especially from more developed nations is coveted by developing countries, because in theory it is meant to bring with it certain positive externalities such as technological and organizational spillover effects (Findlay 1978). This means that foreign direct investment has the potential of increasing the productivity parameter as well as the capital stock.

Foreign Direct Investment (FDI) is often seen as a cure for economic backwardness. Developing nations and their policymakers will therefore go to great lengths to attract foreign investors. Africa is the continent that receives the least foreign direct investment. If the theory on foreign direct investment is reflected in empirics then Africa would greatly benefit from an increased inflow of foreign direct investment. In recent years the investment trend seems to be turning and Africa as a whole has improved its position as a recipient of the world's FDI flows (Blanke et al. 2011). This is great news for the growth trajectory of Africa if one is to believe theory.

South Africa is one of the major recipients of the FDI inflows to Africa, especially after the trade embargo ended in 1993/94. It is therefore interesting to see what impact if any FDI inflows have had on South Africa's total factor productivity. While the theory predicts a positive effect of FDI on TFP the empirical literature on the subject reveals no definitive answer, no consensus exists. The hypothesis of this study is that there is a positive and significant effect of FDI on TFP in South Africa over the period 1971-2011. The data revealed that there is correlation between the two, though significant results were only found after smoothing the data and the results were not robust. When controlling for the productivity level at the technological frontier the effect of FDI on TFP was no longer significant. What the analysis did show was that there are significant and robust effects of both the productivity level at the technological frontier and trade as a share of GDP on the TFP level and growth rate in South Africa. Potential reasons for the results are discussed at length in chapter 6.

In the paper, abbreviations for total factor productivity (TFP) and foreign direct investments (FDI) will be used throughout, a thorough understanding of the terms are therefore needed:

Total factor productivity (TFP) is the productivity that is not accounted for by capital and labor in the production function, the residual. Although claim that this is synonymous with technology, however this is not correct as the TFP accounts for technology as well as anything else that affects production but is not accounted for by the factors; capital and labor.[1]

Foreign direct investment (FDI) is, according to the United Nations Conference on Trade and development, Investment reflecting a long-term interest and relationship, made by an investor from one economy to an enterprise resident in a different economy. The investments involve both the initial transaction between the two entities and all succeeding transactions.[2]

[1] A thorough explanation of the concept of TFP and the method for finding it is presented in chapter 4.
[2] A complete explanation of FDI, as it is given by unctad.org, is found in appendix 6.

This thesis consists of seven chapters: The introduction is followed by chapter 2, where a short summary of growth theory and an extensive presentation of the theory of Findlay (1978) on how FDI affects TFP is presented. Chapter 3 presents the literature and former empirical studies on the effects of FDI on TFP and related subjects. Chapter 4 presents the method and the calculations for finding South Africa’s TFP and chapter 5 explains the econometric method and datasets specifications used in the regression analysis. The results of the regression analysis are presented and discussed in chapter 6 and a conclusion and suggestions for further research subject follow in chapter 7.

2. Theory

2.1 Growth theory

Economic growth and what creates it has been the cause of concern for economists through the ages. There are countless theories and papers devoted to the subject, the results and claims that have been the outcome of this are often varied and more or less a product of the time in which they were created. In recent times, and with all the economic unrest the world is experiencing, the question has become ever more important.

The two main branches of growth theory today are Neo-Classical/ exogenous growth and endogenous growth, their main focus being on what creates growth in production. In the short run, production growth depends on growth in the capital stock, labour force and productivity. This is given by the standard production function Y=F(K,L,A). However in the long run, production growth will depend on productivity growth as there will be decreasing returns to capital. In exogenous growth theory pioneered by Ramsey (1928), Solow (1956) and Swan (1956) it is claimed that the factors that create growth in the long run, namely productivity growth, are insusceptible to influence. On the other hand, endogenous growth theory explains growth as a product of investment in research-and-development and human capital and therefore growth is susceptible to e.g. governmental policies. Endogenous growth theory was largely developed by Arrow (1962), Romer (1986/1990) and Lucas (1988).

In between these theories we have so called hybrid theories. These theories explain economic growth through technology diffusion between countries; as a result of this diffusion there will be convergence between countries. Findlay (1978) is one of these theories; the theory explains how foreign direct investment affects technology diffusion which again affects productivity growth. Other theories that support the technology diffusion and convergence hypothesis are Nelson and Phelps (1966) and Benhabib and Spiegel (1994). However they focus specifically on the role of human capital and do not model the specific transmission mechanism of foreign technology as Findlay (1978) has done.

2.2 A Simple Dynamic Model

Findlay (1978) creates a simple dynamic model that captures some of the ways in which technology is transferred, especially focusing on the role of foreign direct investment (FDI). His theory is the main theory that the hypothesis of this paper is based on. Findlay (1978) developed his model by combining two ideas on how technology is spread, namely the convergence theory associated with Veblen (1915) and Greschenkron (1962) and the "contagion" idea formed by Arrow (1971).

The convergence theory is also often referred to as "the advantage of backwardness". This theory states that the greater the relative gap in development between a country and the technological frontier at the outset of a process of industrialization, the faster the country will be able to "catch up". The theory was supported and enhanced by Nelson and Phelps (1966).

The other idea is that the diffusion of technology can be considered as a parallel to the spread of contagious disease. This idea was formed (though not formally) by Arrow (1971). The idea is based on the fact that technical innovations are most effectively copied when there is personal contact between the technically advanced and those who wish to implement the technology. There are many historic examples of technology spreading in such a manner although in earlier times the technological diffusion was caused by the migration of individuals such as Dutch shipwrights to Sweden or Italian architects to Russia. Today this "contagion" is spread through large multinational corporations using FDI as their instrument. (Findlay 1978)

Findlay (1978) uses these two ideas as a base and builds a dynamic model around them. The Veblen-Greschenkron effect, or rather the advantage of backwardness, is found in the following way. Assume first that the world is divided into two regions, one advanced and the other backward. A(t) is an index for technological efficiency (TFP) in the advanced region so that

(2.1) $$A(t) = A_0 e^{nt}$$

The equation above states that the technological efficiency in advanced countries grows at a constant rate n. Letting B(t) be the corresponding technological efficiency level in the backward country the following equation can be formulated

(2.2) $$dB/dt = \lambda\left[A_0 e^{nt} - B(t)\right]$$

Equation (2.2) shows how the distance to the technology frontier will affect the change in technological efficiency in the backward region over time. Here λ is a positive constant dependent on exogenous variables such as the education of the labour force and the quality of management. (λ can be understood as a measure of how much the backward economy is able to soak up the new technology, e.g. a less educated workforce gives a smaller λ and so lessens the effect of FDI).

The advantage of backwardness can be shown graphically; figure 2.1 shows how the technology level in the backward economy converges towards the long term equilibrium technology gap. Here $\hat{B}$ is the backward country's technological growth rate and the curve is found by dividing both sides of equation (2.2) by B(t). (A thorough explanations of all the calculations made in this chapter are presented in appendix 1).

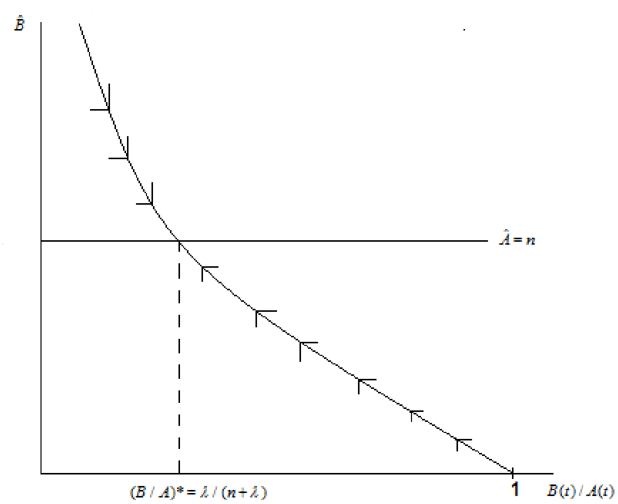

Figure 2.1: The advantage of backwardness

By integrating the differential equation (2.2) we get the following equation:

(2.3) $$B(t) = \frac{\lambda}{(n+\lambda)} A_0 e^{nt} + \frac{(n+\lambda)B_0 - \lambda A_0}{(n+\lambda)} e^{-\lambda t}$$

This equation gives the level of technological efficiency in the backward region. B_0 is the preliminary level of efficiency in the backward region. It can be seen that when time approaches infinity the efficiency in the two regions will approach an "equilibrium gap" $\lambda/(n+\lambda)$. This gap varies directly with λ and inversely with n. If the initial relative productivity (B_0/A_0) is less than the "equilibrium gap" there will be convergence in the model and the rate of technological progress in the backward region will exceed n but at a decreasing rate until the "equilibrium gap" is reached as seen in figure 2.1. (Findlay 1978)

The other idea that the model is built on, the contagion idea, goes to the very core of this thesis namely the idea that contact with "outside" firms will create technological progress. FDI investments create productivity growth. The levels of integration of foreign firms in the economy are measured by an index of the capital stock of foreign-owned (and managed) firms in the backward economy, to the capital stock of the domestically owned firms. By letting $K_f(t)$ and $K_d(t)$ be the capital stocks for foreign and domestic firms present in the backward region; and A(t) and B(t) the technical efficiency in the advanced and backward region; the following entities can thus be defined as;

$$x \equiv \frac{B(t)}{A(t)} \qquad\qquad y \equiv \frac{K_f(t)}{K_d(t)}$$

Here x represents the advantage of backwardness and y the "contagion" hypothesis. Combining these, we can assume the following equation:

(2.4) $$\dot{B}/B = f(x, y)$$

where

$$\partial f / \partial x < 0, \ \partial f / \partial y > 0$$

The sign of the effects of x and y on the technological growth rate, $\dot{B}/B$, can be explained in the following way: A high x means that the technology gap is low and this will slow technology growth in the backward country. Whereas a high y indicates a relatively high presence of foreign capital in the domestic economy and this will enhance technology growth.

Equation (2.4) gives the growth rate of the backwards economy which is dependent on both the technology gap and the contagion hypothesis. Findlay (1978) stressed that in interpreting (2.4) one must remember that technology diffusion is a function of many other factors as well. He lists as examples; education level of the domestic workforce, market structure, and laws and regulations within and surrounding the market. In defining function (2.4) all these other factors are held constant.

The model focuses on the dynamics of x and y so explicitly: how the technology gap and the contagion hypothesis influences the level of technology diffusion over time.

The motion of x is determined by equations (2.1) and (2.4). However to determine the motion of y, foreign and domestic capital need to be determined. Foreign direct investment does not just provide a pure transfer of capital but rather a combination of capital, management and technology that the host country can benefit from (Hymer 1960). However it is difficult to "unscramble" such a combination, so one approach, and the one Findlay (1978) chose to use, is to see foreign and domestic capital as distinct factors of production. Giving each factor its own separate rate of return, he labeled the rates of return of foreign and domestic capital ρ_f and ρ_d.

This means that the factor-price frontier curves for domestic and foreign capital can be separated thus making the analysis simpler. Drawing the factor-price frontier for domestic capital in the backwards region, one can see that the DD' curve represents the technological choices available to the domestic firms at the initial moment t_0. The factor frontier in figure 2.2, gives the maximum profit level in the domestic firms at a given technology level and for each possible level of the real wage rate. It is well established in economic theory that the slope of the price frontier is negative. (Findlay 1978)

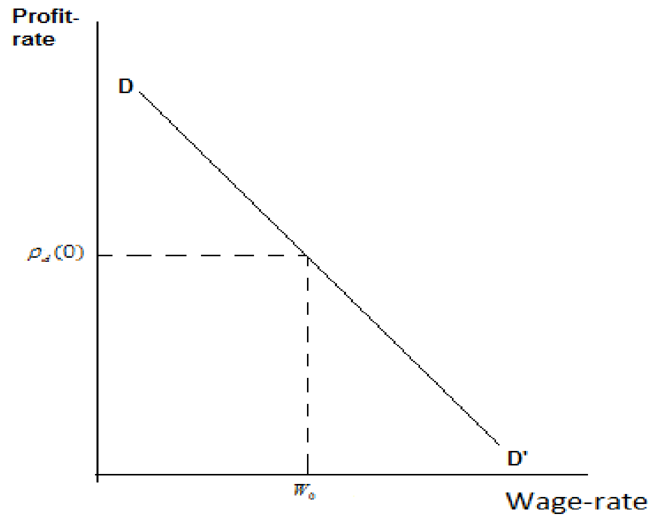

Figure 2.2 : Domestic Sector Price Frontier

In figure 2.2 the real wage at an initial moment in time w_0 is exogenously given, thus giving the profit rate ρ_d for the same period. The initial capital stock $K_d(0)$ determines the total level of output produced by the domestic sector at that time while the level of employment is determined by the wage rate w_0 and the capital stock $K_d(0)$. It is assumed that there is no scarcity in the labor supply.

Figure 2.3 shows the corresponding factor price frontier of the foreign investors. In Findlay (1978) it is assumed that $\rho f > \rho_d$, the return to foreign capital is greater than the return to domestic capital, and so the foreign price frontier is depicted further to the right in figure 2.3 than the domestic price frontier in figure 2.2 (This is not a necessary assumption and it need not always be so).

The wage the foreign investors pay workers is the common real wage plus a markup of α (α is a positive constant). The markup is paid mainly for the reasons of public relation and it is paid for the same "quality" of labor as in the domestic sector. The total output of the foreign investors is thus given by the capital stock $K_f(0)$ and the wage $(\alpha+1)w_0$. The corresponding profit rate is then $\rho_f(0)$.

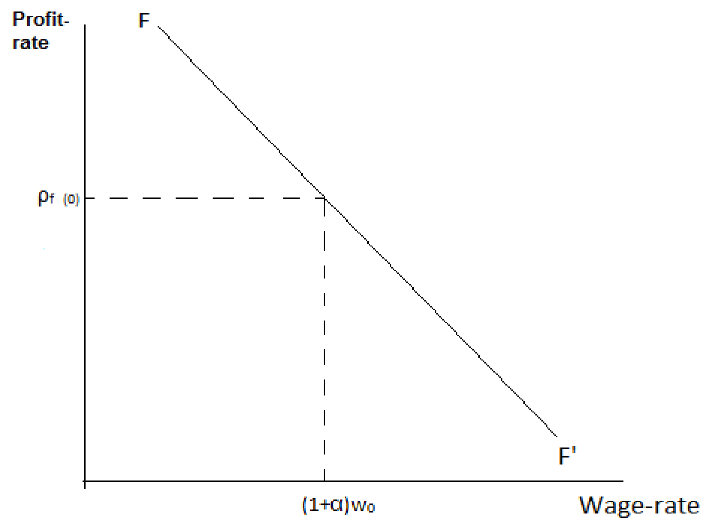

Figure 2.3 : Foreign Sector Factor Price Frontier

At any initial level of capital the foreign sectors factor price frontier FF', shifts to the right with the rate of n in accordance with Equation (2.1). This happens as explained above because it is assumed that the technology of the foreign sector grows exogenously with n. The Domestic sectors factor price frontier DD' will shift to the right at the rate $\dot{B}/B$ given by equation (2.4). The rate depends on the gap to the technological frontier (foreign economy), A(t)/B(t), and the contagion hypothesis, namely how much foreign to domestic capital there is in the economy, $K_f(t)/K_d(t)$. The initial values of all four are assumed given, but to understand the following motion the rate of change of $K_f(t)$ and $K_d(t)$ needs to be specified.

Findlay (1978) takes capital accumulation in the domestic sector to equal a fixed fraction, s, of the sum of the domestic sector's own profits $\rho_d(t)K_d(t)$ and the return from a proportional tax τ on foreign profits $\rho_f(t)K_f(t)$, (specified in appendix 1), thus giving the following equation:

(2.5) $$\frac{\dot{K}_d}{K_d} = s\rho_d(t) + s\tau\rho_f(t)\frac{K_f(t)}{K_d(t)}$$

Equation (2.5) gives the motion of the change in domestic capital over time, but for this motion to be determined both ρ_f and ρ_d need to be specified. It is assumed that $\rho_d(t)= \rho_d(0)$ for all t. This is because it is assumed that in the domestic sector the rate of change in the wage rate is equal to the rate of change in productivity for that sector, given by equation (2.4). And as DD' moves to the right in figure 2.2 so the wage rate follows, giving a constant profit rate of $\rho_d(t) = \rho_d(0) = \bar{\rho}_d$. The assumption that the wage rate grows at the same rate as the productivity makes the first term on the right of equation (2.5) a constant.

From figure 2.3 it is apparent that the profit of foreign firms is a function of A(t) and the wage rate (α+1)w(t), and as just shown, the wage rate is a function of B(t). So explicitly the profit of foreign firms $\rho_f(t)$ depends on A(t) and B(t). This leads to the restrictive hypothesis

(2.6) $$\rho_f(t) = R\left[B(t)/A(t)\right] \qquad \text{with } R' < 0$$

This equation is homogeneous of degree zero in A(t) and B(t). If A(t) and B(t) grow proportionally then $\rho_f(t)$ will remain the same. However if the wage rate increases faster than the FF' in figure 2.3 this means that the B(t)/A(t) will rise and it follows that $\rho_f(t)$ falls so that R'<0. This makes the growth rate of the domestic capital stock a decreasing function of "the advantage of backwardness" effect, B(t)/A(t), and an increasing function of the relative presence of foreign capital, $K_f(t)/K_d(t)$. (Findlay 1978)

Assuming that a constant fraction r of after tax profits is attained by the foreign companies for investing, the growth rate of the foreign sector's capital stock is assumed proportional to net received profits, giving the following

(2.7) $$\frac{\dot{K}_f}{K_f} = r(1-\tau)\rho_f(t)$$

A dynamic model can now be expressed building on the equations presented above.

(2.8) $$\dot{x} = \phi(x, y)$$

(2.9) $$\dot{y} = \psi(x, y)$$

Equation (2.10) is found by differentiating x with respect to time

(2.10) $$\dot{x} = B/A\left[(\dot{B}/B) - (\dot{A}/A)\right],$$

As a result of (2.10) and because $\dot{A}/A = n$ all combinations of x and y where the growth in the backward country equals the growth at the front, $\dot{B}/B = n$, will yield a constant relative productivity, $\dot{x} = 0$. This can be seen in figure 2.4 and is given by the positively sloped line TT.

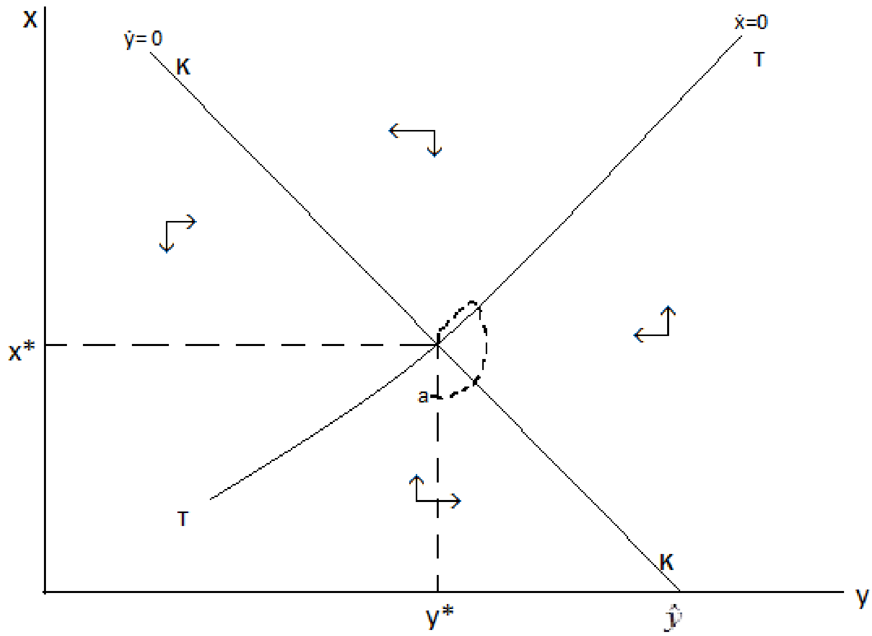

Figure 2.4: Phase Diagram

The technological growth rate $\dot{B}/B$ is a decreasing function of x and an increasing function of y, given by (2.4), and so $\dot{x} < 0$ above TT and $\dot{x} > 0$ below the TT as a result of

$$\partial \dot{x} / \partial x < 0, \; \partial \dot{x} / \partial y > 0$$

When figuring out the y dynamics an equation for ẏ is needed, this is found by differentiating y with respect to time.

(2.11) $$\dot{y} = K_f / K_d \left[(\dot{K}_f / K_f) - (\dot{K}_d / K_d) \right]$$

This means that $\dot{y} = 0$ whenever the growth rate of the capital stock is the same in both foreign and domestic sectors. Equations (2.5), (2.6) and (2.7) give the following equation as the required condition for $\dot{y} = 0$

(2.12) $$\rho_f = R(x) = \frac{s\bar{\rho}_d}{r(1-\tau) - s\tau y}$$

From equation (2.12) it can be seen that for each value of x there is an associated ρ_f and so consequently a y value so that the equation becomes balanced. The denominator of (2.12) is always positive because of R(x)>0 and $s\bar{\rho}_d$ >0, since R'(x) <0, an increase in y is always followed by a decrease in x for $\dot{y} = 0$ to hold. If it is assumed that as ρ_f is restricted by a maximum profit rate, then y will also be restricted by a value $\hat{y}$. This can be seen in figure 2.4. The KK curve is downward sloping and cuts the y axis at $\hat{y}$. By inserting (2.12) into (2.11) and differentiating with respect to y and x it can be seen that:

(2.13) $$\left.\frac{\partial \dot{y}}{\partial y}\right|_{\dot{y}=0} = -s\tau\rho_f y < 0$$

(2.14) $$\left.\frac{\partial \dot{y}}{\partial x}\right|_{\dot{y}=0} = \left[r(1-\tau) - s\tau y\right] R'(x) y < 0$$

This means that when there is an increase in y, meaning that the relative presences of foreign firms in the economy has increased, there will be an equal increase in the domestic sector's tax revenues. Hence savings increases making the domestic capital stock grow faster, while the foreign capital stock remains unchanged, leading again to a fall in y. With an increase in x, the domestic sector has become relatively more developed decreasing the distance to the technological frontier, which will reduce the profit rate of foreign capital and thus its growth rate. This again will reduce the domestic capital growth as the tax revenue on foreign capital is lessened. However the foreign capital's growth rate declines more as a result of the fact that the denominator in (2.12) has to remain positive and so the coefficient R'(x) in (2.14) is positive and y falls. So at any point to the left of the KK line in figure 2.4, y must increase, whereas at any point to the right of the KK, y must decrease.

The intersection of the curves $\dot{x} = 0$ and $\dot{y} = 0$ gives the long run steady values x^* and y^*, that is the domestic to foreign technological efficiency and foreign to domestic capital stability. In the phase diagram figure 2.4, stability is assured by the fact that (2.13) and (2.14) are both negative and so the trace condition is satisfied, while the determination condition is also satisfied as seen in equation (2.15)

(2.15) $$\left\{\frac{\partial\dot{x}}{\partial x}\frac{\partial\dot{y}}{\partial y}-\frac{\partial\dot{y}}{\partial x}\frac{\partial\dot{x}}{\partial y}\right\}>0$$

In figure 2.4 starting out in point a the economy lies beneath both the TT and the KK curve. This implies that the level of backwardness is high, which means that the domestic technical change will grow faster than foreign technical change, $\frac{\dot{B}}{B}>n$, making x increase. When the economy lies below the KK curve then the relative presence of foreign investment is low, meaning that the growth rate of the capital stock in the foreign sector is greater than for the domestic sector and so y will increase until KK is reached. At this point the growth rate of the foreign capital stock will equal the growth rate of the domestic capital stock and the accumulation of tax revenues. Once KK is crossed then y will begin to fall because K_d increases more than K_f. x is still increasing because the TT curve is not crossed. When the TT curve is crossed then the x will begin to fall because the domestic technical growth rate is now smaller than the foreign technical growth rate, $\frac{\dot{B}}{B}<n$. y is still falling as a result of the diminished tax revenue due to the fall in relative foreign investment. This leads to the equilibrium point (x*,y*) where both the domestic and foreign technical growth rates and capital growth rate are equal and stable.

2.3 Critiquing the model

The hypothesis that Findlay (1978) wishes to answer with the model is as follows " Other things being equal, the rate of change of technical efficiency in the backward region is an increasing function of the relative extent to which the activities of foreign firms with their superior technology pervade the local economy." (Findlay 1978) He finds that when using his model his hypothesis holds.

The model is highly simplified and gives no explanation as to what drives self-innovation or how a country that started out relatively less well-off can reach and thus become the technological frontier. (There are numerous historical examples of this, e.g. how Japan copied the US car industry and later overtook the efficiency gap to become the new “car-manufacturing-frontier”). Findlay (1978) also disregards all other influences that other economists have said to be of great importance to productivity growth and sums them up in one positive constant, λ. An example of this is the educational level. Findlay (1978) admits that the educational level plays a part but that in this model it is exogenous and only affects the productivity level through the level of λ. Another drawback of the model is that it does not take into account any investment cost that foreign investors may encounter. In real life cost of investment and risk are major factors in investment decisions and these factors may lead to underinvestment compared to the model predictions. Though these are obvious drawbacks of the model, the model is still a good starting point for this thesis as its main focus is how foreign direct investments have influenced the productivity growth of South Africa over the last 40 years.

Findlay (1978) predicts that foreign direct investment has a direct impact on productivity growth dependent on the recipient's distance from the technological frontier and the amount of presence of foreign firms, the relative “contagion” of FDI. Using this as a starting point the following hypothesis can be formed for the effect that FDI has had on total factor productivity growth in South Africa. Because of South Africa’s “troubled” past, the Apartheid regime and the following trade sanctions and restrictions enforced on the country, it is not a stretch to assume that FDI was low in this period. This paper will therefore try to answer the following question:

What effect has foreign direct investment had on the total factor productivity growth of South Africa over the last 40 years?

With the underlying hypothesis that:

-TFP growth has increased after the trade sanctions were lifted in 1993

-FDI has increased after the trade sanctions were lifted in 1993

-FDI has had a positive significant effect on TFP growth in South Africa over the last 40 years.

3. Previous Empirical Research

South Africa's economic history is the perfect example of how closely economics, policy and politics are interlinked. Today South Africa is a democratic middle-income, developing country. Still, it was only in 1994 that universal adult suffrage was introduced at the general election which resulted in a change of regimes from the pro-apartheid party The National Party headed by F.W. de Klerk to the National African Congress headed by Nelson Mandela. Before the election the segregation of the apartheid regime ruled, and the black majority had little-to-no economic or legal rights. The fundamental transformation into a democratic state, along with the lifting of the trade embargo placed on South Africa, as political sanctions against the apartheid regime, have considerably influenced economic development and productivity performance since then (McCarthy, 2005). So what exactly has led to the growth in South Africa? Has it been factor driven or is it driven by efficiency gain measured by total factor productivity (TFP)?

How has FDI influenced the development in productivity performance? South Africa is one of the biggest receivers of FDI in Africa. (Blanke et. al. 2011) In fact South Africa accounted for 36% of FDI inflow to Africa from 2000-2002 (Asiedu 2005). FDI to Africa has increased over the last decade and governments view it as an important source of productivity and economic growth. Still Africa is lagging behind other developing nations when it comes to attracting FDI, although this is a trend that, according to the world economic forum, is turning (Blanke et.al. 2011). Hence empirical research on how FDI has affected TFP is becoming increasingly more relevant when answering the question; what affects TFP growth in developing countries.

A considerable number of the previous empirical research work, that has been conducted on foreign direct investment and growth, has investigated the effect FDI has on GDP growth. This paper's focus is on the effect that FDI has on TFP growth and so the papers trying to account for GDP growth will have to be interpreted with caution as their results cannot be equated to an analysis on TFP growth. However there is an established relationship between TFP growth and GDP growth in the literature. The results in the articles estimating FDI effects on GDP growth can therefore give an indication as to what the relationship between FDI and TFP growth will be. Solow (1957) found that a large part of the GDP growth in the US was due to TFP growth (Acemoglu 2009) Easterly and Levine (2001) support this finding with results that show that cross-country difference in TFP growth account for more than 60 percent of output growth. And Rattsø and Stokke (2012) found in their analysis of South Africa for 1960-2005 that, as a result of the increased openness that South Africa experienced after the trade embargo ended, as much as 60 percent of the growth in GDP, due to increased openness, was a result of increased productivity. The empirical literature presented here therefore both consists of analysis of the effects of FDI on TFP and on GDP.

When looking at Findlay (1978)'s dynamic model there is a clear expectation that FDI should have positive effects on TFP growth and economic growth. This is also the general understanding of policymakers and politicians (Blanke et.al. 2011). However the empirical literature presents no general consensus on the effect that FDI has on growth. A review of the empirical literature by Contessi and Weinberger (2009) discusses that the reason for this might be because studies based on aggregate data using growth regression are poorly adapted to finding the growth effect of FDI because of methodological problems, such as endogeneity issues.

There is a divide between the papers that find a significant positive result and those that find insignificant results both positive and negative. The results vary greatly depending on the method and type of data used. However what seems to be the takeaway from a great deal of the studies is that the effects of FDI operate through many different channels and the more these channels can be isolated the greater is the likelihood that the real effect of FDI on both TFP and GDP growth is found.

3.1 South Africa, economic and productivity growth

Evidence from different sources shows that economic growth to a large extent is driven by TFP growth (Acemoglu 2009)(Easterly, Levine 2001). However Fedderke and Simkins, (2009) find that this is not evident for developing countries which often display a heavy reliance on capital growth which switches to a reliance on TFP growth as the GDP per capita increases.

Fedderke and Simkins (2009) found using the method of growth accounting, that South Africa follows the pattern of other developing nations. The growth in the 1970's and 1980's was highly dependent on capital and labor inputs and not on TFP growth. Whereas in the 1990's growth was driven by the TFP growth and the contributions of the other inputs were relatively weak. In fact they found that the contribution of growth in the labor force input to GDP growth was negative and the contribution of the growth in the capital input to GDP growth was relatively weak.

A similar but different result was found by Arora (2005). He analyzed data that span from 1980-2003 and found that there was an increase in real GDP growth after 1994 and that this increase was due to an increase in the TFP growth rate, which increased from an average of -0,4% for 1980-94 to an average 1,3% for 1995-2003. He also found that formal employment declined between 1995 and 2003 but that this was more than offset by an increase in informal employment. He concluded that the increase in TFP growth reflects in part policy and institutional change (Arora, 2005). Thus, amongst other things, the more open economy that emerged after 1994 has greatly benefitted the economic and TFP growth of South Africa. This is supported by Rattsø and Stokke (2012) who find that a more open economy reduces the cost of technology adoption and lead to a higher degree of technological catch-up. One of the way in which a more open economy can increase TFP is through contact with other firms. Findlay (1978) refers to it as the contagion hypothesis, namely FDI. When the trade embargo against South Africa was lifted in 1993 (The Peterson Institute for International Economics 2008) this created opportunities for foreign companies to invest. It can be seen in the data presented later in this paper that the size of the FDI inflows increased after 1993/1994. The increase in FDI inflows has not been as large as many policymakers had hoped and even though South Africa is one of the great recipients of FDI in Africa, she is still lagging behind counties with similar developmental profiles in Asia and South America (Blanke et.al. 2011) (Athanasios,2005).

In their study of the growth impact of FDI in South Africa from 1956-2003 Fedderke and Romm (2005) found that there was a significant positive effect, and while there was a short term crowd-out effect of domestic investment in the long run there was clear positive spillover effect from FDI to domestic capital and labor. Another factor that may have affected the TFP growth in South Africa is the distance to the technology frontier. The theory of how this affects the productivity growth was presented in the previous chapter but empirical evidence has been presented by Harding and Rattsø (2009). Using the US as the measure of the technological frontier they show that industrial performance in South Africa is related to the world technological frontier though they do not find that the industries are catching up. Not including the technological frontier as a control variable in this study can thus lead to a serious omitted variable problem.

3.2 Empirical research on the link between FDI and GDP growth

The research on how FDI affect GDP is much more extensive than the research on how FDI affect TFP although as mentioned both topics are troubled by methodical difficulties and no general consensus exists. In Massoud (2008) this lack of general consensus is explained by a claim that FDI sectorial distribution impact growth differently. When the data is aggregated sectorial differences in the absorption of FDI spillover e.g. in manufacturing and agriculture, may have contradicting effects and so can cancel each other out creating a wrong interpretation of the aggregated growth effect of FDI. Massoud (2008) found positive effect on growth when FDI was directed at the manufacturing sector and a negative effect when FDI was directed at the agricultural sector. Alfaro and Charlton (2007) trying to account for the same problem used a different approach, distinguishing between different "qualities" of FDI and using industry level dataset of 29 counties they found that FDI on the industry level was associated with higher growth.

Borensztein, De Gregorio and Lee (1998) however, using data on 69 developing countries over two decades found that FDI had a crowding in effect on domestic capital but that the effect on growth was dependent on a certain level of human capital. "The contribution of FDI to economic growth comprises of two effects. First, FDI increases the overall level of investment, attracting higher levels of domestic investment. This effect is not enhanced by the interaction of human capital. And second, FDI is more productive than domestic investment, a result that does depend on the interaction with human capital" (Borensztein, De Gregorio and Lee 1998). Alfaro et al. (2004) also found that the effect of FDI was dependent on other variables but they found that it was dependent on the developmental state of counties' financial markets.

3.3 Empirical research on the link between FDI and TFP growth

Though most of the former empirical research on FDI has concentrated on the effect it has on economic growth, recently there has been an increasing interest in the effect it has on TFP growth. As the importance of TFP growth for economic growth has become increasingly apparent so has the interest in understanding what increases TFP growth. "In order to understand the growth of nations, it is important to develop a better understanding of the forces that shape TFP" (Woo 2009).

In his cross country study using a large sample of countries over the period 1970-2000 Woo (2009) found that FDI had a positive and direct effect on TFP growth. What he also found was that there was no evidence that the impact of FDI on TFP was dependent on other factors such as education. This goes against parts of the previously reviewed literature from Borensztein, Gregorio and Lee (1998) and Alfaro et al. (2004). It is an interesting finding as it suggests that FDI will gain any recipient country no matter their developmental state.

Akinolo (2006) also finds a small but significant effect of FDI on TFP. Other findings are not so clear cut, Senbeta (2009) analyses a sample of 22 Sub-Saharan African countries over the period 1965-2000 using aggregate data on TFP and net FDI inflows. The results obtained when running both a static and a dynamic model was that FDI had positive effects on TFP in the long run and a negative effect in the short run; similar results were found by Lui (2006).

Ng (2007) found only a weak positive effect of FDI on TFP in two of the fourteen Sub-Saharan African counties used in his study, and for the other countries he found no effect. Because of the nature of the data he used, he was able to decompose the TFP value into two components: efficiency change and technical change. According to Ng (2007) FDI, in the cases where there is an effect, this will lead to the transfer of “soft” knowledge such as managerial and organizational skills as opposed to “hard” knowledge namely technology.

De Mello (1999) found, using both time series and panel data on a selection of OECD and non OECD countries, that a positive effect on productivity was dependent on the degree of complementary and substitution between FDI and domestic investment. Whereas Roy (2008) shows that the distance to the technology frontier is an important factor when it comes to a county’s ability to take advantage of FDI. He finds that there is a positive and significant effect of FDI on TFP but the effect is diminishing the further the country is from the technological frontier.

3.4 Firm level, through what channels does FDI affect TFP?

To see directly how the industry, and what industries, benefit from FDI one would need to use firm-level data. This goes beyond the scope of this paper but it is useful to understand what lies underneath the aggregate data in order to interpret it correctly and with caution. When it comes to the direction of FDI spillovers three main channels have been identified: horizontal intra-industry economic linkage and backward and forward vertical inter-industry linkages. Inter-industry refers to the link between suppliers and buyers whereas intra-industry refers to the relationship between domestic and foreign controlled firms in the same industry (Wang 2010). Wang (2010) investigated the effect that FDI has had on the productivity growth in Canada though both intra-industry and backwards and forward inter-industry linkages. She finds significant effects of FDI on industries’ productivity through the inter-industry channel both backwards and forwards. Research papers looking at developing or transition economies often find positive spillover only through backward linkages. Javorcik (2004) using firm level data from Lithuania, found that positive spillover effects from FDI could be measured in backward linkage from foreign affiliates to their local suppliers.

A meta-analysis by Bedi and Mebratie (2011) found three interesting points which had bearing on their analysis and to some extent on this paper. The first finding was that studies relying on cross- section data are more prone to finding significant spillover effects from FDI compared to studies that rely on firm-level panel data. This is because firm-level panel data gives the opportunity to control for firm specific fixed effects such as productivity. Secondly the results are not sensitive to the choice of dependent variables, be it labor productivity, total factor productivity or output. And third, it is more likely that studies will report significant results if FDI is measured as share of capital as opposed to a share of output or employment. The findings from their meta-analysis correspond well with the results of their regression analysis. Bedi and Mebratie (2011) analyzed South African manufacturing firms, using data from two periods 2003 and 2007. The analysis revealed no spillover effect of FDI on the labor productivity of domestic firms. The authors conclude that this can be attributed to the fact that foreign firms do not seem to have superior productive knowledge compared to their domestic affiliates and counterparts.

With some of the previous empirical research now rewired how does this affect the hypothesis presented in the previous chapter? Though Findlay (1978)'s theory leaves little room for speculation that there is a clear positive effect of FDI on TFP, the empirical studies create doubt. The results are mixed, however a majority of the papers reviewed find positive effects, especially when looking at the papers that are considering TFP growth specifically.

The empirical research is a sobering reminder that theory usually works best on paper. Still a slight majority of the finding in the literature reviewed above reveals a positive effect. Hence the hypothesis that FDI have had a positive effect on South Africa's TFP over the last 40 years is plausible.

4. TFP Growth Rate: The Method and Analysis

The TFP growth rate, or the Solow residual as it is also called, is the residual growth in production when growth in the capital and labor inputs have been accounted for. A common misconception of the term is that it is synonymous with technological growth (Hulten 2001). However it should rather be understood as the shift in the production function when the inputs, capital and labor, are held constant. Hence the TFP growth rate accounts for any factor other than capital and labor that affect GDP growth.

Though well established in economic theory, the concept of TFP growth is still disputed. Abramovitz (1956) renamed the term “the measure of our ignorance”. After all, the TFP growth rate is the residual growth when the growth of inputs has been accounted for and can thus include a number of variables that affect growth. Technical and organizational innovation being amongst them but also measurement error, omitted variables, aggregation biased and model misspecification (Hulten 2001). In order to estimate how, and to what extent, FDI inflows to South Africa have affected the TFP growth rate, the TFP growth rate first has to be found.

4.1 Growth Accounting, the Method

To calculate the TFP growth rate, Solow (1957) used the aggregate production function $Y(t) = F(K(t), L(t), A(t))$ but with a Hicksian neutral shift parameter and constant returns to scale as in (4.1)

(4.1) $$Y(t) = A(t)F(K(t), L(t))$$

The Hicksian A measures a shift in the production function when the inputs, capital and labor, are held constant. Equation (4.1) can be differentiated with respect to time. Dropping the time dependence and denoting the partial derivatives by F_K and F_L gives the following equation

(4.2) $$\frac{\dot{Y}}{Y} = \frac{F_K K}{Y}\frac{\dot{K}}{K} + \frac{F_L L}{Y}\frac{\dot{L}}{L} + \frac{\dot{A}}{A}$$

Denoting the growth rates of the output, capital stock and labor by g, g_K and g_L gives equation (4.3) where F_K and F_L, the partial derivatives of the factors, represent the output elasticity of each of the inputs.

(4.3) $$g = \frac{\dot{A}}{A} + \frac{F_K K}{Y} g_K + \frac{F_L L}{Y} g_L$$

The growth rate of capital and labor represents the movement along the production curve whereas $\frac{\dot{A}}{A}$ represents a shift in the production curve brought about by a change in the TFP. (Hulten 2001)

In reality the output elasticity of each input is hard to come by and they depend on many different things. To simplify, here it is assumed that the market offers the condition of perfect competition. Thus, the marginal product of labor will equal the wage paid to the worker and the marginal product of capital will equal the rents to the capital owner ($F_L \equiv w$, $F_K \equiv r$). The former equation can then be rewritten by defining

$$\alpha_K = r\frac{K}{Y}$$

$$\alpha_L = w\frac{L}{Y}$$

This gives the growth accounting equation (4.4) where $\frac{\dot{A}}{A}$ is the TFP growth rate.

(4.4) $$\frac{\dot{A}}{A} = g - \alpha_K g_K - \alpha_L g_L$$

This equation is used to calculate the TFP growth rate given data on labor force growth, factor shares, capital stock growth and output growth (Acemoglu 2009).

Equation (4.4) presents a "world" where inputs are paid their marginal values and there are constant returns to scale, "then the value of output equals the sum of the input values. This "product exhaustion" follows from Euler's Theorem and implies that the value shares, α_K and α_L

equal to 1." (Hulten 2001) It is then possible to calculate the TFP growth rate knowing only one of the marginal factor products.

There are some drawbacks to calculating the TFP in this way: the first is that it only considers the quantitative changes in the factors and more or less ignores the qualitative changes. Qualitative changes in the labor force can be the combination of age, gender and education level and for capital it can be the length in which the capital is in use. Not measuring for change in the qualitative changes can result in under or over valuing the TFP growth rate (Barro 1998).

Another issue that has been raised with the method is that it is dependent on the assumption of marginal cost pricing. This means that there has to be perfect competition for the method to hold. In reality the market form is likely to lie somewhere in between perfect competition and monopoly. Imperfect competition can give a biased estimate of the TFP growth rate. There is also the issue of measuring technical or rather the TFP change as one variable. Changes in TFP may affect the factors differently and so it may be prudent to separate the term into two different terms one for each factor. This is referred to in the literature as the "factor augmentation" formulation of technology. In the productivity function below the a and b stand for the separated effects that productivity has on the factors capital and labor.

$$Y_t = F(a_t K_t, b_t L_t)$$

Still this approach is not without its flaws, because productivity growth depends on income share as well as technical innovation. And so a change in income share can have an effect on the TFP without there having been any technical change. This reinforces the importance of separating the terms productivity growth and technical change. (Hulten 2001)

4.2 Finding the TFP growth rate

To find the TFP growth rate data on fixed capital stock, the labor force and GDP growth is needed. Capital growth was found using data on fixed capital stock in constant 2000 prices (Rand). The data was obtained from Quantec.co.za in a series that spanned from 1970-2008. The remaining years were calculated using data on gross fixed capital formation (constant 2000 prices Rand) for the entire period 1970-2011. The equation used for this was $K_t = K_{t-1} + I_t - (K_{t-1} * \delta)$, where K is the fixed capital stock, I the gross fixed formation and δ the depreciation rate. The depreciation was found by separating for the effect of δ for the overlapping values of the fixed capital stock and the gross fixed capital formation from 1971- 2008. The average deprecation for 2004-2008, 6,77% was used as the depreciation rate. This gave the entire series of fixed capital stock 1970-2011 and the capital growth rate for 1971-2011 was calculated.

As data on the size of the labor force was only obtained for the years 1990-2010, two different datasets will be presented. Dataset 1 that uses data on the labor force for the period 1991-2010 and dataset 2 substituting the labor force growth with population growth from 1971-2011. The data series on the labor force and the population size were obtained from worldbank.org and their growth rates were calculated.

Data on GDP in constant 2005 Rand was also obtained from worldbank.org and the growth rate was calculated. Using the two data sets created, the annual TFP growth rate can be found using two different methods. It can be calculated by either using factor shares from the national account, or with estimated factor shares found using the OLS regression method.

To calculate the TFP growth rate using data form the national account a Cobb-Douglas productivity function is needed. The assumption of perfect competition is still valid and the factors are therefore paid their marginal production value w and r. The assumption of constant returns to scale also holds but it is not a required assumption. This means that the weight of the factors will sum to one.

$$Y = AL^{\alpha_L}K^{1-\alpha_L}$$

The α_L can be found using data from the national account. Data on compensation of employees in current Rand was divided by BNP in current Rand for the corresponding year (the data was retrieved from treasury.gov.za, Quantec.co.za and worldbank.org).The factor share of labor was used to find the capital factor share $\alpha_K = 1 - \alpha_L$. After calculating the weight of the factors, then the growth rates of capital, labor force and BNP were needed. Using equation (4.4) the TFP growth rate for each year was calculated. The calculations were done on both data sets.

In table 4.1 it can be seen that the average annual TFP growth rate for the two data sets differ, varying from 0,06% for dataset 2 (1971-2011) to 0,22% for dataset 1 (1991-2011). However these numbers are not comparable as they are the measurements of very different timespans. The annual average of dataset 2 for the corresponding dataset 1 timeframe (1991-2010) was then calculated, giving an annual average TFP growth rate of 0,74%. When comparing and interpreting these averages it looks as if the annual average TFP growth rates of dataset 2 is overvalued compared to the more accurate dataset 1. However, when one compares year by year calculations it becomes clear that the population growth rate is not a bad substitute for labor force growth rate. The average factor ratios were also calculated for both data sets. The average factor distribution for 1971-2011, seen in row 2, was 50/50, whereas for 1991-2010 the average was 53/47. This indicates that the economy has become more capital intensive in recent times.

Table 4.1: Calculated annual average TFP growth rates and factor ratios for data set 1 and data set 2 (1991-2010 and 1971-2011)

	TFP growth rate 1971-2011	TFP growth rate 1991-2010	Capital ratio	Labor ratio
Dataset 1 (1991-2010)	n.a	0,22 %	0,53	0,47
Dataset 2 (1971-2011)	0,06%	0,74 %	0,50	0,50

Figure 4.1 compares dataset 1 and 2, year by year. It can be seen that, while there are some differences, both calculations follow a very similar growth path. The TFP growth rate from dataset 1 lies below the TFP growth rate for dataset 2 consistently, until 2009 when the curves cross and the TFP growth of dataset 1 falls less and rises more than TFP growth of dataset 2. A reason for this can be that in 2009 the world economic crisis hit South Africa and South Africa experienced a recession. The recession affected the GDP growth rate and the unemployment rate (Assubuji, Luckscheiter 2009). For dataset 1 this meant that two of the elements that influence the TFP growth rate decreased, and so the TFP growth rate will be less affected by the economic crises. Whereas for dataset 2 the whole effect of the decrease in GDP growth rate is captured by the TFP growth rate and so the TFP growth rate will fall further than for dataset 1. Despite the problem dataset 2 has with capturing the effects of fluctuations in the labor force

the TFP growth rates follow each other closely. The data on the labor-force growth rate can thus be substituted with the population growth rate so long as the tendency for overestimation of the TFP growth rate is noted when interpreting the results.

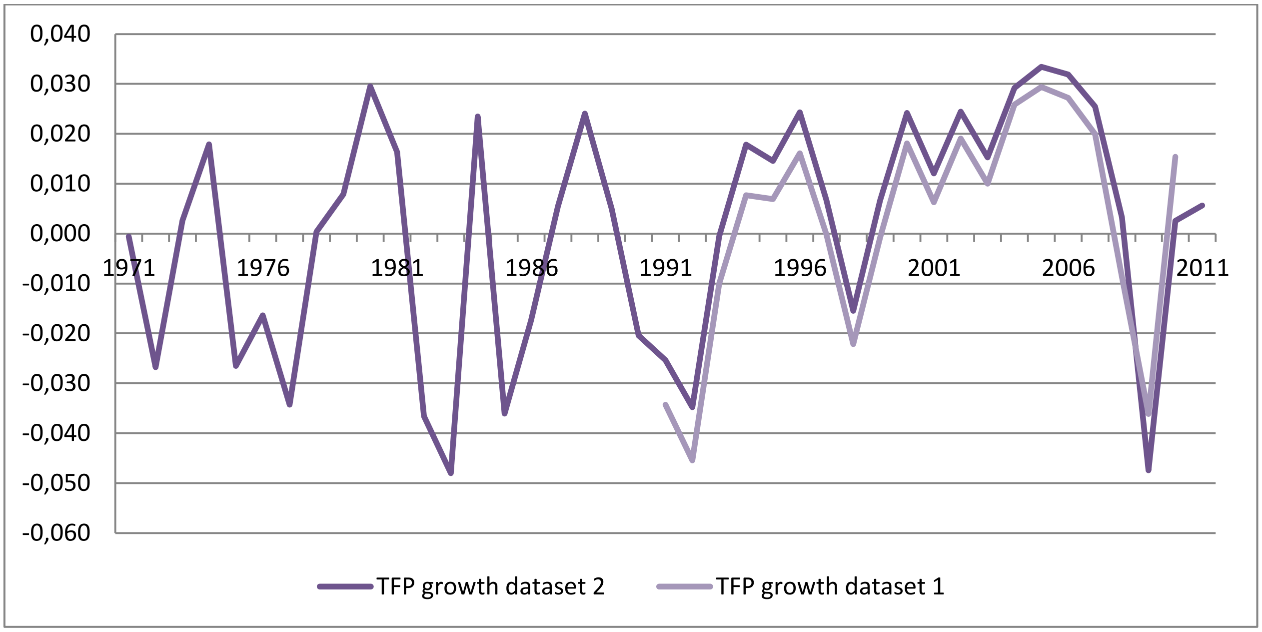

Figure 4.1: The annual TFP growth rate for dataset 1 (1991-2010) and dataset 2 (1971-2011).

From the level calculations of dataset 2, illustrated in figure 4.2, it can be seen that there is a relatively steady decline in the TFP level until 1993 when it started to increase. This is as expected as it was in 1993 the trade embargo on South Africa was lifted. The embargo that started on a small scale already in the 1960's evolved into a full trade embargo in 1986 and remained so until it was lifted in 1993, when it was clear that the Apartheid regime had fallen (The Peterson Institute for International Economics 2008). The growth rate averages for the period before and during the trade embargo (1971-1993) and after the trade embargo (1994-2011) is -0,84% and 1,19%. Similar results were found by Arora (2005) who despite analyzing a shorter time series (1980-2003) found average growth rates of -0,4% during and 1,3% after the end of the trade embargo. The similarities between these results help establish the validity of the calculated TFP data from dataset 2.

The recent downturn that can be seen in the graph can be explained by the current global economic crisis, that amongst other things was caused by the financial crisis that stared in 2007. In the second quarter of 2009, South Africa experienced a recession that hit key drivers of growth, such as trade, investment and the manufacturing sector (Assubuji, Luckscheiter 2009). The level TFP turns exactly at the point in time when the recession hit. However the recession was short lived in South Africa and, as can be seen in the graph, South Africa soon recovered and started growing again (Blanke et al. 2011)

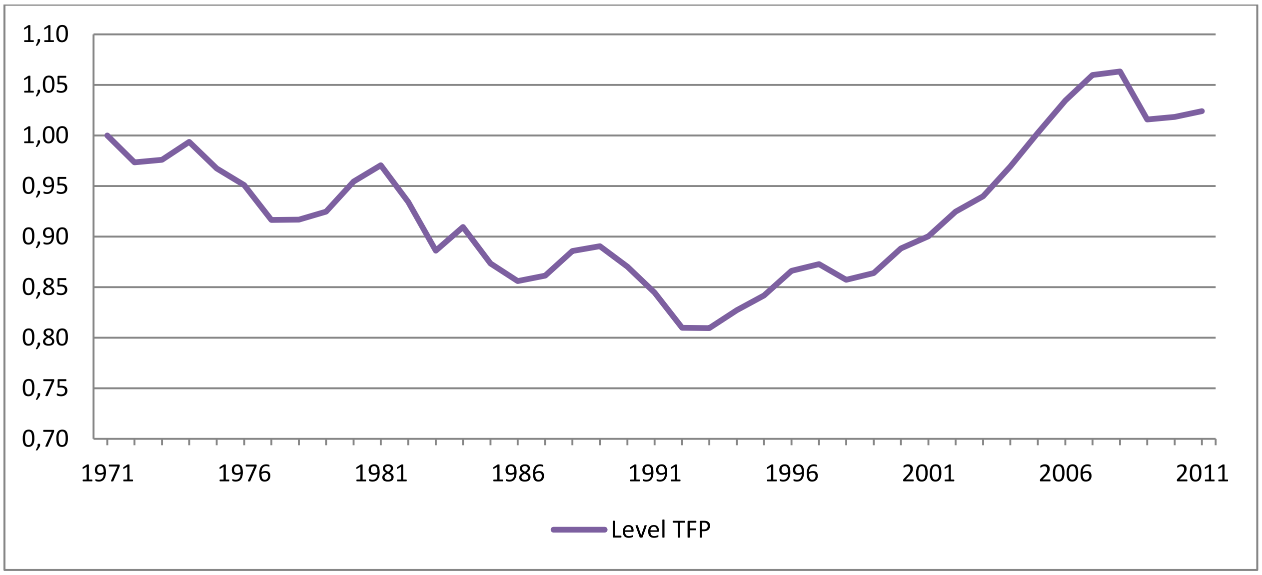

Figure 4.2: The level of TFP from dataset 2 (1971-2011). It is calculated by equating the base year, here 1971, to one and then using the TFP growth rate to calculate the whole series.

The TFP growth rate can also be calculated using estimated factor shares. The factor shares are found by estimating the production function using the Ordinary Least Squares (OLS) method. The advantage of estimating the factor shares rather than calculating them is that no assumptions on the size of the factor shares are needed. Hence, the total income share can exceed or be less than one. The disadvantage however is that the factor share is the same at every observation and does not allow for any shift in the composition of factors. As was seen when calculating the TFP growth rate, the factor shares changed when averaging the factors shares for the period 1991-2010 compared with 1971-2011. This indicates that the factor shares do vary from period to period and that there is a tendency in a shift in factor shares over time. This is an effect that will not be included when estimating the factor shares.

There are several disadvantages to using regression analysis: correlation and measurement error being amongst them. If the growth rates of capital and labor are measured with error, then the estimated coefficients for the variables will give inconsistent estimates of the factor shares. This concern is especially valid for the capital share as the measurement of the capital stock is not considered to be very accurate. Measurement error can therefore lead to under estimation of the contribution of capital to economic growth and thereby an overvaluation of the effect of the TFP growth rate (Barro 1998). Using OLS is thus not the best approach to obtaining realistic values of TFP growth, as it tends to give upward biased estimates. Still it is a useful tool as the estimates can be used to check the reasonability of the calculated factor shares obtained from the growth accounting procedure.

Three regressions were run on both data sets using equation (4.2). The first using raw data and then using a moving average procedure for 3 and then 5 years. The moving average procedure reduces the effects in the data that are due to random variation. The procedure helps reveal more clearly the underlying trends. The regressions gave negative coefficients for the labor force factor share for both data sets. This can mean one of two things: either the data is unreliable or labor does not influence productivity, since South Africa has an oversupply of unemployed people. Either way the results are not realistic and so the regression results are dismissed. The regressions cannot be used to estimate the TFP. (The regression results are presented in appendix 2).

The calculated TFP growth rate from data set 2 will be used as the measure of TFP growth in South Africa for the remainder of the thesis.

4.3 Moving average

Figure 4.3 shows the calculated TFP growth rate and level after using a 3-year moving average procedure. This entails averaging the previous, the present and the following values for every year giving a data series from 1973-2010. Using moving average reduces the temporary variation and makes it be easier to see the trend in the data. The level TFP of the 3-year smoothed average has the same characteristics as the level TFP in figure 4.3. And it decreases until around 1993, when the trade embargo was lifted. However the moving average level TFP does not decrease as much as the level TFP in figure 4.2. This is reflected in the moving average TFP growth rate which is "smoother" not peaking as high or low as the TFP growth rate of dataset 2 in figure 2.1.

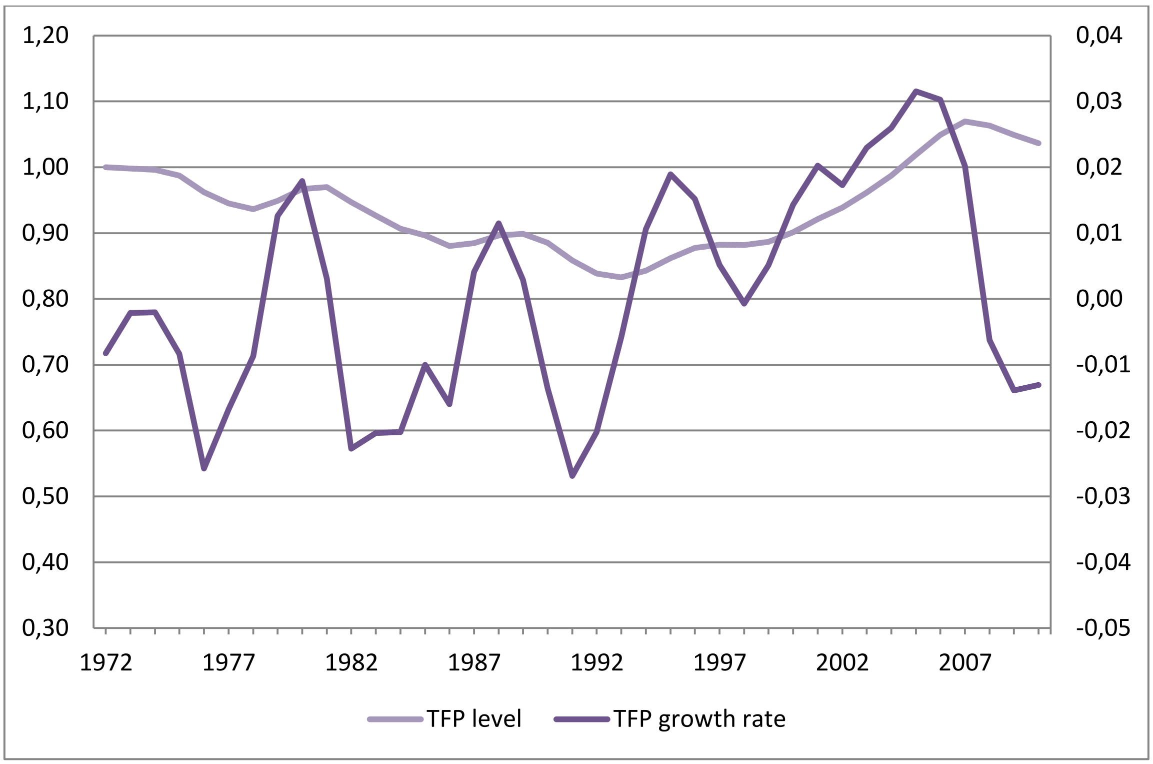

Figure 4.3: The TFP growth rate and TFP level when taking 3-year moving average.

5. Data and Econometric Model Specifications

The dataset used in the analysis is a time series for the period 1971-2011. The methods used to analyze the data are growth accounting calculation and ordinary least squares (OLS) regression to find the TFP growth rate, shown in chapter 4. Also used is an error correction model estimated using OLS regression method to find the effect that FDI has had on TFP in South Africa. The error correction model offers the opportunity to study both the short and the long term effect of FDI on TFP. The model, as will be shown in this chapter, allows for the study of non-stationary time series with one unit root given that the data is co-integrated. The following equation gives a simple illustration of the relationship this paper is investigating.

$$TFP = f(FDI, X)$$

X represents all other variables that affect TFP, some of which will be controlled for in the regression analysis: The productivity at the technological frontier and the trade as a share of GDP.

5.1 Estimation of time series data

In basic time series analysis a static model is used

(5.1) $$y_t = \beta_0 + \beta_1 z_t + u_t \qquad t = 1, 2, ..., n$$

The effect of z on y is investigated, and because this is a static model only the immediate effect that z has on y will be registered, where u_t is the error term. The ordinary least squares (OLS) method find estimates by minimizing the sum of the squared error terms. In order to get consistent and unbiased estimates when performing OLS regression analysis on a time series models, a number of assumptions have to be fulfilled.

- The model needs to be linear in its parameters.
- None of the independent variables can be constant, or a perfect linear combination of the others; this is what is referred to as *No Perfect Collinearly*.

- The error term at time t, has to be uncorrelated with each explanatory variable in every time period. This can be shown mathematically $E(u_t \,|X) = 0,\ t = 1,2,\ldots,n.$ and is referred to as the assumption of *Zero Conditional Mean*.
- The assumption that $Var(u_t|X) = Var(u_t) = \sigma^2, t = 1,2,..,n.$ states that variance of the error term cannot depend on X (which is represented by z in equation (5.1)). The error term and the variable X are independent and the variance of the error term has to be constant over time. This is the assumption of *Homoscedasticity*, when this assumption does not hold the errors are heteroskedastic. There also need to be
- *No Serial Correlation*, meaning that the errors in the different time periods are uncorrelated, $Corr(u_t, u_s) = 0$, for all $t \neq s$. (Wooldridge 2009)

These five assumptions are what is referred to as the time series Gauss-Markov assumptions and if they hold they ensure that the OLS estimators are the best linear unbiased estimator (BLUE) conditional on X. (Wooldridge 2009). By assuming that the five Gauss- Markov assumptions hold and using OLS we get BLUE estimators. However, in order to be able to use the t and F statistics, which are useful tools when testing the significance of one or all of the variable coefficients, we also need to assume *Normality.* What this assumption entails is that not only is the error term independent of X but it is also normally distributed (0, σ^2). These six assumptions ensure that the OLS estimators are normally distributed, given X, and that under the null hypothesis each t statistics has a t distribution and each F statistic has an F distribution. (Wooldridge 2009)

The static model given by (5.1) can be extended to include lags. This means that by adding the effect of the previous period and the period before the effects "of the past" can be measured in time t's dependent variable. Simply put, it measures how the past has directly impacted the present. There are two ways to lag a time series model either lagging all the variables including the dependent (as is done below in (5.2)), or lagging only the explanatory variables. The former is named an autoregressive distributed lag (ADL) model and the latter distributed lag (DL) model (Brooks 2008). The ADL model includes the effect that the dependent variable of the previous period has on the dependent variable at present period.

(5.2) $$y_t = \beta_0 + \gamma y_{t-1} + \beta_1 z_t + \beta_2 z_{t-1} + u_t$$

Lagging a model makes it possible to study the effects that the z of e.g. one period ago has on y. This is useful because many variables, such as e.g. governmental investment in education, will not have an immediate effect on TFP but over time the effect can be great. In a static model this “long term” effect is ignored. The autoregressive part of the equation is the lagged dependent variable and it captures the effect of shocks to the dependent variable.

An important issue when analyzing time series data is whether the data is stationary or not. When a time series process is strictly stationary the probability distributions are stable over time, and the distribution is time independent. Typical examples of stationary time series are exchange rates and interest rates, (however in “short” time series these can be seen as non-stationary as well, hence the stationary process of the variable can depend on the length of the time series).

If a variable is non-stationary this entails that the data can wander far from its mean value and so relationships can be hard to determine unless some prerequisites are fulfilled. Typical examples of non-stationary time series are price series. Prices increase over time and so the distribution is time dependent. There needs to be stability over time for the relationship between the dependent and independent variable, using regression analysis, to be reasonably specified. However, time series tends to be trended with stationary growth rates, which means that they are integrated to some degree d, I(d). Examples of this are household consumption and the consumer price index which both have a strong trend component. A non-stationary time series has what is referred to as a unit root. To make a time series stationary they can then be differentiated making them an I(0) process. (Alogoskoufis, Smith, 1991). “Thus, for d =0 z_t will be stationary and for d = 1 the change is stationary.” (Engle, Granger, 1987) Whether a series is stationary or not is critical information when choosing the right estimation method.

A problem associated with non-stationary time series is that when a shock occurs, the effect of the shock does not die out. This can be illustrated using equation (5.2), the coefficient of the autoregressive term γ expresses how a shock to the dependent variable in a previous period will affect the dependent variable at present. If γ<1 (given that at time 0: γ^0=1 and as time approaches infinity: γ∞=0), then the time series is stationary, meaning that the distribution is time independent, the time series is integrated at degree 0, I(0). The size of γ determine how fast the shock will “die out” so that the dependent variable can return to its stationary point. When γ=1 then a shock will create a permanent change in the variables growth path; the shock does not “die out”. This entails that the data is non-stationary to some degree I(d), most likely it will be I(1) as most economic data are (Brooks 2008) . In theory the coefficient could also be greater than one, γ>1, however this is not very probable in reality because it means that a shock would have an increasing effect on the dependent variable over time.

There are two separate models that are used when referring to non-stationary data: the trend stationary process and the random walk model with drift. (Brooks 2008). In a trend stationary process the variable is time dependent but the growth fluctuates along a trend path. In the random walk model with drift a shock to the dependent variable will shift the growth path for that variable with the exact amount of the shock, so that it appears that the data is “wandering” randomly.

Usually when the variables are integrated at the first degree, the error term will also be I(1) although if the variables are co-integrated then a combination of these variables will be stationary, I(0). Engle and Granger, (1987) explain co-integration simply with: “An individual economic variable, viewed as a time series, can wander extensively and yet some pairs of series may be expected to move so that they do not drift too far apart”. Examples of co-integrated series are short and long term interest rates and household income and expenditure. They are all individually non-stationary, I(1), but they move together through time following a similar path. (Engel, Granger, 1987) The presence of co-integration makes regressions that involve I(1) variables potentially meaningful. (Wooldridge 2009)

5.2 The error correction model

Former empirical studies have found that the short term and long term effects of FDI on TFP can differ and so a model that captures both effects is required (Fedderke, Romm 2005) (Senbeta 2009) (Lui 2006). The error correction model has these qualities, because of its combination of both differentiated and lagged terms. In addition it enables the use of OLS when the data is integrated and it is able to "handle" non-stationary time series as long as they are co-integrated. This means that if the assumptions presented in the previous sub-chapter hold and the time series are co-integrated then the estimators obtained will be BLUE.

The error correction model is derived using the ADL model (5.2) taking the first difference of both the dependent and independent variables. This gives the equation (5.3) that considers both the long term and the short term effects of the independent variables on y.

$$y_t - y_{t-1} = \beta_0 + \gamma(y_{t-1} - y_{t-2}) + \beta_1(z_t - z_{t-1}) + \beta_2(z_{t-1} - z_{t-2}) + u_t$$

(5.3)
$$\Delta y_t = \beta_0 + \gamma \Delta y_{t-1} + \beta_1 \Delta z_t + \beta_2 \Delta z_{t-1} + u_t$$

Once the variables have been differentiated and it is assumed that y and z are co-integrated with a parameter θ, then an additional I(0) variable can be included: $s_t = y_t - \theta z_t$ is an I(0) with zero mean, the lags of s_t can be added to the equation (here only one lag will be added).

$$\Delta y_t = \beta_0 + \gamma \Delta y_{t-1} + \beta_1 \Delta z_t + \beta_2 \Delta z_{t-1} + \delta s_{t-1} + u_t$$

(5.4)
$$\Delta y_t = \beta_0 + \gamma \Delta y_{t-1} + \beta_1 \Delta z_t + \beta_2 \Delta z_{t-1} + \delta(y_{t-1} - \theta z_{t-1}) + u_t$$

Equation (5.4) is a representation of the error correction model; the term $\delta(y_{t-1} - \theta z_{t-1})$ is the error correction term. (Wooldridge 2009) In this model θ defines the long run relationship between z and y, and δ describes the short run relationship or rather δ describes the speed of adjustment back to equilibrium (Brooks 2008). As stated above, for the error correction model to give meaningful estimates when using the OLS regression method, the time series need to be co-integrated. This will enable the use of I(1) time series without having to worry about spurious regression problems.

5.3 Model specifications

The aim of this paper is to test the effect of FDI on the TFP growth rate. The model used; the error correction model contains both first difference and lagged variables. The first regression run will be on the following model

(5.5) $$\Delta ln\, A_t \;=\; \alpha_0 + \;\alpha_1 ln\, A_{t-1} \;+\; \alpha_2 FDI_{t-1} \;+\; \alpha_3 \Delta FDI_t + u_t$$

The left hand side is the first difference of the natural logarithm (ln) of level TFP, which is equal to the TFP growth rate. The right hand side contains the first lag of the ln level TFP, the lagged FDI and the first difference of the FDI. If the coefficient α_1 is significant and lies in-between -1 and 0 then FDI will only have a short term effect on the TFP growth rate, the effect is given by α_2. A definition of the long run used in econometric is that all the variables have some long term value that they converge towards, meaning that in the long-run A_t=A_{t-1}=A and so on. This means that in the long run all the differentiated terms will equal zero as A_t-A_{t-1}=A-A=0. When rewriting equation (5.5) the long run effect of FDI on the TFP level is found to be $-\alpha_2/\alpha_1$. (Brooks 2008)

The first difference and lagged control variables are added to the model, separately and then together. The control variables are: the level TFP at the technological frontier, ΔlnA_t^* and lnA^*_{t-1}, (which in this and many other empirical papers has been taken to be the level TFP of USA) and the total trade as share of GDP, $\Delta(T/GDP)_t$ and $(T/GDP)_{(t-1)}$. A regression excluding the FDI variables will also be run to see if the exclusion of FDI will affect the control variables. This gives the five regression models that will be estimated in the analysis: (5.5), (5.6), (5.7), (5.8) and (5.9).

(5.6) $$\Delta ln\, A_t \;=\; \alpha_0 + \;\alpha_1 ln\, A_{t-1} \;+\; \alpha_2 lnFDI_{t-1} \;+\; \alpha_3 \Delta lnFDI_t + \alpha_4 lnA^*_{t-1} + \alpha_5 \Delta lnA^*_t + u_t$$

(5.7) $$\Delta ln\, A_t \;=\; \alpha_0 + \;\alpha_1 ln\, A_{t-1} \;+\; \alpha_2 lnFDI_{t-1} \;+\; \alpha_3 \Delta lnFDI_t + \alpha_6 (T/GDP)_{t-1} + \alpha_7 \Delta (T/GDP)_t + u_t$$

(5.8) $$\Delta ln\, A_t \;=\; \alpha_0 + \;\alpha_1 ln\, A_{t-1} \;+\; \alpha_2 lnFDI_{t-1} \;+\; \alpha_3 \Delta lnFDI_t + \alpha_4 lnA^*_{t-1} + \alpha_5 \Delta lnA^*_t + \alpha_6 (T/GDP)_{t-1} + \alpha_7 \Delta (T/GDP)_t + u_t$$

$$(5.9) \qquad \Delta ln\, A_t = \alpha_0 + \alpha_1 ln\, A_{t-1} + \alpha_4 lnA^*_{t-1} + \alpha_5 \Delta lnA^*_t + \alpha_6 (T/GDP)_{t-1} + \alpha_7 \Delta (T/GDP)_t + u_t$$

5.4 Possible issues with the model

<u>*Non-stationary series:*</u> If non-stationary data is used without accounting for it being non-stationary then this can lead to spurious regressions. If the variables are trending over time then the regression can give a high R^2 value even if the variables are unrelated, because the regression picks up the underlying common trend. If the data is non-stationary and a standard regression is used then the "t-ratios" does not follow a t-distribution and the F-statistic will not follow an F-distribution. According to Brooks (2008) the majority of financial and economic time series are non-stationary I(1) processes, meaning they contain a single unit root and so testing for this is crucial to know whether the estimates are useful. To test for the presence of unit roots in the time series at hand, a Dickey-Fuller (DF) test is used. In all simplicity what is tested is a null hypothesis that the series contains one unit root, $\gamma = 1$, vs. the alternative hypothesis that the series is stationary. To ease the calculation and interpretation, the following regression is used $\Delta y_t = \psi y_{t-1} + u_t$ where ψ=0 ($\gamma - 1 = \psi$) with a $\text{test statistic} = \frac{\hat{\psi}}{\widehat{SE(\hat{\psi})}}$, which does not follow the t-distribution under the null hypothesis. A problem with this test is that it is only valid if the error term just consists of white noise. If the dependent variable contains serial correlation the test estimates will be oversized. A solution for this will be augmenting the test using p-lags to the dependent variables; this is referred to in the literature as an Augmented Dickey-Fuller (ADF) test. The lags ensure that the dependent variable is not serial correlated. It is important to choose the optimum number of lags; as too few will not remove all the serial correlation while too many will increase the coefficients standard errors. (Brooks 2008) The following equation shows the ADF-test:

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + u_t$$

The ADF-test was performed on the variables, levels and difference, and then on the error terms of the error correction model regressions. The results imply that the variables are non-stationary and that the estimated error terms are stationary which means that there is co-integration. The error correction model is therefore correctly specified (for test results see appendix 4 and 5). The ADF test performed on the differentiated variables shows that they are stationary so this confirms that the time series only has one unit root and therefore only need to be differentiated once.

Endogeneity:

Omission of important variables or including irrelevant variables: Excluding a determinant of the dependent variable from the regression will give biased and inconsistent estimates of the coefficients of all the other variables, if the omitted variable is correlated with all the included variables. Even if the omitted variable is not correlated with all the included variables the coefficient of the constant term will still be biased and so will the standard errors. This can be a serious problem for the regressions in this paper because it is likely that there are variables that affect the TFP that have not been accounted for, e.g. political stability and/or infrastructure. These variables are probably also correlated with the FDI and so the estimates produced in the next chapter can suffer from biases as a consequence of omitted variables. (Brooks 2008)

Though not relevant for the regressions run in this paper, including irrelevant variables can give inefficient coefficients. This means that the standard errors will be inflated compared with a regression not containing the irrelevant variable. This can contribute to finding variables, which would have been marginally significant in the true regressions, not to be significant in the regressions including the irrelevant variable. As the model in this paper contains few variables, which have been accounted for through former empirical studies, it is highly unlikely that this model will have included irrelevant variables. However of the two, omitting relevant variables is deemed a more serious problem. (Brooks 2008)

Simultaneity: In equation (5.5) it can easily be deducted that the model most likely suffers from simultaneity. Simultaneity entails that one or more of the explanatory variables is determined conjointly with the dependent variable, thus the relationship runs both ways. In (5.5) the effect on TFP of FDI is modeled, although it is not implausible that the relationship may run the other way, reverse causation, or that TFP and FDI both affect each other conjointly. It has been shown that developed countries tend to attract more FDI than developing countries (Blanke et.al. 2011). This can mean that countries with higher TFP growth attract more FDI, and more FDI again will increase the TFP growth, creating a symbiotic relationship between the two. Because of the possible presence of this symbiosis it is difficult to prove causality between FDI and TFP growth. OLS used on regressions that contain variables that are simultaneously determined with the dependent variable will generally be biased and inconsistent (Wooldringe 2009). This is due to the fact that the simultaneity and any form of endogeneity will violate the assumption of "*Zero Conditional Mean*", $E(u_t\,|X) = 0,$ t=1,2,…,n.

A possible solution to both the problem of omitted relevant variables and simultaneity is using the instrument variable (IV) method. The method involves finding an "instrument" that is correlated with the endogenous explanatory variable but not correlated with the error term. This means that the instrument variable will be exogenous. In order for the IV-estimation to give precise estimates the instrument variable has to be strongly correlated with the corresponding endogenous explanatory variable. This is where the regression at hand runs into problems, as there are no obvious instruments that are correlated with FDI but not with the error term. In previous econometric papers, one period lags are used as an instrument for FDI (Alfaro et. al 2004) (Borenztein et. al 1998) (Roy 2008). Wheeler and Mody (1992) show that FDI is self-determining, which means that FDI is highly correlated with the lag of FDI. However it does not seem unlikely that if FDI is correlated with the error term so will the lag of FDI be. Hence this paper concludes that no "good" instrument for FDI is found. The instrument variable method will not give "better" estimates than OSL estimation. However as the model used already contains the lags of FDI and all the other control variables, this can be seen as a way to elevate the endogeneity issue.

5.5 Data description

<u>The dependent variable:</u> The time series on the TFP growth rate and TFP level have been thoroughly explained in chapter 4. The data used for the calculations came from various sources (Quantec.co.za, Worldbank.org, Treasury.gov.za). The TFP level is normalized to one for the year 1971 and then the natural logarithm is taken. The difference between the present and previous period is found and it is this that gives the differentiated variable on the left hand side of equation (5.5).

<u>The independent variables:</u> *Foreign direct investment inflow (FDI)* was obtained from UNCTAD.org. The time series came in current prices USD. To avoid spurious regression problems that can occur with current prices variables, the time series was divided by total investment (I) or rather the fixed capital formation in current USD, giving the FDI as a share of I (the fixed capital formation data was obtained from the Worldbank.org). As discussed in the previous chapters, it is expected that the FDI as a share of I will have a positive effect on TFP. Looking at the graphed levels of FDI/I and TFP we see that the path has been similar but that there has been a sharp increase in FDI inflows after the blockade ended. This increase was not mirrored by the TFP level. The TFP level has also increased but not anywhere near the amount that the FDI share of investment increased. As the correlation coefficient between the two variables is positive at 0.21, this indicates that there is a weak positive relationship between the variables. What is interesting is that the correlation between the variables, separating the period before and after the trade embargo, is decreasing. This corresponds with the graphed level relationship below. Studying the data at hand, one can conclude that if there is a significant effect of FDI on TFP this effect is likely to be small and positive. The series FDI/I will be referred to as FDI as of now.

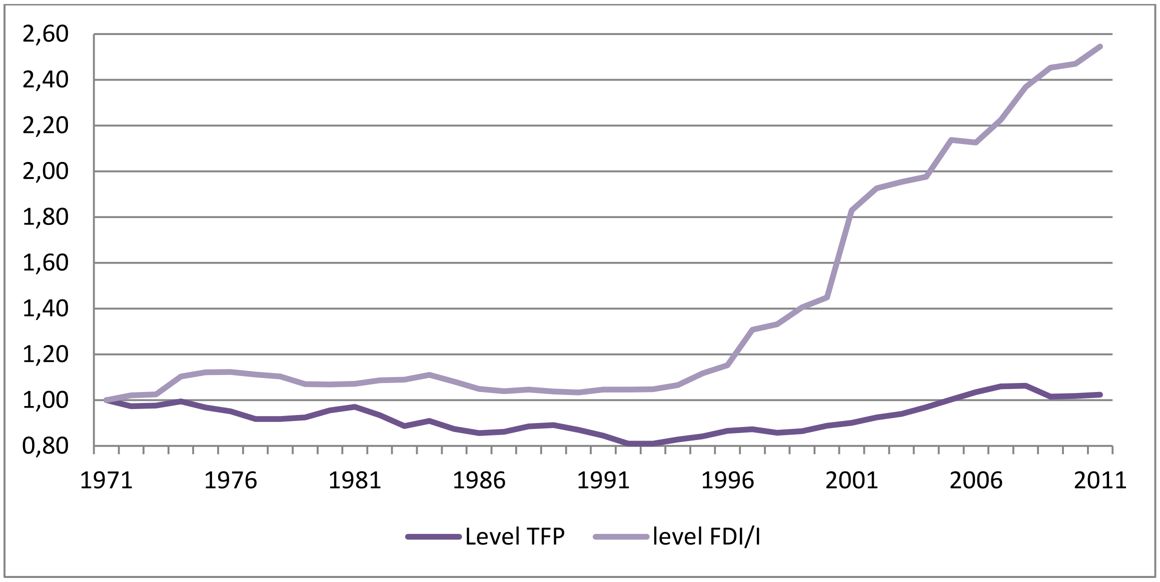

Figure 5.1: Level comparison of FDI/I and TFP.[3]

<u>*Control variables:*</u> *Productivity at the technological frontier (A*)* is taken to be the United States TFP[4] percentage change from year to year. It was obtained from the Bureau of Labor statistics (bls.gov) for the entire period 1971-2011. The time series was leveled and the logarithm ln was taken in the same manner as for the dependent variable. Both the theory of Findlay (1978) and previous empirical research have stressed the importance of the productivity level at the technological frontier when the effects on TFP are to be estimated. The Graph below shows that after the trade embargo ended in 1993, South Africa's TFP has started to "shadow" the productivity at the frontier. Not catching up but following a similar pattern as the TFP at the technological frontier. The correlation between the TFP in South Africa and the TFP in The United States was negative with a coefficient of -0,91 for the period 1971-1993, indicating a strong negative relationship before and during the trade embargo. For the period after the trade embargo 1994-2011, the correlation coefficient at 0.95 reveals a strong positive linear relationship between the variables. This is intuitive as the trade embargo largely shielded the South African economy from development at the technological forefront. It is only after the

[3] The FDI/I level is only used for this illustration. The FDI/I level is not used in the regression analysis in chapter 6.
[4] In the United States total factor productivity is labeled Multi Factor Productivity (MFP) and so in the data source it is named so. However the term total factor productivity will be used consistently throughout this paper.

trade embargo ended that the domestic TFP level has started to emulate the TFP level at the technological frontier.

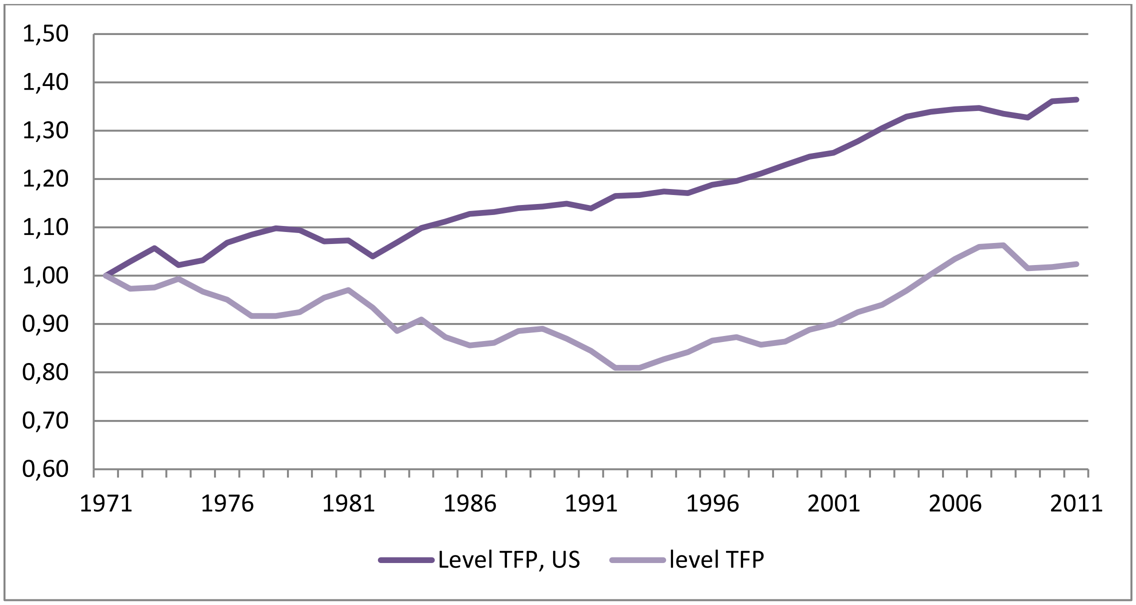

Figure 5.2: The level productivity at the technological frontier and South Africa compared.

Total trade as a share of GDP was obtained from Worldbank.org. It is the sum of imports and exports of goods and services. Trade is another channel through which South Africa has contact with the "outside" world and can thus be a way through which technical progress and knowhow can be transferred. The variable has a strong positive correlation with the TFP level. A correlation coefficient of 0.75 was found for the period 1971-2011. When separating the observations into before and after the trade blockade the data reveals, as was expected, that the correlation increased considerably after the trade blockade ended. It increased from 0,62 before and during the blockade to 0,83 after.

6. The Effect of FDI on TFP, -the Analysis

This chapter presents the empirical analysis of FDI and TFP growth in South Africa during 1971-2011. Based on the dataset presented in chapter 5, five regressions were run on the data controlling for the effect of the different variables. No significant effect of FDI on TFP was found. However, significant and consistent effects of both lagged TFP level at the technological frontier and the lagged and differentiated trade as share of GDP were found in regressions 2, 3, 4 and 5.

As pointed out in chapter 3, this paper is not the only one that does not find significant effects of FDI on TFP. The results of the first regressions join a long line of other empirical papers that place a question mark behind the theory that FDI will positively affect TFP growth. However, since both FDI and TFP are flow variables which can fluctuate a great deal from year to year, it is difficult to pick up on a potential underlying effect. This is dealt with in regressions 6 to 10 in table 6.2, where the data is manipulated using a 3 year moving averaging procedure. Apart from the effects of FDI, table 6.2 mirrors table 6.1. When a moving average procedure is performed on the data, the regressions reveal positive and significant effects of FDI on TFP. Still this effect disappears when controlling for the TFP growth at the technological frontier.

There can be many reasons explaining why the effects of FDI on TFP are somewhat inconclusive: Aggregation of the data, the fact that FDI inflows to South Africa have been low, and/or omitted variables amongst other things. However, the inconclusive results is a reminder that FDI is not, as it is sometimes portrayed by politicians and policy makers, a magical fix-all-cure that is synonymous with growth. The regression results and possible explanations for them will be discussed in this chapter.

6.1 The regression results

6.1.1 The results using the original data set

The five regressions in table 6.1 reveal no significant effect of FDI on the TFP. Still the results are of interest because both the lagged productivity at the technological frontier variable and the trade variables are consistently significant, and the effects are more or less stable throughout regression 2, 3, 4 and 5. This means that productivity growth at the technological frontier affect South Africa's productivity, though not through FDI as expected, but more likely through trade. The trade variables are consistently highly significant, both the differentiated and the lagged variables.

It can be seen in table 6.1 that regression 1 gives no significant results, whereas regression 2, when controlling for the TFP growth at technological frontier, the lagged variable is significant at the 5% level. In regression 3 and 4 the effect of trade is controlled for. Regressions 3, 4 and 5 have significant autoregressive terms that lie in-between 0 and -1, meaning that the effects on TFP growth is only short term but there is a long-term effect on the TFP level. The coefficient of the autoregressive term indicates the speed of transition back to the "old" growth rate. For regressions 3, 4 and 5 this means that the TFP growth rate returns to its original state at a rate of 16,4%, 16,3% and 16,1% a year.

The first four regressions are looking at the effect that FDI has on TFP whereas regression 5 examines if the effect of productivity growth at the technological frontier and trade is still stable when excluding the FDI variables. The first four regressions reveal no significant effect of FDI on TFP. The empirical literature might be able to shed some light on the predicament; as discussed in chapter 3 the empirical literature is divided on the outcome of the analysis and though some find significant effects of FDI on TFP this is often dependent on the type of data that is analyzed, the country studied and other differences. This study used aggregated country data and, due to data constraints, the sector, industry or firm specific effects were not controlled for. Massoud (2008) found that different sectors have conflicting effects of FDI on their TFP. This can mean that in an aggregated study the effects cancel each other out. This can be a plausible explanation for the lack of results of FDI on TFP in table 6.1 as it has not been possible to control for the effects on the different sectors such as industry, agriculture and mining. The results or rather the lack of results is supported by Ng (2007) who only found a significant effect of FDI on TFP in 2 out of 14 Sub-Saharan African countries.

Table 6.1: Regression results, the dependent variable is ΔlnA_t

	regression 1	regression 2	regression 3	regression 4	regression 5
Constant	-0,009 (0,007)	-0,024** (0,010)	-0,103** (0,045)	-0,107** (0,044)	-0,099** (0,042)
$lnA_{(t-1)}$	-0,067 (0,057)	-0,085 (0,055)	-0,164** (0,072)	-0,163** (0,068)	-0,161** (0,067)
$d(FDI/I)_t$	0,094 (0,056)	0,038 (0,059)	0,053 (0,049)	0,006 (0,050)	
$(FDI/I)_{(t-1)}$	0,117 (0,071)	0,025 (0,081)	0,045 (0,063)	-0,044 (0,070)	
$dlnA^*_t$		-0,109 (0,270)		0,081 (0,234)	0,011 (0,219)
$lnA^*_{(t-1)}$		0 ,114** (0,052)		0,110** (0,044)	0,098** (0,037)
$d(T/GDP)_t$			0,309* (0,078)	0,308* (0,075)	0,295* (0,072)
$(T/GDP)_{(t-1)}$			0,166** (0,077)	0,148*** (0,075)	0,134*** (0,073)
R^2	0,105	0,223	0,391	0,492	0,476
period	1971-2011	1971-2011	1971-2011	1971-2011	1971-2011

Standard deviations in parentheses. *,**,*** indicate significance at the 1%, 5% and 10% level.

Regression 2, where the effect of the productivity at the technological frontier is controlled for, reveals that if the productivity at the technological frontier in the previous period changes with 1% then the TFP growth rate in South Africa at present would increase with 0,114% -points. This result is significant at 5%. When the trade variables are included in regression 4 the effect of the lagged productivity at the technological frontier on the dependent variables decreases slightly to 0,110% points, still significant at the 5 % level. Because the autoregressive term is negative and significant for regression 3 and 4 there is only a short term effect on the TFP growth rate. However there is a long term effect on the South African TFP level. Regression 4 is the regression with the most credibility since both the productivity level at the technological frontier and the trade variables are included. This is therefore the regression used when calculating the long term effect on the TFP level. The long term relationship between the productivity at the technological frontier on South Africa's TFP level, is found in the following way:

$$lnA = \frac{0,11}{0,163} lnA^* \rightarrow \frac{\partial lnA}{\partial lnA^*} = 0,67$$

The elasticity is 0,67, which implies that if the TFP level at the technological frontier increases with 1% then the TFP level in South Africa will increase with 0,67% in the long run.

This indicates that the results are stable, and that the productivity at the technological frontier does indeed affect South Africa's domestic productivity both the short run growth rate and the long run level. The results do not, however, indicate convergence as the long-term elasticity would need to exceed one, nor is there divergence because the elasticity is positive. The results can be seen in conjunction with what was found by Harding and Rattsø (2009), that South African industries are related to the technological frontier but that there is no evidence of them catching up.

It can be seen from the results of regression 3, 4 and 5 that both the lagged and differentiated trade variables affect TFP significantly. The lagged trade as share of GDP is significant at 5% for regression 3 and 10% for regression 4. Here a one percentage point increase in the previous period trade as share of GDP will give a 0,166% point increase in the TFP growth rate for regression 3 and a 0,148% point increase for regression 4. The long term level effect of trade from regression 4 is given by the following equation

$$lnA = \frac{0{,}148}{0{,}163}\frac{T}{GDP} \quad \rightarrow \quad \frac{\partial lnA}{\partial \frac{T}{GDP}} = 0{,}91$$

If the trade share is increased by 1% point this will then increase the TFP level in the long-run with 0,91% .

Regression 5, which has excluded the FDI variables, gives very similar results to regression 4. This is a strong indication that the effect of technological transfer works mainly through trade and not through FDI. As mentioned in the previous chapter: trade with the "out-side" world is another form of contact with more developed economies. It can also be seen as a measure of economic openness, as a more closed economy will have less trade with the outside world. It is not unexpected that trade would significantly influence TFP as it is such an important link to the technological frontier. However, that no significant effect of FDI on TFP was found was, though not entirely unexpected, still somewhat disappointing.

6.1.2 Moving average manipulation

Another possible explanation for the lack of significant effects of FDI on TFP is that both FDI and the TFP are flow variables, which means that they can fluctuate greatly from year to year making it difficult to pick up on the underlying effects. By manipulating the variables so that each observation is an average of the previous, present and future observation, a so called moving-average procedure, the data become much smoother and should more easily reveal underlying relationships.

The results of the regressions run on the manipulated data are presented in table 6.2. Regressions 8, 9 and 10 have autoregressive terms that are significant and that lie between 0 and -1. The effect on the TFP growth rate is therefore only temporary whereas there is a long-term effect on the TFP level. The TFP growth rate, which is the dependent variable, will move back towards its original growth rate at a rate of 15,2% and 15,5% each year for regression 8 and 9.

The result of regression 6 reveals that the effect of FDI on TFP is significant for both the differentiated and the lagged variable, at different levels. A one percentage point increase in the change of FDI as share of investment from one period to the next will give a 0,156% -point increase in the TFP growth rate. This result is significant at 10%. As for the lagged FDI variables, a one percentage point increase in the FDI as share of investments in the previous period will give a 0,181% -point increase in the TFP growth rate of this period. This result is highly significant at 1%. It thus seems that averaging the data has brought out an underling effect, and that FDI does indeed influence TFP growth. However, when controlling for productivity growth at the technological frontier the significance disappears altogether. This is apparent in regressions 7 and 9.

In regression 8, a significant effect of FDI on TFP is still present when controlling for the effects of trade. The effect is significant at 5% and it gives that a one percentage point increase in the lagged FDI as share of investment will give a 0, 12%-point increase in the TFP growth rate. The long term effect of the FDI level on the TFP level is given by

$$lnA = \frac{0{,}120}{0{,}152} ln\frac{FDI}{I} \quad \rightarrow \quad \frac{\partial lnA}{\partial \frac{FDI}{I}} = 0{,}79$$

This means that if the FDI share increases with one percentage point, then in the long run South Africa's TFP level will increase with 0,79%. However the significance of this effect disappears in regression 9, indicating that neither the short run growth effect nor the long-run level effect are robust.

The short term effects of both the lagged productivity level at the technological frontier and the trade as share of GDP in table 6.2 are, as they were in table 6.1, still significant though slightly decreased. The long term effect on the TFP level has also decreased slightly. With the manipulated data, if the TFP level at the technological frontier increases with 1%, then the TFP level in South Africa will increase with 0,58% in the long run. And if the trade share is increased by 1% point this will then increase the TFP level in the long-run with 0,85%.

$$lnA = \frac{0,090}{0,155} lnA^* \rightarrow \frac{\partial lnA}{\partial lnA^*} = 0,58$$

$$lnA = \frac{0,132}{0,155} ln\frac{T}{GDP} \rightarrow \frac{\partial lnA}{\partial \frac{T}{GDP}} = 0,85$$

Though the results are slightly lower, it still reveals the robustness of the estimates. It can thus be concluded with a fairly high degree of certainty that there is a positive effect of both the lagged productivity level at the technological frontier and trade as share of GDP.

Regression 10 shows that without the FDI variables the short term effect of the trade variables decreases and long term effect on the TFP level increases. The long-term level effect of the productivity level at the technological frontier increases to 2.

$$lnA = \frac{0,118}{0,059} lnA^* \rightarrow \frac{\partial lnA}{\partial lnA^*} = 2$$

This implies that if the productivity level at the technological frontier increases with 1% then the productivity level in South Africa will increase with 2 %. This is an unlikely result as it not only implies convergence but also that the South African TFP level increases twice as fast as that at the technological frontier. All other evidence covered by this thesis suggests otherwise and so the results of regression 10 are deemed not valid.

The results from table 6.2 have proved the robustness of the effect of trade and productivity at the technological frontier on South Africa's TFP, but it failed to prove the relationship between FDI and TFP. Though a slight indication was given that such a relationship does exist, the results from regression 8 were not robust.

Table 6.2: Regression results, the dependent variable is ΔlnA$_t$

	regression 6	regression 7	regression 8	regression 9	regression 10
Constant	-0,010***	-0,017**	-0,102*	-0,095*	-0,020*
	(0,005)	(0,007)	(0,037)	(0,033)	(0,006)
$\ln A_{(t-1)}$	-0,039	-0,067	-0,152**	-0,155*	-0,059***
	(0,040)	(0,040)	(0,059)	(0,052)	(0,034)
$d(FDI/I)_t$	0,156***	0,081	0,102	0,013	
	(0,087)	(0,088)	(0,075)	(0,070)	
$FDI/I_{(t-1)}$	0,181*	0,124	0,120**	0,037	
	(0,055)	(0,075)	(0,048)	(0,061)	
$d\ln A^*_t$		-0,508		-0,456	-0,426
		(0,359)		(0,284)	(0,269)
$\ln A^*_{(t-1)}$		0,073***		0,090*	0,118*
		(0,042)		(0,033)	(0,027)
$d(T/GDP)_t$			0,326*	0,359*	0,265**
			(0,086)	(0,077)	(0,098)
$T/GDP_{(t-1)}$			0,160**	0,132**	0,089
			(0,062)	(0,056)	(0,103)
R^2	0,262	0,378	0,514	0,650	0,586
period	1972-2010	1972-2010	1972-2010	1972-2010	1972-2010

Standard deviations in parentheses. *,**,*** indicate significance at the 1%, 5% and 10% level.

6.2 Comparing the results to the Theory

Findlay (1978) predicted that foreign direct investment would have a direct impact on productivity growth depending on the recipient's distance from the technological frontier and the amount of presence of foreign firms. What the results of the preceding analysis have shown is that even when averaging the data, the effect of FDI on TFP is not consistently significant. When controlling for the distance to the technological frontier, the significant results that were found in the averaged data disappeared altogether. There was however both robust and consistently significant effects from both the distance to the technological frontier and the trade as share of GDP variables.

What this suggests is that the effect that was described by Findlay (1978) as the contagion hypothesis, namely the presence of foreign capital as share of domestic capital, might not just be FDI but also trade or, as the results from this analysis indicate, mainly trade. When South Africa trades with other nations and foreign companies this is interaction, in many cases, with higher technologically developed countries and companies. This can lead to a “contagion” of technological knowhow that again leads to an increase in the TFP level as the results indicate.

There can be many reasons for why the empirics, in this case, do not comply with the theory. For instance Findlay (1978) does not account for the cost that foreign firms may incur when investing. This may lower the profitability of foreign firms, making it less likely for them to invest. Blanke et al. (2011) point to many problematic factors when doing business and/or investing in countries in Sub-Saharan Africa. Some of them are: corruption, inadequate supply of infrastructure, inefficient government bureaucracy, crime and theft and inadequately educated workforce amongst other things. These are all important factors that are considered by investors when making an investment decision and their presence can decrease the profitability of an investment. This is not accounted for in Findlay (1978) although the cost can help explain the size of foreign investment inflow to South Africa over the last 40 years. Though a major contender on the continent, FDI inflows to South Africa have been relatively low on a world scale and for some years it have even been negative[5].

[5] For explanation on how FDI inflow can be negative see appendix 6.

South Africa was as good as isolated from the technological frontier during the trade blockade that lasted from 1986 until 1993. During this time South Africa's TFP and the TFP at the technological frontier diverged. When the trade blockade was lifted after 1993 the gap between the two started shrinking and the South African TFP now seems to be following the TFP at the technological frontier, though there is no sign of convergence.

It is possible that the model will fit better in the future when more data on a post-apartheid South Africa can be obtained. Africa as a whole and South Africa in particular has seen an increasing interest from foreign investors since 2009 (Blanke et al. 2011) and, if the trend continues, the FDI inflow to South Africa will greatly increase. These changes to the main variables over time will possibly give results that are more in line with the theory if the same regression analysis is conducted on future data.

6.3 Answers to the research question and underlying hypothesis

At the end of chapter 2 the following research question was posed: What effect has foreign direct investment had on the total factor productivity growth of South Africa over the last 40 years? And three underlying hypotheses were formed. The question and hypothesis have been the connecting threads throughout this thesis. They have been answered thoroughly by the different chapters of this paper however; this sub-chapter provides a summarized answer to the questions posed at the outset.

Short answer to the research question:

The analysis has provided no clear answer for this question. Though there is possibly a weak positive effect as some of the regression indicated this cannot be sufficiently proven in this paper. And thus the answer to the research question has to be little to none. However, both methodical difficulties and lack of data can be the cause of the inconclusive results.

Answering the hypotheses:

1. TFP growth has increased after the trade sanctions were lifted in 1993

From evidence presented in chapter 4 it is clear that the TFP growth has indeed increased after 1993 when the trade sanctions were lifted.

2. FDI has increased after the trade sanctions were lifted in 1993

FDI has increased after the trade sanctions were lifted in 1993. As a share of Investment FDI level has increased significantly more that the TFP level.

3. FDI has had a positive significant effect on TFP growth in South Africa over the last 40 years.

This cannot be entirely determined; although some of the results indicate a positive effect the results are not robust.

7. Conclusion

This thesis has investigated the effect of FDI on TFP in South Africa over the period 1971-2011. Findlay (1978) claims that FDI will increase a country's productivity because it increases the presence of foreign investors which bring with them more advanced technology. First the TFP growth rate was calculated for the South African economy. From this calculation it could be seen that South Africa's productivity has increased after the trade embargo was lifted in 1993. Data on FDI inflows revealed a similar trend. As for the effect of FDI on TFP, there were no significant effects to speak of. There were, however, significant and robust effects of both productivity at the technological frontier and trade as share of GDP. This means that there is a "contagion" effect as Findlay (1978) calls it but it works mainly through trade and not through FDI. A problem with the analysis might be that the FDI share in South Africa still is relatively low. If this share were increased this might alter the results.

Previous empirical studies on the topic provide mixed results and there is no underlying consensus. Studies looking at the effect of FDI on TFP and GDP growth in Africa are often represented in the group of studies finding no or few significant results. One of the reasons for this might be the relatively small size of FDI inflows to Africa.

For future research it would be interesting to investigate whether there are sectorial differences in how FDI affects South Africa's TFP. The lack of significant effects in this study can be caused by sectorial differences. It would therefore be interesting to see if such differences exist and, if so, in what sectors FDI would provide the largest positive effects on TFP. An equivalent study to this thesis conducted on future data could also prove interesting as more post-apartheid data could be included and a potential effect of the trend of increased FDI inflows to South Africa could be measured.

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Appendix

Appendix 1: Mathematical review of Findlay (1978)

(2.6) $$A(t) = A_0 e^{nt}$$

(2.7) $$dB/dt = \lambda\left[A_0 e^{nt} - B(t)\right]$$

To find the curve in figure 2.1, (2.2) is re-written in the following manner: Both sides of (2.2) is divided by B(t) making the expression on the left the growth rate.

$$\hat{B} = \lambda\left(\frac{A(t) - B(t)}{B(t)}\right), \text{ where } \hat{B} = \frac{dB/dt}{B} = \frac{\dot{B}}{B}$$

$$\Rightarrow \; = \lambda\left(\frac{A(t)}{B(t)} - 1\right)$$

$$\hat{B} = \lambda\left(\frac{1}{B(t)/A(t)} - 1\right)$$

This is the equation for the curve in figure 2.1 showing the advantage of backwardness.

Differentiating (2.2) using the method of finding the homogeneous and particular solutions gives the following:

Homogeneous solution:

First rewrite the equation, and then define A_0e^{nt} as a function of time independent of B, assume the function equal to zero.

$$\dot{B} = \lambda(A_0 e^{nt} - B(t))$$

$$\dot{B} + \lambda B(t) = f(t) = 0$$

$$\dot{B} = -\lambda B(t)$$

Then integrate, this gives the homogenous solution $B_H(t)$,(C is an unknown constant):

$$\underline{B_H(t) = Ce^{-\lambda t}}$$

Particular solution:

Will now solve the equation using the particular method, this entails "guessing" the integral, since this is an exponential function the answer is likely to include e, the educated guess here then will be the following equation where D is unknown:

$$B_P(t) = De^{nt}$$

Finding D: Start out by integrating De^{nt} as this is the same as the left-hand side of (2.2) insert this and the value for $B_P(t)$ into (2.2) then solving for D.

$$Dne^{nt} = \lambda(A_0 e^{nt} - De^{nt})$$

$$D(n+\lambda) = \lambda A_0$$

$$D = \frac{\lambda A_0}{n+\lambda}$$

Insert D into the equation for $B_P(t)$ which gives the following solution

$$\underline{B_P(t) = \frac{\lambda A_0}{n+\lambda} e^{nt}}$$

Adding the two solutions gives:

$$B(t) = B_P(t) + B_H(t)$$

$$B(t) = \frac{\lambda A_0}{n+\lambda} e^{nt} + Ce^{-\lambda t}$$

When finding C a limit value B_0=B(0) has to be introduced, this is the equations lower boundary.

$$B_0 = B(0) = Ce^{-\lambda * 0} + \frac{\lambda A_0}{n+\lambda} e^{n*0} = C + \frac{\lambda A_0}{n+\lambda}$$

Solving for C then gives

$$C = B_0 - \frac{\lambda A_0}{n+\lambda}$$

Inserting this into the equation for B(t) above gives the following equation:

(2.8) $$B(t) = \frac{\lambda}{(n+\lambda)} A_0 e^{nt} + \frac{(n+\lambda)B_0 - \lambda A_0}{(n+\lambda)} e^{-\lambda t}$$

Defining,

$$x \equiv \frac{B(t)}{A(t)} \qquad y \equiv \frac{K_f(t)}{K_d(t)}$$

Can therefore assume that

(2.9) $$\dot{B}/B = f(x,y)$$

Where,

$$\partial f/\partial x < 0, \ \partial f/\partial y > 0$$

This is because a high x means that the technology gap is low and this will slow technology growth in the backward country, whereas a high y indicates a relatively high presence of foreign capital in the domestic economy, and this will enhance technology growth.

Need an expression for capital accumulation in the domestic sector which is given by taking a fraction, s, of the domestic sector profits and the return form a proportional tax on foreign profits:

$$\dot{K}_d = s(\rho_d(t)K_d(t) + \tau\rho_f(t)K_f(t))$$

$$\dot{K}_d = s\rho_d(t)K_d(t) + s\tau\rho_f(t)K_f(t)\big| / K_d(t)$$

This gives the following equation:

(2.10) $$\frac{\dot{K}_d}{K_d} = s\rho_d(t) + s\tau\rho_f(t)\frac{K_f(t)}{K_d(t)}$$

Then the domestic and foreign profits need to be defined; assume that $\rho_d(t) = \rho_d(0) = \bar{\rho}_d(t)$ for all t, so there is a constant domestic profit rate throughout time, the foreign profit rate is given by the distance to the technological frontier. This can be seen in figure 2.3 chapter 2 of the thesis.

(2.6) $$\rho_f(t) = R\left[B(t)/A(t)\right] \qquad \text{with} \qquad R' < 0$$

The rate of growth in the foreign sector's capital stock is proportional to the net retained profits from that sector giving the following equation (2.7), where r is a constant fraction of after tax profits that will be invested in the backward economy.

(2.7) $$\frac{\dot{K}_f}{K_f} = r(1-\tau)\rho_f(t)$$

Can now formulate the dynamic model:

(2.8) $$\dot{x} = \phi(x, y)$$

(2.9) $$\dot{y} = \psi(x, y)$$

Differentiate x with respect to time

$$x = \frac{B}{A} \rightarrow \dot{x} = \frac{\dot{B}A - B\dot{A}}{A^2}$$

this gives the equation

(2.10) $$\dot{x} = B / A\left[(\dot{B} / B) - (\dot{A} / A)\right],$$ (x-isocline)

Because $\dot{A}/A = n$ all combinations of x and y where $\dot{B}/B = n$ will yield $\dot{x} = 0$. $\dot{B}/B$ is a decreasing function of x and an increasing function of y, given by (2.4)

$$\partial\dot{x} / \partial x < 0, \; \partial\dot{x} / \partial y > 0$$

Correspondingly the y-isocline can be found by differentiation y with respect to time

$$y = \frac{K_f}{K_d} \rightarrow \dot{y} = \frac{\dot{K}_f K_d - K_f \dot{K}_d}{K_d{}^2}$$

(2.11) $$\dot{y} = K_f / K_d\left[(\dot{K}_f / K_f) - (\dot{K}_d / K_d)\right]$$ (y-isocline)

Will find when the y-isocline equals zero by inserting (2.5), (2.6) and (2.7) into (2.11) and equaling the equation to zero.

$$\underbrace{K_f / K_d}_{y}\left[(\dot{K}_f / K_f) - (\dot{K}_d / K_d)\right] = 0$$

$$\Rightarrow y\left[r(1-\tau)\rho_f(t) - \left(s\rho_d(t) + s\tau\rho_f(t)\underbrace{\frac{K_f(t)}{K_d(t)}}_{y}\right)\right] = 0$$

$$\Rightarrow \left[r(1-\tau)\rho_f(t) - s\rho_d(t) - s\tau\rho_f(t)y\right]y = 0$$

$$\Rightarrow \rho_f(t)\left[r(1-\tau) - s\tau y)\right] - s\rho_d(t) = 0$$

Since $\rho_d(t) = \rho_d(0) = \bar{\rho}_d$

This gives the equation (2.12) which is a required condition for the y-isocline to equal zero.

(2.12) $$\rho_f(t) = R(x) = \frac{s\bar{\rho}_d}{r(1-\tau) - s\tau y}$$

By inserting (2.12) into (2.11) and differentiating with respects to y and x we get

$$\dot{y} = \left[r(1-\tau)\rho_f(t) - s\rho_d(t) - s \right] y$$
$$\frac{\partial \dot{y}}{\partial y} = r(1-\tau)\rho_f(t) - s\rho_d(t) - 2s\tau\rho_f(t)y$$

When $\dot{y} = 0$ then

$$\rho_f(t) = \frac{s\rho_d(t)}{r(1-\tau) - s\tau y} \Rightarrow s\rho_d(t) = r(1-\tau)\rho_f(t) - s\tau y \rho_f(t)$$

Insert for this in $\frac{\partial \dot{y}}{\partial y}$:

$$\frac{\partial \dot{y}}{\partial y} = r(1-\tau)\rho_f(t) - (r(1-\tau)\rho_f(t) - s\tau y \rho_f(t)) - 2s\tau\rho_f(t)y$$

This gives:

(2.13) $$\left.\frac{\partial \dot{y}}{\partial y}\right|_{\dot{y}=0} = -s\tau\rho_f y < 0$$

As $\rho_f = R(x)$ there is only need to insert for this when we are differentiating with respect to x,

$$\dot{y} = \left[r(1-\tau)R(x) - s\rho_d(t) - s\tau R(x)y \right] y$$

$$\left.\frac{\partial \dot{y}}{\partial x}\right|_{\dot{y}=0} = r(1-\tau)R'(x)y - s\tau R'(x)y^2$$

(2.14) $$\left.\frac{\partial \dot{y}}{\partial x}\right|_{\dot{y}=0} = \left[r(1-\tau) - s\tau y\right]R'(x)y < 0$$

(2.13) and (2.14) are both negative and so the trace condition is fulfilled, the model also gives

$\partial\dot{x} / \partial x < 0$ and $\partial\dot{x} / \partial y > 0$

$$\underset{+}{[--]} - \underset{-}{[-+]} > 0$$

This means that the determination condition is fulfilled and along with the trace conditions this means that the equilibrium is stable.

(2.15) $$\left\{\frac{\partial \dot{x}}{\partial x}\frac{\partial \dot{y}}{\partial y} - \frac{\partial \dot{y}}{\partial x}\frac{\partial \dot{x}}{\partial y}\right\} > 0$$

Appendix 2: Estimations of TFP using OLS.

Estimated values using OLS on datasets 1 and 2. South Africa's GDP growth was the dependent variable.

	constant	capital growth	Labor force/population growth
Dataset 1 (1991-2010):			
Raw data	0,005	0,576	0,359
	(0,020)	(0,461)	(0,415)
Moving average, 3 years	0,059**	0,298	-1,178
	(0,032)	(0,498)	(0,750)
Moving average, 5 years	0,063	0,462	-1,381
	(0,037)	(0,653)	(0,842)
Dataset 2 (1971-2011):			
Raw data	0,037*	0,248	-0,920
	(0,016)	(0,173)	(0,703)
Moving average, 3 years	0,045*	0,275*	-1,299*
	(0,011)	(0,105)	(0,477)
Moving average, 5 years	0,052*	0,303*	-1,620*
	(0,007)	(0,065)	(0,329)

Standard deviations in parentheses. * and** indicate significance at level 5% and 10%

Appendix 3: Data used for TFP calculations

Data description:

Variables	explanation	average	standard deviation	source
$\dot{Y}/Y$	GDP growth rate	dataset 1: 0,026859 dataset 2: 0,02589	dataset 1: 0,021893 dataset 2: 0,02302	worldbank.org
$\dot{K}/K$	Fixed capital growth rate	dataset 1: 0,020139 dataset 2: 0,030256	dataset 1: 0,01444 dataset 2: 0,020601	Quantec.co.za
$\dot{L}/L$	Labor force growth rate (for dataset1) Population growth rate (for dataset2)	dataset 1: 0,028382 dataset 2:0,02043	dataset 1: 0,01603 dataset 2: 0,005065	worldbank.org
$\dot{A}/A$	Calculated total factor productivity	dataset 1: 0,00221 dataset 2: 0,000562	dataset 1: 0,021474 dataset 2: 0,023178	Quantec.co.za, worldbank.org, treasury.gov.za
α	Labor factor share	dataset 1: 0,473795 dataset 2: 0,498418	dataset 1: 0,031168 dataset 2: 0,037385	treasury.gov.za, Quantec.co.za, Worldbank.org

Dataset 1:

	$\dot{A}/A$	$\dot{Y}/Y$	α	(1-α)	$\dot{L}/L$	$\dot{K}/K$
1991	-0,034	-0,010	0,516	0,484	0,038	0,009
1992	-0,045	-0,021	0,524	0,476	0,041	0,005
1993	-0,010	0,012	0,512	0,488	0,040	0,004
1994	0,008	0,032	0,502	0,498	0,042	0,007
1995	0,007	0,031	0,501	0,499	0,037	0,011
1996	0,016	0,043	0,499	0,501	0,039	0,015
1997	0,000	0,026	0,496	0,504	0,037	0,016
1998	-0,022	0,005	0,502	0,498	0,037	0,018
1999	-0,001	0,024	0,497	0,503	0,039	0,009
2000	0,018	0,042	0,480	0,520	0,038	0,010
2001	0,006	0,027	0,466	0,534	0,033	0,011
2002	0,019	0,037	0,445	0,555	0,026	0,011
2003	0,010	0,029	0,450	0,550	0,025	0,015
2004	0,026	0,046	0,441	0,559	0,019	0,020
2005	0,029	0,053	0,435	0,565	0,021	0,025
2006	0,027	0,056	0,427	0,573	0,022	0,034
2007	0,020	0,055	0,438	0,562	0,024	0,045
2008	-0,009	0,036	0,438	0,562	0,038	0,050
2009	-0,036	-0,015	0,451	0,549	-0,014	0,050
2010	0,015	0,029	0,455	0,545	-0,015	0,037

Dataset 2:

	$\dot{A}/A$	$\dot{Y}/Y$	α	(1-α)	$\dot{L}/L$	$\dot{K}/K$
1971	-0,001	0,043	0,561	0,439	0,023	0,069
1972	-0,027	0,017	0,556	0,444	0,023	0,069
1973	0,003	0,046	0,526	0,474	0,023	0,066
1974	0,018	0,061	0,514	0,486	0,023	0,065
1975	-0,027	0,017	0,539	0,461	0,022	0,068
1976	-0,016	0,022	0,554	0,446	0,022	0,060
1977	-0,034	-0,001	0,546	0,454	0,021	0,048
1978	0,000	0,030	0,524	0,476	0,021	0,039
1979	0,008	0,038	0,509	0,491	0,022	0,038
1980	0,029	0,066	0,473	0,527	0,024	0,049
1981	0,016	0,054	0,516	0,484	0,025	0,051
1982	-0,037	-0,004	0,543	0,457	0,025	0,041
1983	-0,048	-0,018	0,535	0,465	0,026	0,034
1984	0,023	0,051	0,539	0,461	0,026	0,029
1985	-0,036	-0,012	0,521	0,479	0,026	0,021
1986	-0,017	0,000	0,516	0,484	0,026	0,009
1987	0,006	0,021	0,518	0,482	0,025	0,005
1988	0,024	0,042	0,505	0,495	0,024	0,012
1989	0,005	0,024	0,503	0,497	0,023	0,015
1990	-0,020	-0,003	0,514	0,486	0,021	0,014
1991	-0,025	-0,010	0,516	0,484	0,021	0,009
1992	-0,035	-0,021	0,524	0,476	0,021	0,005
1993	-0,001	0,012	0,512	0,488	0,021	0,004
1994	0,018	0,032	0,502	0,498	0,022	0,007
1995	0,015	0,031	0,501	0,499	0,022	0,011
1996	0,024	0,043	0,499	0,501	0,023	0,015
1997	0,007	0,026	0,496	0,504	0,023	0,016
1998	-0,015	0,005	0,502	0,498	0,024	0,018
1999	0,007	0,024	0,497	0,503	0,024	0,009
2000	0,024	0,042	0,480	0,520	0,025	0,010
2001	0,012	0,027	0,466	0,534	0,021	0,011
2002	0,024	0,037	0,445	0,555	0,014	0,011
2003	0,015	0,029	0,450	0,550	0,013	0,015
2004	0,029	0,046	0,441	0,559	0,012	0,020
2005	0,033	0,053	0,435	0,565	0,011	0,025
2006	0,032	0,056	0,427	0,573	0,011	0,034
2007	0,025	0,055	0,438	0,562	0,011	0,045
2008	0,003	0,036	0,438	0,562	0,011	0,050
2009	-0,047	-0,015	0,451	0,549	0,011	0,050
2010	0,003	0,029	0,455	0,545	0,014	0,037
2011	0,006	0,031	0,449	0,551	0,012	0,037

Appendix 3: Data used for the error correction model estimation

Data description:

Variables	explanation	average	standard deviation	Source
lnA	Total Factor productivity, (Index normalized to 1 in 1971)	-0,080	0,073	Quantec.co.za, worldbank.org, treasury.gov.za
FDI/I	Foreign direct investment as share of Investment (Gross fixed capital formation)	0,039	0,072	unctadstat.unctad.org
lnA*	Total Factor productivity in the US, (Index normalized to 1 in 1971)	0,156	0,091	stats.bls.gov
T/GDP	Total trade as share of GDP	0,527	0,074	Worldbank.org

Correlation matrixes for the data used by the error correction model:

1971-2011	lnA	FDI/I	A*	T/I
lnA	1.0000	0.2119	0.2584	0.7445
FDI/I	0.2119	1.0000	0.4102	0.2411
A*	0.2584	0.4102	1.0000	0.2877
T/I	0.7445	0.2411	0.2877	1.0000

1971-1993	lnA	FDI/I	A*	T/I
lnA	1.0000	0.5107	-0.9095	0.6197
FDI/I	0.5107	1.0000	-0.5945	-0.0941
A*	-0.9095	-0.5945	1.0000	-0.4675
T/I	0.6197	-0.0941	-0.4675	1.0000

1994-2011	lnA	FDI/I	A*	T/I
lnA	1.0000	0.0261	0.9532	0.8259
FDI/I	0.0261	1.0000	0.0011	0.2290
A*	0.9532	0.0011	1.0000	0.7397
T/I	0.8259	0.2290	0.7397	1.0000

Dataset:

	lnA	dlnA	FDI/I	d(FDI/I)	lnA*	dlnA*	T/GDP	d(T/GDP)
1971	0,000	..	0,051	..	0,000	..	0,480	..
1972	-0,027	-0,027	0,021	-0,030	0,029	0,029	0,482	0,002
1973	-0,025	0,003	0,004	-0,017	0,055	0,027	0,481	0,000
1974	-0,006	0,018	0,079	0,075	0,022	-0,034	0,565	0,084
1975	-0,033	-0,027	0,018	-0,061	0,031	0,010	0,578	0,013
1976	-0,051	-0,017	0,002	-0,016	0,066	0,034	0,567	-0,011
1977	-0,087	-0,037	-0,011	-0,013	0,082	0,016	0,555	-0,012
1978	-0,087	0,000	-0,009	0,002	0,093	0,012	0,580	0,025
1979	-0,078	0,009	-0,034	-0,024	0,090	-0,004	0,610	0,030
1980	-0,047	0,031	0,000	0,033	0,069	-0,021	0,627	0,018
1981	-0,030	0,017	0,003	0,003	0,070	0,002	0,587	-0,040
1982	-0,068	-0,038	0,015	0,012	0,039	-0,031	0,533	-0,054
1983	-0,121	-0,053	0,003	-0,012	0,067	0,028	0,457	-0,076
1984	-0,095	0,026	0,021	0,017	0,094	0,028	0,491	0,034
1985	-0,136	-0,041	-0,029	-0,050	0,106	0,012	0,540	0,049
1986	-0,156	-0,020	-0,032	-0,003	0,120	0,014	0,523	-0,016
1987	-0,149	0,006	-0,010	0,022	0,124	0,004	0,506	-0,017
1988	-0,122	0,028	0,007	0,017	0,131	0,007	0,517	0,011
1989	-0,116	0,006	-0,008	-0,015	0,134	0,003	0,481	-0,036
1990	-0,139	-0,023	-0,004	0,005	0,139	0,005	0,430	-0,051
1991	-0,169	-0,030	0,012	0,016	0,130	-0,009	0,392	-0,038
1992	-0,211	-0,042	0,000	-0,012	0,153	0,023	0,386	-0,006
1993	-0,212	-0,001	0,001	0,000	0,154	0,002	0,403	0,016
1994	-0,190	0,022	0,018	0,018	0,160	0,006	0,420	0,017
1995	-0,172	0,017	0,052	0,033	0,158	-0,003	0,449	0,029
1996	-0,144	0,028	0,035	-0,017	0,172	0,014	0,479	0,031
1997	-0,136	0,008	0,155	0,120	0,179	0,007	0,480	0,001
1998	-0,154	-0,018	0,024	-0,131	0,191	0,012	0,502	0,021
1999	-0,146	0,008	0,073	0,049	0,206	0,015	0,481	-0,021
2000	-0,119	0,028	0,044	-0,029	0,220	0,014	0,528	0,047
2001	-0,105	0,013	0,380	0,336	0,226	0,006	0,562	0,034
2002	-0,078	0,027	0,096	-0,284	0,245	0,019	0,620	0,058
2003	-0,062	0,016	0,028	-0,068	0,266	0,021	0,534	-0,086
2004	-0,031	0,031	0,023	-0,005	0,284	0,018	0,531	-0,003
2005	0,002	0,034	0,160	0,137	0,292	0,007	0,552	0,021
2006	0,034	0,031	-0,011	-0,171	0,296	0,004	0,625	0,072
2007	0,058	0,024	0,099	0,110	0,298	0,002	0,655	0,031
2008	0,061	0,003	0,145	0,046	0,289	-0,009	0,746	0,091
2009	0,015	-0,046	0,084	-0,061	0,283	-0,006	0,557	-0,190
2010	0,018	0,003	0,017	-0,066	0,308	0,025	0,549	-0,008
2011	0,023	0,005	0,075	0,058	0,310	0,002	0,583	0,034

Appendix 4: Testing for unit root, Augmented Dickey-Fuller test

The test was performed in StataIC10. As the number of lags can vary the results, the test was run for zero to four lags; the results can be seen in the tables below.

Level variables:

Lags	0	1	2	3	4
1971-2011					
lnA	-1.161	-1.370	-1.283	-1.255	-0.684
FDI/I	-5.893*	-4.130**	-3.413***	-2.294	-2.646
lnA*	-2.454	-2.702	-2.677	-2.325	-1.937
T/GDP	-2.188	-2.251	-2.045	-0.951	-1.053

Sample size: 40 at zero lags, constant term and trend included, 1%*: -4,24, 5%**: -3,54, 10%***:- 3,20

Differentiated variables:

Lags	0	1	2	3	4
1971-2011					
dlnA	-4.569*	-4.370 *	-4.067**	-3.777**	-3.334***
dFDI/I	-10.193*	-6.870*	-8.156*	-3.737**	-4.134*
dlnA*	-6.004*	-5.134*	-3.799**	-3.751**	-4.098**
d(T/GDP)	-6.042*	-4.708*	-5.379*	-3.707**	-3.434***

Sample size: 40 at zero lags, intercept and trend included, 1%*: -4,24, 5%**: -3,54, 10%***:- 3,20

The tests show that none of the level variables are significant and therefore they are non-stationary. This is true for both time periods. The differentiated variables however are significant at different levels and so the differentiated variables are stationary. This entails that the level variables are non-stationary with one unit root. If the variables are co-integrated as will be shown in the next appendix then the error correction model is correctly specified.

Appendix 5: Testing for co-integration

The Augmented Dickey- Fuller test for unit root was run on the error terms of all 8 regressions. All the error terms are significant meaning that they do not contain a unit root and they are therefore stationary. This implies that the regressions are co-integrated and the use of an error correction model is correct.

Lags	0	1	2	3	4
1971-2011					
u_t, regression 1	-4.758*	-4.538*	-4.263*	-3.879**	-3.828**
u_t, regression 2	-4.722*	-4.310*	-3.838**	-3.418***	-3.095
u_t, regression 3	-4.955*	-5.124*	-4.176**	-5.013*	-4.986*
u_t, regression 4	-4.777*	-4.706*	-4.134**	-4.872*	-4.602*

Sample size: 39 at zero lags, intercept and trend included, 1%*: -4,25, 5%**: -3,54, 10%***:- 3,20

Appendix 6: Foreign direct investment description

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"Foreign direct investment (FDI) is defined as an investment involving a long-term relationship and reflecting a lasting interest in and control by a resident entity in one economy (foreign direct investor or parent enterprise) of an enterprise resident in a different economy (FDI enterprise or affiliate enterprise or foreign affiliate). Such investment involves both the initial transaction between the two entities and all subsequent transactions between them and among foreign affiliates.

FDI inflows and outflows comprise capital provided (either directly or through other related enterprises) by a foreign direct investor to a FDI enterprise, or capital received by a foreign direct investor from a FDI enterprise. FDI includes the three following components: equity capital, reinvested earnings and intra-company loans. Data on FDI flows are presented on net bases (capital transactions' credits less debits between direct investors and their foreign affiliates). Net decreases in assets or net increases in liabilities are recorded as credits, while net increases in assets or net decreases in liabilities are recorded as debits. Hence, FDI flows with a negative sign indicate that at least one of the three components of FDI is negative and not offset by positive amounts of the remaining components. These are called reverse investment or disinvestment." *(unctadstat.unctad.org/TableViewer/summary.aspx?ReportId=88)*