Working paper[1]

Forecasting South Africa's Median Growth using a Marshallian Model: A discussion on social ingredients

Jacques Kibambe, Renée Van Eyden, Charlotte Du Toit[2]

Abstract

In this research article, per capita expenditures on health and schooling are utilized in the estimation of a coefficient of labour effectiveness per industrial sectors of the South African economy. Theoretical models are presented and include three cases scenario concerning the effects of health (human constraints like HIV infection) as labour augmentation factor and schooling in a growth accounting equation. Additionally, this research provides a fourth scenario that discusses the diffusion process in the technological progress at the South African sectoral level and its impact on the study of social ingredients. Using a fixed effects model, some features of the diffusion process are explained. This paper makes use of the 'Seemingly Unrelated' equations systems with other smoothing techniques such as the Holt Winters Exponential filters to define a coefficient of labour effectiveness and re estimate sectoral production functions using effective labour. Outcomes of this research are used as ingredients into a marshallian macroeconomic model that utilises the Stein like shrinkages techniques to produce forecasting estimates.

Keywords: Coefficient of effectiveness; Diffusion process; Fixed effects model; Marshallian Macroeconomic Model; Seemingly Unrelated Regressions.

---

[1] The present document constitutes a section of a larger project titled: "Forecasting the South African Median Growth: A Marshallian Macroeconomic Model". The marshallian model (see appendix) includes at least three types of equations: supply; demand; and entry/exit equations. The estimates make use of point or turning point forecasts with some restrictions. In order to obtain improved estimations and predictive precisions for both sectors, our marshallian model combines Stein–like shrinkage techniques. The model also includes, level variables, leading indicator variables and time varying parameters to allow for possible structural breaks or any other factors causing time variance.

[2] Both authors are from the University of Pretoria and they can be contacted via email at the following addresses: Professor Charlotte Du Toit (charlotte.dutoit@up.ac.za); Professor Renée Van Eyden (renee.vaneyden@up.ac.za); and Jacques Kibambe Ngoie, PhD candidate (jacques.kibambe@up.ac.za).

1. INTRODUCTION

The importance of health as human capital has captivated the attention of several researches in macroeconomic as well as policy reports. Developments in the world economy are closely linked to health related predicaments. The labour force through its productivity sees its contribution to economic growth enhanced by human factors such as: the workers endurance and capacities (mental or physical); the workers aptitude to make use of their reasoning ability; the workers devotion to deliver efficiently on time; etc (Canning & Bloom, 2005). The design of any valid macroeconomic policy cannot be performed without inclusion of a health component. A clear underestimation of this reality has often been committed in panel studies on the macroeconomic impact of health that associate health to education. The two might be related as human capital determinants. However, health on its own also constitutes an important ingredient in any growth or development studies. Both require a particular consideration especially on their effects on effective labour.

The disaggregating approach used in this study helps comparing effects of increasing investment on health or schooling at sectoral and national level. One cannot disregard the fact that a healthier worker with higher educational background and more experience is meant to be more productive. Theretofore, the use of physical labour force features ignoring the effectiveness aspect is no longer sufficient in explaining the production setting. Our exercise does not ignore the fact that the technological components also have a labour related contribution. The coefficient of effectiveness used in this paper includes the level of health and schooling investment per worker as well as the level of experience. It remains plausible that other labour augmentation factors have been omitted in our analysis. Nevertheless, useful outcomes can be extracted.

The importance of health in macroeconomic models is much more perceptible in less developed countries where the majority of economies are labour intensive. A stronger level of labour effectiveness will tend to rise up the economic growth and vice-versa. More evidence of these effects has been garnered using microeconomic approaches (Strauss & Thomas, 1998).

The objective of this research is to show that building up a full fledged marshallian macroeconomic model using effective labour is a valid exercise that is much more informative than the traditional macroeconomic models. Secondly the paper aims at presenting evidence that outcomes of investment in health and/or schooling differ according to the sector targeted. We present some parameter estimates for South African productive sectors and the models are meant to be used for any other African economy. Accordingly, this research incorporates an analysis of the technological diffusion process in South African productive sectors.

Health has often been measured in terms of life expectancy. From an expenditure perspective, per capita (or per worker) health expenditures can also be used as an indication of health when data on life expectancy are unavailable. The same is applicable for schooling. Using our calculated effective variables (labour and wage), we have reestimated, in another paper, a complete marshallian model with performed forecasting comparisons between Bayesian and non-bayesian techniques with and without shrinkages for both output growth rates and inflation rates (Kibambe *et al*, 2007). The pathways investigated in this research are plausible in explaining the macroeconomic effect of health and schooling in the South African economy. Nevertheless, data restrictions put limitations to our study. We could only perform the analysis of five sectors (Agriculture; Mining; Constructions & Buildings; Transport & Communications; Manufacturing) from 1995 until 2006.

2. BACKGROUND

As mentioned earlier, social ingredients, which appear in various forms in the growth theory, have a relatively rich history. They underscore most of economic thinking on the issue. Health and education are among the most important social ingredients referred to in macroeconomic studies. From the different papers we could locate, health is presented in the form of life expectancy (see table 1) while weighted average of total years of schooling is the proxy used for education.

The use of effective labour, defined in terms of social variables, has produced interesting outcomes in terms of policy analysis. A study conducted by Fogel (1994) provides evidence that large part of the British economic growth in the 70s (1970 – 1980) was the result of a larger volume of effective labour inputs. Effective labour input was associated with workers with improved health condition and sufficient nutrition. Very similar results were obtained for the Korean economy where improved nutrition caused available labour inputs to rise by one percent for the period 1962 to 1995 (Sohn, 2000).

The effects of health improvement on economic growth follow different channels that converge toward income growth (Bloom *et al.* 2000, 2002, 2003). Investment in human capital associated with labour market participation and worker productivity have influenced the path of economic growth.

An interesting debate raised around the macroeconomic effects of health is that many regressions run in past studies were unable to indicate whether the coefficients obtained were the true reflects of the direct benefits of health on growth or whether it was just a mere proxy of other mismeasured variables (Bloom *et al*. 2003). In order to assuage this criticism, Bloom *et al.* included health in a full-fledged production function and they conducted several tests to determine the direct effect of health on labour productivity. Their model encompasses multiple dimensions of human capital in an aggregate growth function. The combination of life expectancy and years of schooling used by Bloom *et al.* (2005) in their modelling of a coefficient of effectiveness remains a major contribution to the macroeconomic of health. Few questions can be raised around the assumption that the coefficient of effectiveness is equal to one whenever life expectancy and years of schooling are simultaneously equal to zero though. To that extend it is important to enforce that the two parameters are specify in such a way that when health (life expectancy) equals zero the coefficient of effectiveness automatically equals one no matter what value takes the parameter of schooling. In fact, it is hardly conceivable that a workforce unit can increase its effectiveness just by using schooling. In our approach, we have introduced a third factor that is the level of experience acquired. When a worker has no life expectancy, none of the other factors can improve his effectiveness. However, when a worker has some life expectancy with a certain level of education, his effectiveness will be increased by a higher level of experience. The present research does not provide enough tests that indicate whether the impact of experience in the coefficient of effectiveness is not mixed up with other mismeasured factors.

A seemingly difficult exercise to conduct has been the establishment of existing relationship between education (schooling) and economic growth. The majority of studies conducted earlier on schooling as social ingredient to economic growth made use of variables such as: school enrolment; literacy rates; years of schooling; etc. Schooling reflects skill and higher productivity. A higher level of education in the workforce increases the absorption rate of high technology (Barro *et al*. 2000). The interesting question raised in Barro's study relates to the adequacy of these variables in the measurement of the stock of available human capital. The matter is addressed by measuring educational attainment for a panel of countries conducted on intervals of five years. The paper provides relevant findings in term of advice on how to measure the macroeconomic impact of schooling. They made adjustments to cover missing observations using gross school enrolment features capturing the movement from repeaters. Additionally, the average years of schooling used in that research accounts for amendments in the length of schooling in the panel. Our research addresses the issue slightly differently considering the public expenditure side. Both health and schooling are defined in terms of per capita expenditure. It might be unwise to argue that more money spent by the government on schooling or health will directly translates into a larger contribution of these two factors in economic growth. However, once the assumption of efficient use of government expenditures is made, higher per capita expenditures on health or schooling appear as a greater investment in human capital that is expected to generate higher worker productivity. Addressing the issue from an expenditure point of view allow avoiding some of the criticisms made toward earlier studies concerning a potential bias that could occur in estimating the effects of the macroeconomic of health (life expectancy) in countries or sectors with high features for life expectancy. These countries or sectors tend to have older workforces (ageing phenomenon) and that does not always translate into greater labour productivity. Nevertheless, older workforces with higher experience are meant to be more productive as long as they remain in the working age.

3. THEORETICAL MODELS

3.1. Production functions

Assuming a marshallian economy with *n* sectors operating at time t with each a Cobb-Douglas production specification (Zellner, 2003):

$$Q_{it} = A_{iN}(z_{it}L_{it})^{\alpha} K_{it}^{\beta} \quad (1)$$

With: - A_{iN} : Neutral technological change factor per sector;

- z_{it} : Labour augmentation factor reflecting changes in labour quality.

The assumption used in the estimations is that technological factors remain constant over the time period considered as it is a relatively short sample size (11 years). However a good discussion is provided in this theoretical part developing the similar exercise with technological factors varying over time. From the existing literature (see Bloom *et al.*), the coefficient of effectiveness is presented as follows:

$$z_{it} = e^{\gamma s_t + \delta h_t + E_t} \quad (2)$$

However the variable E (index measuring the level of experience or training[3]) is an addition from our own model specification. In this equation, the level of experience that a worker requires in order to perform decently his task in a specific sector also appears in the calculation of z. When the summation of s (per capita investment in schooling), h (per capita investment in health), and E equal zero, therefore the coefficient of effectiveness (z) equals one.

$$z = 1 \quad for\ s; h; E = 0 \text{ and } \ln z = 0 .$$

Logging our z function: $\ln z_{it} = \gamma s_t + \delta h_t + E_{iL}$ (3)

Logging our production function and including the z function:

$$\ln Q_{it} = \ln A_{iN} + \alpha \ln z_{it} + \alpha \ln L_{it} + \beta \ln K_{it} \tag{4}$$

$$\ln Q_{it} = \ln A_{iN} + \alpha\gamma s_t + \alpha\delta h_t + \alpha E_{iL} + \alpha \ln L_{it} + \beta \ln K_{it} \tag{5}$$

The growth accounting equation is obtained with the signs of elasticities by deriving both sides of equation 5 with respect to time. To this regard, two cases scenario are discussed in this paper. Another plausible pathway (see scenario 3) investigated only theoretically in this research lies on the fact that workforces go through a process of recruitment before forming part of a specific industrial sector. Should the industrialised sector decide to recruit someone, a minimum level of investment on health and education is required to be observed in the individual. In other words, at recruitment, the worker is expected to have a certain level of education and to be in good health condition. Theretofore the model specification can be written as follows:

$$z_{it} = e^{\gamma(s_t - s_o) + \delta(h_t - h_o) + E_t} \tag{6}$$

Where s_o and h_o are respectively the minimum levels of money to be invested per unit of workforce. The more money is invested on the worker in terms of health and education, the more productive she is. When there is no extra money spends, with a level of training (E) that is null (case of a novice in the sector), the coefficient of effectiveness equals one. If the worker has acquired experience from previous exposure, E will be greater than one. A delicate exercise will be to find the threshold in terms of basic requirements per industrial sectors (s_o and h_o). At this stage, only general assumptions can be. However the theoretical model is described in scenario 3 which is an amendment of scenario 1 and 2.

[3] It takes the value of zero when the worker has no experience at all and increase according to the level of experience or training acquired.

Scenario 1: A general approach without specific disentangling of A_{iN} ***(assumed to be constant over time).***

$$\dot{Q}_{it} / Q_{it} = \alpha\gamma \dot{s}_t + \alpha\delta \dot{h}_t + \alpha \dot{E}_{it} + \alpha \dot{L}_{it} / L_{it} + \beta \dot{K}_{it} / K_{it} \quad (7)$$

With: $G_Q = \dot{Q} / Q$

$G_L = \dot{L} / L$

$G_K = \dot{K} / K$

The growth accounting equation can be written as follows:

$$G_Q = \alpha\gamma \dot{s}_t + \alpha\delta \dot{h}_t + \alpha \dot{E}_t + \alpha G_L + \beta G_K \quad (8)$$

$$G_Q = \alpha(\gamma \dot{s}_t + \delta \dot{h}_t + \dot{E}_t + G_L) + \beta G_K \quad (9)$$

Assuming an annual increase (*dt = 1*), increasing investment in human capital such as health per capita $\dot{h}$ by one monetary unit will lead to a '$\alpha\delta$' increase in the growth rate of output. Additionally, an increase by one monetary unit of schooling expenditure per capita will lead the growth rate of output to increase by'$\alpha\gamma$ '. Using these outcomes, we can compare the effects of more investment in human capital on the growth rate and make policy recommendations in terms of a sectoral scheme of expenditures in both health and schooling.

Scenario 2: A more specific approach that includes HIV factors as affecting z_{it} ***assuming that the technological factors vary across time.***

The two HIV factors included are the death rate and the absenteeism rate due to advance stage of the infection. It is considered that these factors are among variables affecting the labour augmentation factor.

$$Q_{it} = A_{itN} [z_{it} (T_{it}; a_{it}; d_{it}; o_{it}) L_{it}]^{\alpha} K_{it}^{\beta} \quad (10)$$

- T_{it}: Level of technological investment in labour units;
- a_{it}: Work absenteeism observable in HIV patients;
- d_{it}: Death rate associated to HIV pandemic;
- o_{it}: Other technological factors linked to labour.

Logging both sides of equation 10 and deriving it with respect to time, the growth accounting equation is obtained as follows:

$$\ln Q_{it} = \ln A_{itN} + \alpha \ln z_{it}(T_{it}; a_{it}; d_{it}; o_{it}) + \alpha \ln L_{it} + \beta \ln K_{it} \tag{11}$$

Deriving the all equation with respect to time we obtain the following:

$$\dot{Q}_{it} / Q_{it} = \dot{A}_{itN} / A_{itN} + \alpha \left[\frac{\partial \ln z_{it}}{\partial T_{it}} . \frac{dT_{it}}{dt} + \frac{\partial \ln z_{it}}{\partial a_{it}} . \frac{da_{it}}{dt} + \frac{\partial \ln z_{it}}{\partial d_{it}} . \frac{dd_{it}}{dt} + \frac{\partial \ln z_{it}}{\partial o_{it}} . \frac{do_{it}}{dt} \right] + \alpha \dot{L}_{it} / L_{it} + \beta \dot{K}_{it} / K_{it} \tag{12}$$

+ + + - - - - - - + +

$$G_Q = G_{AN} + \alpha \left[\frac{\partial \ln z_{itL}}{\partial T_{it}} . \frac{dT_{it}}{dt} + \frac{\partial \ln z_{itL}}{\partial a_{it}} . \frac{da_{it}}{dt} + \frac{\partial \ln z_{itL}}{\partial d_{it}} . \frac{dd_{it}}{dt} + \frac{\partial \ln z_{itL}}{\partial o_{it}} . \frac{do_{it}}{dt} \right] + \alpha G_L + \beta G_K \tag{13}$$

Assuming that ARV (Antiretroviral) policies are well implemented over time and both absenteeism and death rates decrease across time period, the result will be that output growth rate in the economy will be strengthen. Otherwise, assuming an increase in *a* and *d* over time, the all output growth rate will be reduced by that effect. Good health policies in terms of HIV should enforce that absenteeism as well as death rates are reduced in developmental sectors to support a more consistent economic growth. Both *a* (absenteeism rate) and *d* (death rate) are assumed to be diminishing over time assuming that ARV policies reduce both parameters: *a*; and *d.* The HIV prevalence rate itself follows a sigmoid pattern.

Considering the sigmoid approach this issue can be addressed on a slightly different manner. In the African context, policy measures have very little effect on controlling the dynamics of HIV/AIDS. For this reason, referring to related literature, we can depict the production implications of HIV/AIDS through a non-linear function assumed to be logistic (see graph 1).

The first stage of the HIV prevalence is expected to be exponential. And as antiretroviral treatment is supplied together with other preventive and counter cyclical actions, the prevalence decreases and is expected to decrease and stop in the long run.

Herewith the parameters we have introduced in the labour augmentation factor concerning HIV:

- *h(t):* HIV prevalence rate;
- *a(t):*work absenteeism observable in HIV/AIDS patients;
- *d(t):* death rate associated to HIV/AIDS pandemic;

The present research assumes the following:

$$h(t) = \varphi_i \frac{1}{1 + e^{-t}} = \varphi_i \frac{e^t}{1 + e^t} \tag{14}$$

$$a(t) = \varphi_i \frac{e^{t - \tilde{\tilde{a}}}}{1 + e^{t - \tilde{\tilde{a}}}} \tag{15}$$

$$d(t) = \varphi_i \frac{e^{t-\tilde{\tilde{d}}}}{1+e^{t-\tilde{\tilde{d}}}} \qquad (16)$$

With:

φ_i : parameter, assumed to be constant[4] over time in our model that captures the link of the HIV prevalence with the sectoral production;

$\tilde{\tilde{a}}$: average period[5] observed for tested HIV positive individual to develop AIDS symptoms;

$\tilde{\tilde{d}}$: average period observed for a tested HIV positive patient to die of AIDS

$$\tilde{\tilde{d}} > \tilde{\tilde{a}}$$

Absenteeism rises with a time lag of $\tilde{\tilde{a}}$ period compared to the prevalence or diagnosis. In other words, the longer is $\tilde{\tilde{a}}$, the longer is the gap and the smaller are the negative effects of the pandemic on economic growth. The same applies to the death rate as well. Death rate raises with a time lag of $\tilde{\tilde{d}}$ period compared to the prevalence or diagnosis.

Applying the concept of derivatives to this case scenario 2, relevant information can be drawn out similarly to scenario 1.

$$a(t) = \varphi_i \frac{e^{t-\tilde{\tilde{a}}}}{1+e^{t-\tilde{\tilde{a}}}}$$

$$\ldots\ldots\ldots = \varphi_i \frac{1}{1+e^{-(t-\tilde{\tilde{a}})}} \qquad (17)$$

$$\lim_{\tilde{\tilde{a}}\to\infty} a(t) = 0\,.$$

The larger is $\tilde{\tilde{a}}$ the smaller is a (work absenteeism as a function of time observable in an infected patient). A perfect ARV supply or a complete eradication of the infection leads $\tilde{\tilde{a}}$ to tend to infinity. In fact talking about infinity in this case just means that the worker will actually never be absent from work because of an HIV infection. Infinity therefore refer to the time of the worker's normal resignation. In other words, an infected patient who receives perfect ARV

---

[4] This assumption can validly be removed since this parameter is supposed to change over time.

[5] This period could also be assumed as average across SSA (Sub-Saharan African) countries (3 years) with *t* (time of reference based on the HIV prevalence).

supply will probably never be absent (absence due to the HIV infection). Linking this to our growth accounting equation, the negative effect of *a(t)* in A_{iN} will disappear.

$$\frac{da(t)}{dt} = \varphi_i \frac{e^{\overset{\approx}{a}-t}}{\left[1+e^{\overset{\approx}{a}-t}\right]^2} = \varphi_i \frac{1}{\left[1+e^{-(\overset{\approx}{a}-t)}\right]\cdot\left[1+e^{\overset{\approx}{a}-t}\right]} \qquad (18)$$

$\lim_{\overset{\approx}{a}\to\infty} \frac{da(t)}{dt} = 0$. For $\overset{\approx}{a}$ getting larger, the increase in *a(t)* across time will be reduced until it reaches 0.

Scenario 3: Each of the two social ingredients includes a minimum level required at recruitment.

$$z_{it} = e^{\gamma(s_t - s_o) + \delta(h_t - h_o) + E_t} \qquad (19)$$

Logging equation 19 and including it in equation 5 we obtaining the following:

$$\ln Q_{it} = \ln A_{iN} + \alpha\left[\gamma(s_t - s_o) + \delta(h_t - h_o) + E_t\right] + \alpha \ln L_{it} + \beta \ln K_{it} \qquad (20)$$

Deriving equation 20 with respect to time (*dt = 1*) we redefine the growth accounting equation:

$$\dot{Q}_{it} / Q_{it} = \dot{A}_{iN} / A_{iN} + \alpha\gamma \dot{\bar{s}}_t + \alpha\delta \dot{\bar{h}}_t + \alpha \dot{E}_{it} + \alpha \dot{L}_{it} / L_{it} + \beta \dot{K}_{it} / K_{it} \qquad (21)$$

With: $\bar{s}_t = s_t - s_o$

$\bar{h}_t = h_t - h_o$

$$G_Q = G_A + \alpha\gamma \dot{\bar{s}}_t + \alpha\delta \dot{\bar{h}}_t + \alpha \dot{E}_{it} + \alpha G_L + \beta G_K \qquad (22)$$

Using this form of our growth accounting equation we understand that whenever recruitment criteria are strengthen up, the per capita expenditures need to be increased as well. Otherwise a negative effect on growth will be observed.

Scenario 4: Considering the diffusion process

Using the diffusion process (Bloom, Canning & Sevilla, 2002b) across sectors the following equation is introduced:

$$\Delta A_{it} = \lambda(\bar{A}_{it} - A_{i,t-1}) + \varepsilon_{it} \qquad (23)$$

Each sector has a ceiling level given by $\overline{A}_{it}$. The sector adjusts toward this level at a rate λ. λ depends on the sector characteristics and the country's level of technology.

$$\overline{A}_{it} = \delta X_{it} + a_t \tag{24}$$

X_{it} : sector's specific variables

a_t : time dummy representing the current level of national TFP (Total Factor Productivity). By including this specific dummy variable, we make the assumption that the convergence of sectoral TFPs is analysed in accordance with a national TFP. For this reason, this paper makes use of fixed effects models.

The lagged technology can be measured by including equation 24 into equation 23 and the following is obtained:

$$\Delta A_{it} = \lambda_i (\delta X_{it} + a_t - A_{i,t-1}) + \varepsilon_{it} \tag{25}$$

The higher is λ_i, the faster is the movement toward complete diffusion process and the smaller is λ_i, the slower is the diffusion process. Complete diffusion is achieved when the difference $\overline{A}_{it} - A_{i,t-1} = 0$. Therefore $\Delta A_{it} = \varepsilon_{it}$, the technological change will only depends on random shocks. This research paper present estimate figures of the diffusion factor considering the five development sectors considered. When the diffusion process is complete the growth equation is presented as follows:

$$\dot{Q}_{it}/Q_{it} = \left(\frac{\varepsilon_{it}}{A_{it}}\right) + \alpha\gamma \dot{s}_t + \alpha\delta \dot{h}_t + \alpha \dot{E}_{it}/E_{it} + \alpha \dot{L}_{it}/L_{it} + \beta \dot{K}_{it}/K_{it} \tag{26}$$

Including equation 25 into the generic growth accounting equation the following is obtained:

$$\dot{Q}_{it}/Q_{it} = \lambda_i \delta\left(\frac{X_{it}}{A_{it}}\right) + \lambda_i\left(\frac{a_t}{A_{it}}\right) - \lambda_i\left(\frac{A_{i,t-1}}{A_{it}}\right) + \left(\frac{\varepsilon_{it}}{A_{it}}\right) + \alpha\gamma \dot{s}_t + \alpha\delta \dot{h}_t + \alpha \dot{E}_{it}/E_{it} + \alpha \dot{L}_{it}/L_{it} + \beta \dot{K}_{it}/K_{it} \tag{27}$$

For a diffusion coefficient λ that tends to zero, the growth equation can be reformulated as follows:

$$\dot{Q}_{it}/Q_{it} = \left(\frac{\varepsilon_{it}}{A_{it}}\right) + \alpha\gamma \dot{s}_t + \alpha\delta \dot{h}_t + \alpha \dot{E}_{it}/E_{it} + \alpha \dot{L}_{it}/L_{it} + \beta \dot{K}_{it}/K_{it} \tag{28}$$

The two extreme cases seem to present similar evidence in terms of $\Delta A_{it} = \varepsilon_{it}$. This equality holds when either the speed of adjustment toward the ceiling rate is zero, or when the speed of adjustment is very high and $\overline{A}_{it} - A_{i,t-1} = 0$. The difference in the two cases is therefore that when there is no movement toward the ceiling rate, growth will be hindered by slower shares from both growth in labour and growth in capital. Investment in schooling and education together with a higher level of experience will be much more required to assist that slow speed of adjustment. However less requirement from extra investment in schooling and education as well as experience will be required when the ceiling rate is achieved provide that the growth rate is satisfactory. If there is no technological diffusion among sectors, it is observed that TFP differentials persist among sectors. That can be measured using fixed effect models. Additionally, having TFP that narrow over time because of a high technological diffusion, TFP differentials will be reducing over time.

3.2. Forecasting

At first, reduced form equations at sectoral level are employed to obtain one year ahead forecasts for the effect of a one Rand increase in per capita expenditure (health or schooling) on the sectoral output growth. Secondly, in order to improve the predictive ability of the models some shrinkage techniques might validly be included. The use of shrinkage techniques has produced better outcomes on country as well as sectoral forecasting. Referring to the Stein's Mean approach, the vector mean using a quadratic loss function including the goodness of fit is to be estimated. And model specifications of balanced loss function including squared error loss function (Dey *et al*, 1994) are as follows:

- Balanced loss function:

$$L(\hat{\theta},\theta) = w(y-\hat{\theta})'(y-\hat{\theta}) + (1-w)(\hat{\theta}-\theta)'(\hat{\theta}-\theta) \quad (29)$$

- Squared error loss function:

$$L_b = w(t'y-\hat{T})^2 + (1-w)(\hat{T}-T)^2 \quad (30)$$

With: - θ: the vector of means

- y: the series considered

- w: a weigh imposed

- T: total of the mean observation vectors

'w' can either be imposed based on theoretical assumptions of the sectoral production functions or using linear programming. For each sector, specific mean vectors can be estimated and their totals are computed in order to allow predicting future output using the predictive means.

4. RESULTS

4.1. Modelling effective labour

A) The coefficient of effectiveness of labour in the manufacturing sector (z_1): Furniture and other manufacturing

A.1) Modelling z_1

It is important to take note that this first set of estimations and testing relate to the coefficient of effectiveness in the manufacturing sector only. The second round of estimations will include all other non-agricultural sectors (point B).

$$z_1 = e^{\gamma s_t + \delta h_t + E_{L1}}$$

- s_t: level of expenditure on education in per capita terms;
- h_t: level of spending on health in per capita terms;
- z_1: level of labour force productivity in the manufacturing sector in per capita terms[6];
- E_1: parameter that captures the level of experience or training invested in the worker for the productive sector.

A.2) Estimating z_1

$$\ln z_1 = \gamma edu + \delta hl + +E_{L1} + \varepsilon$$

Schooling, health, and the experience variables are significant in our regression. It is also important to acknowledge that the signs obtained for both coefficients are in accordance with the underlying theory. In order to produce the fitted series, a cointegration test (table 2) and the

[6] It could include HIV as a determinant of health for both skilled and unskilled labour. Increased spending on ARVs as consequence of higher rate of HIV will be captured through this parameter. The parameter z is normalised at one when both: s; h; and E equal zero. Workers with larger s, h, and E will have a higher coefficient z in the model.

error correction of the model (table 3) have been performed in addition to all other related tests. The performed tests support the idea of cointegration among the series. It is important though to notice that the series (z) used for labour productivity as presented by the SARB (South African Reserve Bank) quarterly bulletin contains the weakness of being computed based on some inconsistencies[7].

B) The coefficient of effectiveness of labour in the non-agricultural sector (z_2)

B.1) Modelling z

$$z_2 = e^{\gamma s + \delta h + E_{L2}}$$

- s: level of expenditure on education in per capita terms;
- h: level of spending on health in per capita terms;
- z_2: level of labour force productivity in the manufacturing sector in per capita terms;
- E_{L2}: parameter that captures the labour augmentation factor in the manufacturing sector.

B.2) Estimating z

As we have observed for the coefficient of effectiveness in the manufacturing sector, the signs and level of significance obtained in our estimations of the fitted z_2 are satisfactory in general. After obtaining effective labour series using the parameters of effectiveness, estimations of sectoral output equations could therefore be performed. With the sectoral growth equations it is easier to estimate a median growth equation (using SUR) and conduct simulations. Simulations are based on an increase in health expenditures through an ARV increase and the effects on both sectoral level and aggregate level. Different scenarios can be imagined. First, a general increase in health expenditures equally spread among sectors using an average amount. Secondly, the spread among sectors performed according to sectoral contribution to GDP and comment on the results. In one of our related study, effective wage equations and sales functions by sector are reestimated with a forecast of the median growth sales function. That can be performed at the inflation level as well. For series that end in 2005 (effective labour series) the one year forecast using exponential smoothing filters (Holt Winters) is applied.

[7] The components included in the computation of the gross domestic product are not exactly the same as the one used in employment figures.

The sectoral estimates include five sectors according to availability and accuracy of data:

- Agriculture;
- Mining;
- Construction & Buildings;
- Transport & Communication;
- Manufacturing.

4.2. Analysis of the technological diffusion process using fixed effects model

We make use of the fixed effects model (table 7) to determine the value of TFP across sectors over time period and assess the speed of convergence needed to comment on the diffusion process. The values of TFPs are obtained by taking the exponential value of TFP (cross fixed effects) coupled to TFP (period fixed effects). In fact, fixed effects model is found very appropriate to this analysis as it implies the use of orthogonal projections involving the removal of cross-section or period specific means from the dependent variable and exogenous regressors (Baltagi, 2001). In fact, this approach indicates that the use of 'demeans' are used in the specific set of regressions performed. Results from the fixed effects model are presented as multiple-graph (graph 8) to assess the overall convergence tendency of the TFP series in the selected South African industrial sectors. From the results obtained, we observe very close trends between Communication & Transport and Mining. However, the general view suggests that the speed of adjustment remains very low. It is a matter of fact that sectoral TFPs converge toward a sectoral steady state however sectors differentials remain considerable.

4.3. Sectoral output equations: Testing scenario 1

4.3.1. Isolated regressions per sectors

Using the fitted coefficient of effectiveness, new series of effective labour per sector have been computed in our results and these features were included in sectoral growth equations. This exercise has produced insightful outcomes in terms of the impact of changes in expenditures on health or education on sectoral growth. To the exception of agriculture, all other sectors present well behaved and reliable estimates. The modelling process used does not enforce any specific input-output scaling. Regressions are conducted on the basis of varying returns to scale and the input shares estimated remain close to underlying theories. There is a major weakness in conducting sectoral regressions individually and in isolation from others.

That approach ignores the 'cross-sectoral' effects that exist in every economy. For this reason the SUR approach is conducted in order to support the obtaining of parameters.

4.3.2. A cross-section SUR model

The 'Seemingly Unrelated Regressions' present the advantage of providing estimates of GLS (Generalised Least Square) specification through a correction of contemporaneous correlation and any type of heteroskedasticity related to the cross-sections. A SUR can either be utilised under the form of a purely 'cross-section SUR' or a 'period SUR'. The 'period SUR' contains the major advantage of correcting heteroskedasticity related to the period and it also corrects for correlation within cross sections. In the present research, a 'period SUR' could not be performed because the number of pool cross-sections (5) does not exceed the number of periods (12). In fact, by using SURegressions, we have estimated a set of sectoral growth equations allowing different coefficient vectors. As mentioned earlier, SUR present the advantage of capturing efficiency observed due to the correlation of cross sections disturbances. Table 22 presents the results of a cross-section SUR with corrected degree of freedom using output growth per sector as dependent variable. To the exception of agriculture, all sectoral growth regressions are well behaved and the levels of significance of the obtained coefficients do not differ much from the expectations.

4.4. Effects of an increase in *h* and *s* on the sectoral growth rates.

The calculation of these coefficients is based on the following regression:

$$\dot{Q}_{it}/Q_{it} = \dot{A}_{itN}/A_{itN} + \left[\frac{\partial \ln z_{it}}{\partial T_{it}}.\frac{dT_{it}}{dt} + \frac{\partial \ln z_{it}}{\partial a_{it}}.\frac{da_{it}}{dt} + \frac{\partial \ln z_{it}}{\partial d_{it}}.\frac{dd_{it}}{dt} + \frac{\partial \ln z_{it}}{\partial o_{it}}.\frac{do_{it}}{dt}\right] +$$

$$\alpha\gamma \dot{s}_t + \alpha\delta \dot{h}_t + \alpha \dot{E}_{itL}/E_{itL} + \alpha \dot{L}_{it}/L_{it} + \beta \dot{K}_{it}/K_{it}$$

With: $\dot{h}_t = \frac{dh(t)}{dt} = \frac{h_{t+1} - h_t}{dt}$

$$\dot{Q}_{it}/Q_{it} = \frac{(Q_{it+1} - Q_{it})/dt}{Q_{it}}$$

Considering a one year ahead forecast, an increase in h_{t+1} by one rand will lead to a '$\alpha\delta$' increase of $\dot{Q}_{it}/Q_{it}$ (see equation 7). Similarly a one rand increase in s_{t+1} leads to a $\alpha\gamma$ increase in $\dot{Q}_{it} / Q_{it}$ (see equation 7). Using estimates from our regression analysis we have computed the size of $\alpha\delta$ in percentage for each of the 5 sectors (see table 24). From table 24, several observations may be drawn. A one Rand increase on health expenditures or schooling expenditures (per capita) in both sectors leads to higher output growth. The size of this rise differs from one sector to another. The manufacturing sector together with the construction sector has the highest parameters followed by mining and finally transport and communication. The size of these parameters depends on the level of significance that effective labour variables have on our sectoral growth equations. And the contribution that a one Rand increase in per capita expenditures, at sectoral level, has on the aggregate growth depends on the size of the sector's contribution to the national economic growth. In the fourth quarter of 2006, South Africa reached an economic growth of 5.6 percent with several major contributors: the manufacturing industry contributed 1.4 percent; the finance, real estate and business services industry with 1.0 percent; the wholesale trade, hotels and restaurants industry contributed with 0.8 percent; the storage and communication industry contributed with 0.5 percent (Quarterly bulletin). When expenditures on health are categorised according to productive sectors, the return on the national growth is much higher than an aggregate increase that disregard sectoral differences.

4.5. Effects of an increase in the level of experience on the sectoral growth rates.

Considering scenario 1 (equation 7), an increase of the experience (training) index E by one unit will lead to an α increase in the growth rate of output. Using this concept, a comparison can be conducted for different sectors in order to determine how the level of experience (or training) affects the sectoral growth with different magnitudes. It is irrevocable that the level of training matters for all productive sectors, however, one year of extra training will produce different effects (magnitudes) depending on how significant is the effective labour variable in a given sector. In fact, the effect of E on the sectoral output growth depends on the level of significance of the effective labour variable. Looking at sectoral parameters, the same interpretation made for table 24 holds for the coefficient of E as well.

5. CONCLUSION

Five sectors were used for the purpose of generating effective labour variables using a coefficient of effectiveness for each sector and sectoral production functions were reestimated using the obtained effective labour series. The data was difficult to obtain due to lack of a well disaggregated data warehousing system as it is for most African countries. Although every attempt will be made to garner sufficient micro data for other African economies in order to extend the same analysis at a continental level through a marshallian macroeconomic model. These conclusions should be treated as in need of further strengthening since some of the coefficients such as the one for agriculture are still difficult to reconcile with theoretical expectations. Nevertheless, the broadest conclusion to be extracted from the analysis at this stage can only be that it pays to allocate social expenditures according to sectoral productivity and it also pays to include a coefficient of effectiveness in production functions. In many cases it has been noticed that using an effective labour variable did not reduce the predictive ability of the model and that introduced new rooms to shock the models through social variables though. Additionally, outcomes from the theoretical models can validly be used to advise policy makers on the harming effects that the HIV pandemics has on the economic growth. By simply controlling the absenteeism rates and the death rates related to the pandemics, the negative impact of the disease can easily be assuaged. However, our analysis did not include other channels through which HIV/AIDS might affect economic growth considering other types of direct or indirect costs at both private and national level. Furthermore this analysis constitutes a pioneer work in the field for deeper researches.

References

Barro, R. 1991. "Economic Growth in a Cross-Section of Countries." *Quarterly Journal of Economics* 106 (2): 407-43.

Barro, R. 1996. "Health and Economic Growth." Harvard University, Cambridge, MA. Processed.

Barro, R., and Lee, JW. "International Data on Educational attainment Updates and Implications." University, Cambridge, MA. Processed.

Baumol, W. 1986. "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show." *American Economic Review* 76 (5): 1072-85.

Bloom, D.E., and D. Canning. 2000. "The Health and Wealth of Nations." *Science* 287 (5456): 1207-08.

Bloom, D.E., D. Canning, and J. Sevilla. 2002b. "Technological Diffusion, Conditional Convergence, and Economic Growth." Working paper no. 8713. National Bureau of Economic Research, Cambridge, MA.

Bloom, D.E., D. Canning, and J. Sevilla. 2004. "The Effect of Health on Economic Growth: A Production Function Approach." *World Development* 32 (1): 1-13.

Bloom, D.E., D. Canning, and J. Sevilla. 2005. "Health and Economic Growth: Reconciling the Micro and Macro Evidence." Harvard School of Public Health, MA. Processed.

Commission on Macroeconomics and Health. 2001. *Macroeconomics and Health: Investing in Health for Economic Development.* Geneva: World Health Organization.

Dowrick, S., and M. Rogers. 2002. "Classical and Technological Convergence: Beyond the Solow-Swan Model." *Oxford Economic Papers* 54 (3): 369-85.

Fogel, R.W. 1997. "New Findings on Secular Trends in Nutrition and Mortality: Some Implications for Population Theory." *Handbook of Population and Family Economics*, vol. 1. New York. Elsevier.

Sohn, B. 2000. "How Much Has Health Improvement Contributed to the Korean Economic Growth?" Brown University, Providence, RI. Processed.

Stein, C. (1962). Confidence Sets for the mean of a Multivariate Normal Distribution. J. R. Stat. Soc. Ser B 24.

Van der Merwe, A. and Viljoen, C. (1998). "Bayesian Analysis of the Seemingly Unrelated Regression Models." ms., Department of Mathematical Statistics, University of the Free State, Bloemfontein. South Africa.

Zarnowitz, V. (1986). "The Record and Improvability of Economic Forecasting." *Economic Forecastings,* 3, 22-31.

Zellner A. (1986a). "Bayesian Estimation and Prediction Using Asymmetric Loss Functions." *J. Amer. Statist. Assoc.* 81, 446-451.

Zellner, A. and Vandaele, W.A. (1974). "Bayes-Stein Estimators for k-means, Regressions and Simultaneous Equation Models." Amsterdam. 627-653.

Zellner, A. (2002). "Bayesian Shrinkage Estimates and Forecasts of Individual and Total or Aggregate Outcomes." H.G.B. Alexander Research Foundation. Graduate School of Business. University of Chicago.

Zellner, A. and Guillermo I. (2003). "The Marshallian Macroeconomic Model: A Progress Report." H.G.B. Alexander Research Foundation. Graduate School of Business. University of Chicago.

APPENDIX: Structure of the Marshallian Model

Supply equations:

$\dot{S}_{pni} / S_{pni}$: Time variable for change in sector's production

$S_{pni} = AL^{\alpha/\theta} K^{\beta/\theta} G^{\varphi/\theta}$ or $S_{pni} = AL^{\alpha \log l} K^{\beta \log k}$ *with* $\theta = \alpha + \beta + \varphi$

$$\dot{S}_{pni} / S_{pni} = \dot{A}_{ni} / A_{ni} + (\alpha/\theta)\dot{L}_{ni} / L_{ni} + (\beta/\theta)\dot{K}_{ni} / K_{ni} + (\varphi/\theta)\dot{G}_{ni} / G_{ni}$$

or $$\dot{S}_{pni} \big/ S_{pni} = \dot{A}_{ni} \big/ A_{ni} + \alpha \log l\, \dot{L}_{ni} \big/ L_{ni} + \beta \log k\, \dot{K}_{ni} \big/ K_{ni}$$

With 'n' sectors and 'i' countries

Demand equations:

$$\dot{S}_{dni} / S_{dni} = \delta_1 \dot{P}_{dni} / P_{dni} + \delta_2 \dot{Y}_{dni} / Y_{dni} + \delta_3 \dot{n}_{ni} / n_{ni}$$

Entry equations:

$$\dot{N} \big/ N = \varpi_0 + \varpi_1 \dot{\pi} \big/ \pi + \varpi_2 \dot{f} \big/ f$$

$$\dot{\pi} \big/ \pi = \kappa_0 + \kappa_1 \dot{P} \big/ P + \kappa_2 \dot{m} \big/ m + \kappa_3 \dot{A} \big/ A + \kappa_4 \dot{r} \big/ r$$

$$\dot{P}_{ni} / P_{ni} = \sigma_0 + \sigma_1 \dot{I}_{ni} / I_{ni} + \sigma_2 (S_{dni} - S_{pni}) + \sigma_3 \dot{t}_{ni} / t_{ni} + \sigma_4 \dot{s}_{ni} / s_{ni}$$

$$\dot{I}_n / I_n = \ell_1 \dot{o}_n / o_n + \ell_2 \dot{w}_n / w_n$$

***Factor market demand equation**:*

$$\dot{L}_{dni} / L_{dni} = \partial_1 \dot{S}_{pni} / S_{pni} - \partial_2 \dot{w}_{ni} / w_{ni} + \partial_3 \dot{I}_{ni} / I_{ni}$$

$$\dot{K}_{dni} / K_{dni} = \varphi_1 \dot{S}_{pni} / S_{pni} - \varphi_2 \dot{r}_{ni} / r_{ni} + \varphi_3 \dot{n}_{ni} / n_{ni}$$

Factor Supply equations:

$$\dot{w}_{ni} / w_{ni} = \beta_1 \dot{P}_{ni} / P_{ni} + \beta_2 \dot{e}_{ni} / e_{ni} + \beta_3 \dot{d}_{ni} / d_{ni} + \beta_4 \dot{wex}_{ni} / wex_{ni} + \beta_5 \dot{LU}_{ni} / LU_{ni}$$
$$+ \beta_6 \dot{UN}_{ni} / UN_{ni} + \beta_7 \dot{AP}_{ni} / AP_{ni}$$
$$\dot{r}_{ni} / r_{ni} = \varsigma_1 \dot{i}_{ni} / i_{ni} + \varsigma_2 \dot{dc}_{ni} / dc_{ni} + \varsigma_3 \dot{ICC}_{ni} / ICC_{ni}$$

Variables list:

- S_p: Sector's Total Production
- S_d: Sector's Total Demand
- *w*: nominal wage
- *Ac*: accessibility supposed to be improved by the monorail
- *Imc*: implementation cost of the monorail translated into higher fiscal pressure (higher tax burden)
- z: labour productivity likely to increase due to higher work accessibility
- *r*: user cost of capital (or nominal cost for capital services)
- *p*: product price
- *o:* oil price
- *T*: technology
- *I*: international price
- *n:* number of individuals or households
- Y_d: disposable income (individual or households)
- *G*: Gross fixed capital formation
- *t:* taxes on production
- *s:* subsidies on production
- *e:* educational level
- *d:* Company description
- *wex*: years of working experience
- *LU*: level of unionisation

- *UN*: level of unemployment
- *AP:* employer's ability to pay
- *i:* interest rate
- *dc:* economic depreciation rate of capital
- *ICC*: International Cost of Capital
- *Π:* abnormal profit made by firms operating in the sector
- *m:* market share of operating firms
- *f:* sector's accessibility
- *N:* number of firms in the sector

Graph 1: HIV Prevalence over time

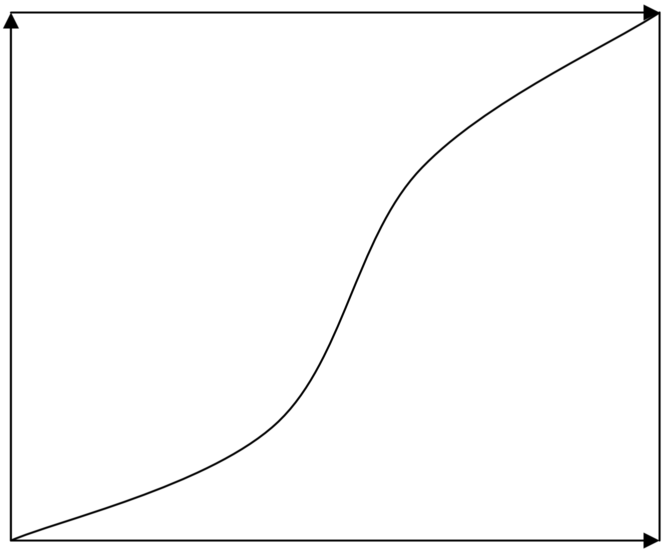


Table 1: Long run estimates

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
EDU	0.001448	0.000225	6.429589	0.0000
HL	0.000327	6.26E-05	5.226992	0.0000
E_{L1}	3.771453	0.096022	39.27696	0.0000
R-squared	*0.669579*	*Mean dependent var*		*4.516807*
Adjusted R-squared	*0.648261*	*S.D. dependent var*		*0.135782*

Table 2: Cointegration test

Null Hypothesis: $RESIDZ_1$ has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic based on SIC, MAXLAG=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.960005	0.0494
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

*MacKinnon (1996) one-sided p-values.

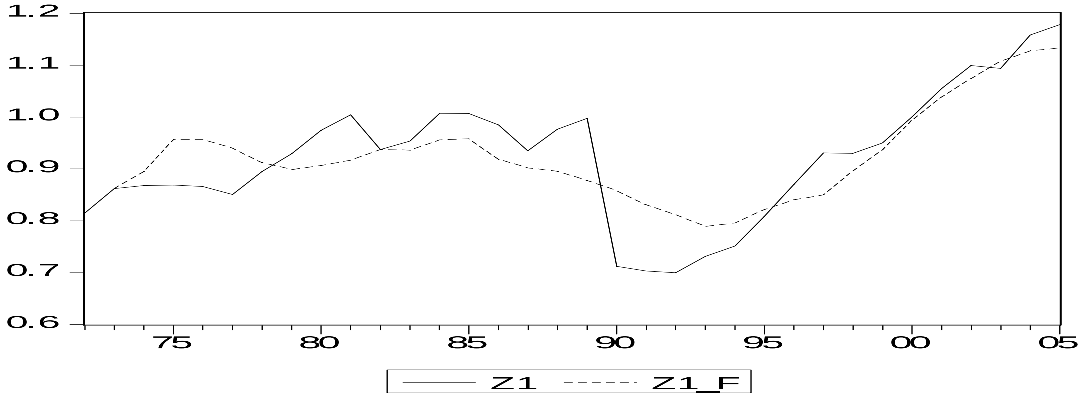
Table 3: Error Correction Model (ECM)

Dependent Variable: $DLNZ_1$

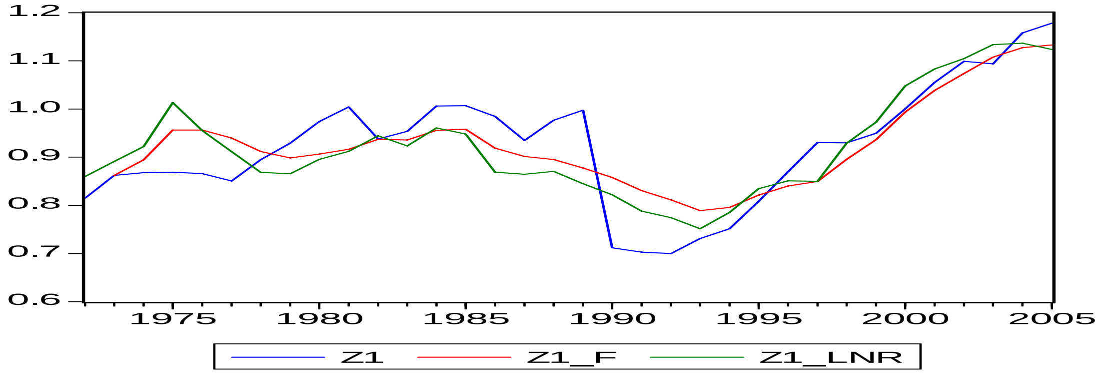
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEDU	0.000739	0.000503	1.470010	0.1523
DHL	0.000156	0.000357	0.437548	0.6650
$RESIDZ_1(-1)$	-0.405542	0.150622	-2.692437	0.0117
C	0.006673	0.013453	0.496037	0.6236
R-squared	*0.256171*	*Mean dependent var*		*0.011162*
Adjusted R-squared	*0.179224*	*S.D. dependent var*		*0.071412*

Graph 2: Actual versus Fitted: Model z_1



Graph 3: Estimated z1 with z1 derived from the long run regression



With: - z_1_F: Fitted z_1

- z_1_LNR: z_1 derived from the long run equation.

Graph 4: The effective labour function: elman

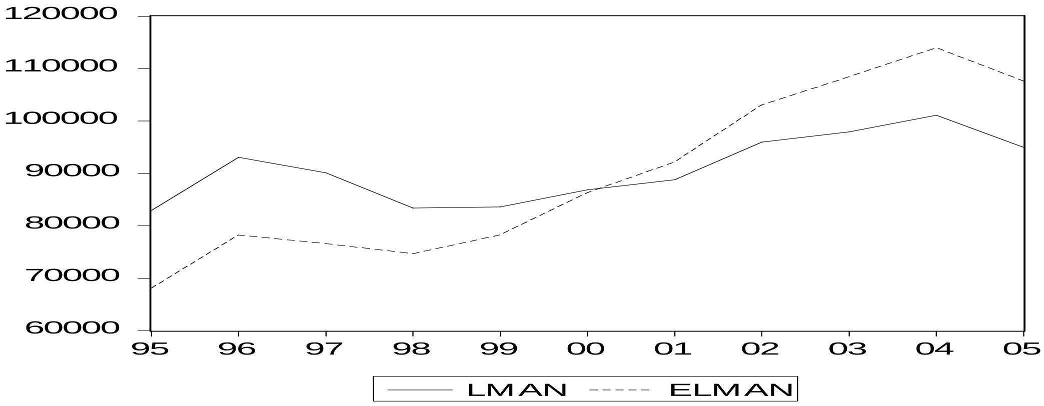


Table 4: The long run estimate

Variable	Coefficient	Std. Error	t-Statistic	Prob.
HL	0.000348	0.000123	2.827949	0.0081
DUMEDU	0.000294	0.000164	1.797308	0.0820
E_{L2}	0.600606	0.066106	9.085514	0.0000
R-squared	*0.790371*	*Mean dependent var*		*-0.310857*
Adjusted R-squared	*0.776846*	*S.D. dependent var*		*0.140839*
S.E. of regression	*0.066531*	*Akaike info criterion*		*-2.498202*
Sum squared resid	*0.137217*	*Schwarz criterion*		*-2.363524*
Log likelihood	*45.46944*	*F-statistic*		*58.44007*
Durbin-Watson stat	*0.449506*	*Prob(F-statistic)*		*0.000000*

Graph 5: The long run residual

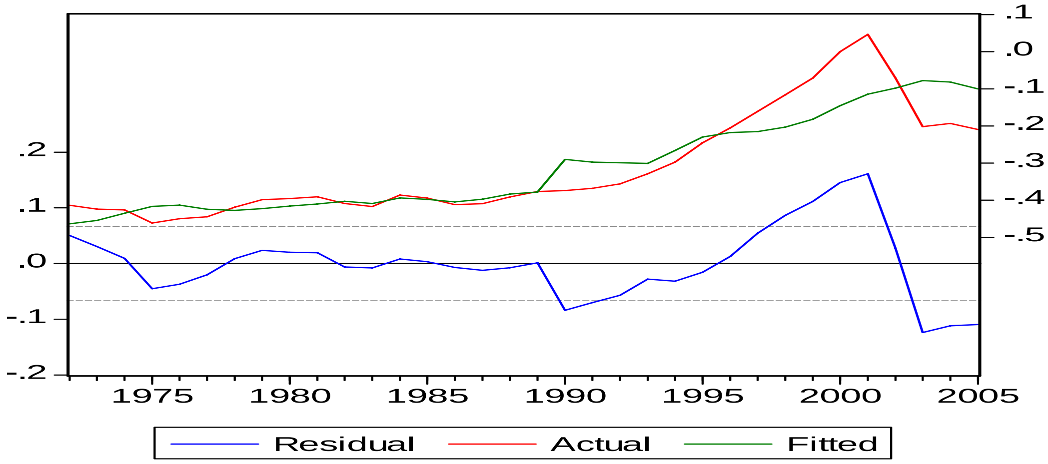


Table 5: Cointegration test

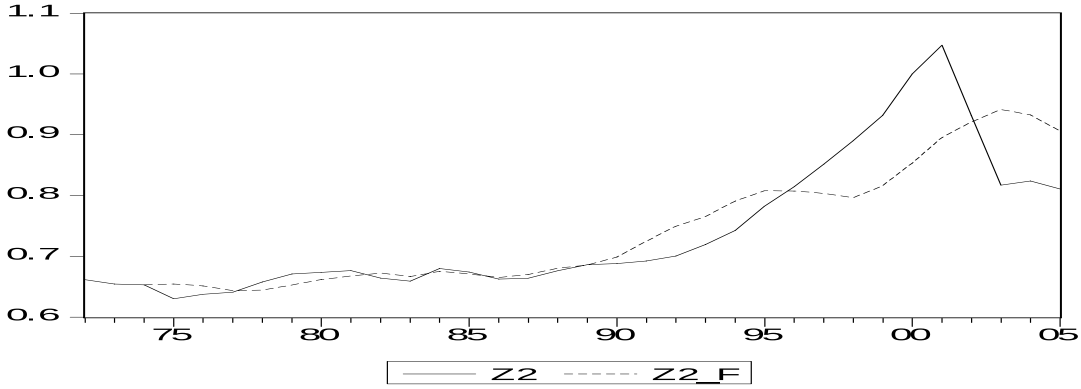
Augmented Dickey-Fuller test statistic	**-3.221096*** **
1% level	-3.653730
5% level	-2.957110
10% level	-2.617434

**MacKinnon (1996) one-sided p-values.*

Table 6: Error correcting model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HL)	0.000368	0.000215	1.712202	0.0988
D(HL(-1))	-0.000228	0.000210	-1.084469	0.2881
D(LNZ2(-1))	0.668374	0.170260	3.925610	0.0006
D(DUMEDU)	5.76E-05	0.000116	0.495495	0.6244
RESIDZ2(-1)	-0.365407	0.128755	-2.837997	0.0087
C	-0.000301	0.008363	-0.036005	0.9716
R-squared	*0.431400*	*Mean dependent var*		*0.006700*
Adjusted R-squared	*0.322054*	*S.D. dependent var*		*0.041757*
Sum squared resid	*0.030734*	*Schwarz criterion*		*-3.460403*
Log likelihood	*65.76366*	*F-statistic*		*3.945271*
Durbin-Watson stat	*1.921253*	*Prob(F-statistic)*		*0.008538*

Graph 6: Actual versus Fitted: Model z_2



Graph 7: Including long run estimate: Model z2

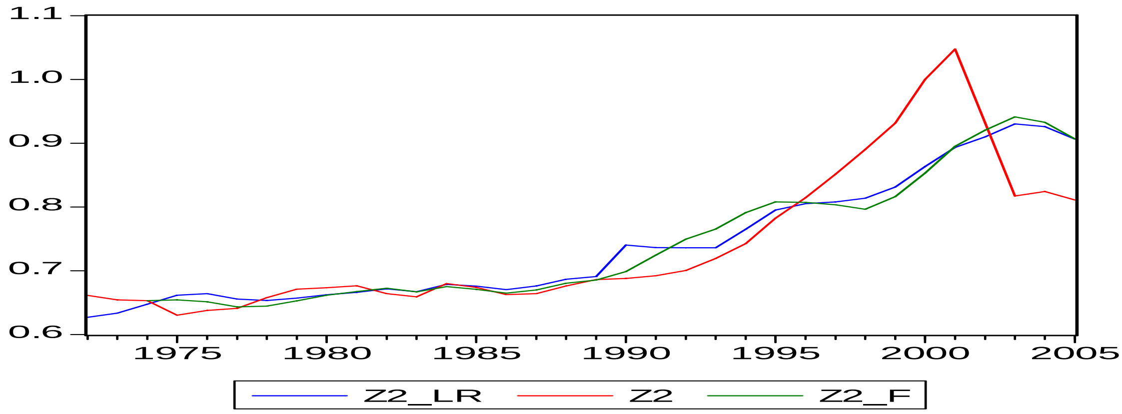


Table 7: Fixed effects model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.937235	1.805991	1.072671	0.2895
LNK?	0.494892	0.109752	4.509205	0.0001
LNL?	0.257374	0.107738	2.388886	0.0215
Fixed Effects (Cross)				
_AGRIC--C	-0.851961			
_MAN--C	0.903629			
_MIN--C	-0.157423			
_COMTRS--C	-0.114270			
_CONSTR--C	0.220025			
Fixed Effects (Period)				
1995--C	-0.156320			
1996--C	-0.101010			
1997--C	-0.069780			
1998--C	-0.065816			
1999--C	-0.042143			
2000--C	0.001738			
2001--C	0.013244			
2002--C	0.048587			
2003--C	0.062101			
2004--C	0.093687			
2005--C	0.113865			
2006--C	0.101848			

Effects Specification

Cross-section fixed (dummy variables)
Period fixed (dummy variables)

R-squared	0.992211	Mean dependent var	10.92981
Adjusted R-squared	0.989058	S.D. dependent var	0.740116
Sum squared resid	0.251744	Schwarz criterion	-1.407508
Durbin-Watson stat	0.472393	Prob(F-statistic)	0.000000

Graph 8: TFP across sectors over time

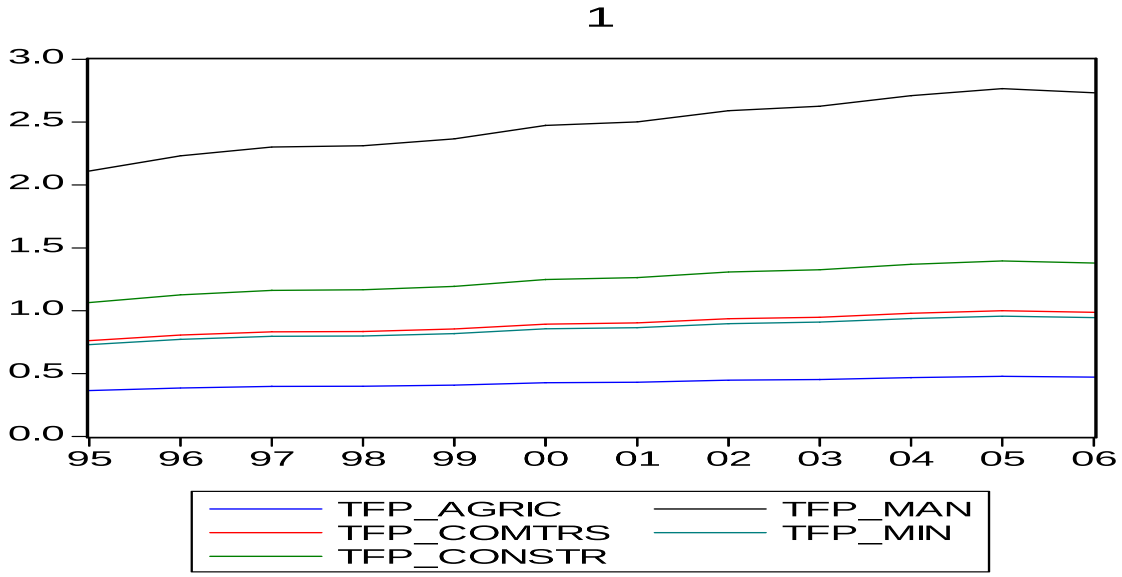


Table 8: Long run regression of LNYAGRIC (Log of agricultural output) on capital (LNKAGRIC) and effective labour (LNELAGRIC_SM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNKAGRIC	3.967104	2.950402	1.344598	0.2117
LNELAGRIC_SM	24.76007	10.70353	2.313262	0.0460
C	-369.0831	175.9170	-2.098052	0.0653
R-squared	*0.525614*	*Mean dependent var*		*10.17638*
Adjusted R-squared	*0.420195*	*S.D. dependent var*		*0.087889*
Log likelihood	*17.14934*	*F-statistic*		*4.985942*
Durbin-Watson stat	*1.647653*	*Prob(F-statistic)*		*0.034881*

Graph 9: Long run residual (Agriculture)

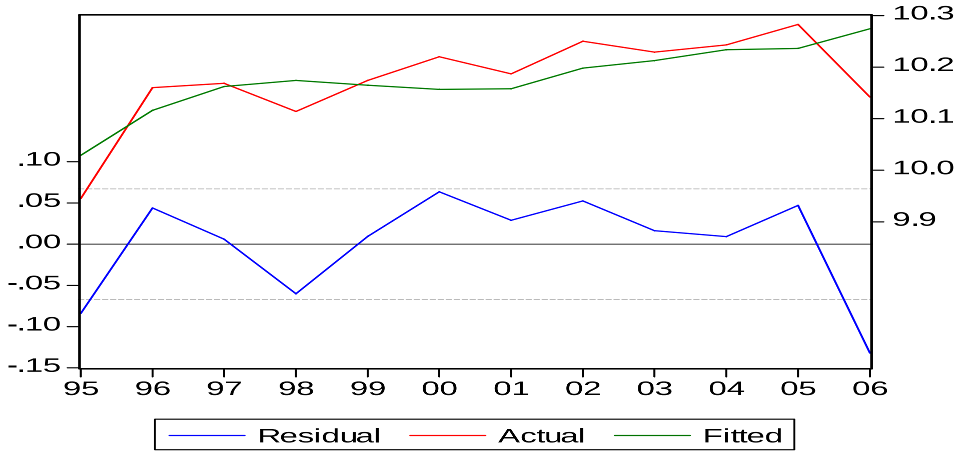


Table 9: Cointegration test

ADF Test Statistic	-1.742080	1% Critical Value*	-4.3260
		5% Critical Value	-3.2195
		10% Critical Value	-2.7557

*MacKinnon critical values for rejection of hypothesis of a unit root.

Table 10: Error correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNYAGRIC(-1))	-0.822767	0.115140	-7.145789	0.0056
D(LNYAGRIC(-2))	-0.359423	0.080557	-4.461708	0.0210
D(LNELAGRIC_SM(-1))	6.42E+08	1.98E+08	3.241459	0.0478
D(LNELAGRIC_SM(-2))	-6.40E+08	1.97E+08	-3.241428	0.0478
RESIDAGRIC(-1)	-0.135101	0.172320	-0.784010	0.4902
C	-1266.425	388.0274	-3.263752	0.0470
R-squared	*0.978361*	*Mean dependent var*		*0.003281*
Adjusted R-squared	*0.942295*	*S.D. dependent var*		*0.041757*

Graph 10: Actual (YAGRIC) versus Fitted (YAGRIC_F)

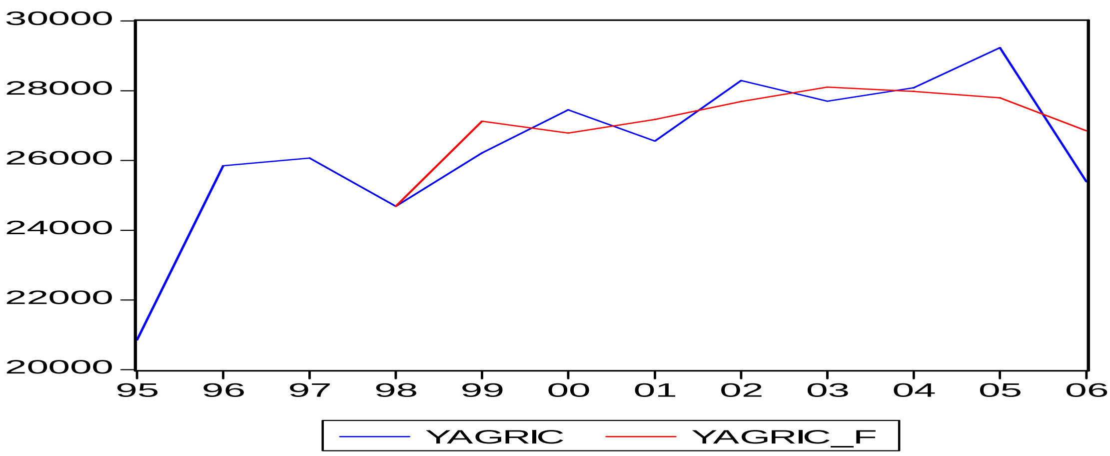


Table 11: Long run regression of LNYMIN (Log of Mining Output) on capital (LNKMIN) and effective labour (LNELMIN_SM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNKMIN	0.735996	0.204247	3.603461	0.0057
LNELMIN_SM	0.094988	0.054368	1.747144	0.1146
C	1.036020	2.804829	0.369370	0.7204
R-squared	*0.592706*	*Mean dependent var*		*11.08793*
Sum squared resid	*0.003989*	*Schwarz criterion*		*-4.549978*
Log likelihood	*31.02723*	*F-statistic*		*6.548518*
Durbin-Watson stat	*0.671088*	*Prob(F-statistic)*		*0.017563*

Graph 11: Long run residual (Mining)

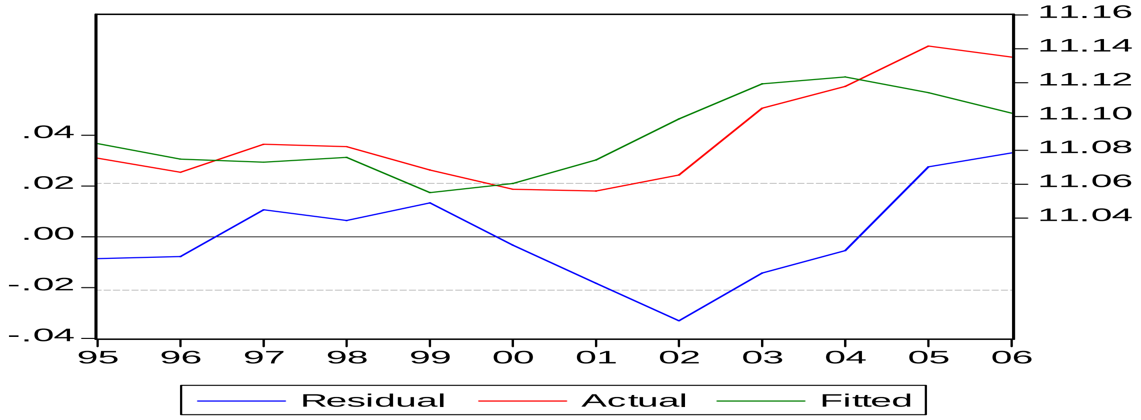


Table 12: Cointegration test

ADF Test Statistic	-1.720712	1% Critical Value*	-4.3260
		5% Critical Value	-3.2195
		10% Critical Value	-2.7557

*MacKinnon critical values for rejection of hypothesis of a unit root.

Table 13: Error correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNYMIN(-1))	0.361318	0.130047	2.778365	0.0321
D(LNKMIN(-1))	-1.010303	0.296536	-3.407020	0.0144
RESIDMIN(-1)	-1.306875	0.193425	-6.756483	0.0005
C	0.008196	0.002590	3.164653	0.0195

R-squared	*0.906847*	*Mean dependent var*	*0.006803*
Adjusted R-squared	*0.860270*	*S.D. dependent var*	*0.016872*
Log likelihood	*39.02587*	*F-statistic*	*19.47004*
Durbin-Watson stat	*3.177162*	*Prob(F-statistic)*	*0.001705*

Graph 12: Actual (YMIN) versus Fitted (YMIN_F)

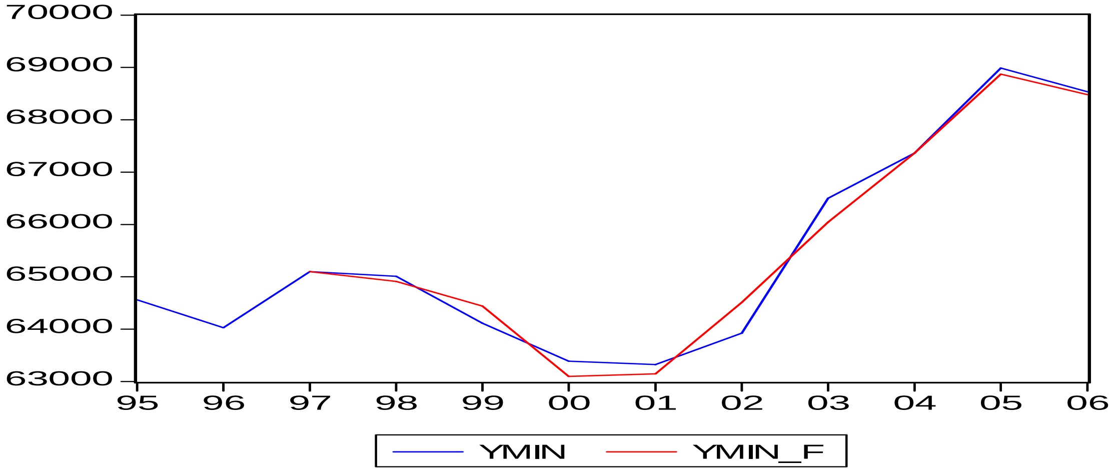


Table 14: Long run regression of LNYCONSTR (Log of Construction & Buildings Output) on capital (LNKCONSTR) and effective labour (LNELCONSTR_SM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNKCONSTR	0.706290	0.043565	16.21225	0.0000
LNELCONSTR_SM	0.349187	0.105169	3.320247	0.0089
C	-0.928966	1.408352	-0.659612	0.5260

R-squared	*0.967806*	*Mean dependent var*	*10.07238*
Adjusted R-squared	*0.960652*	*S.D. dependent var*	*0.186337*
Sum squared resid	*0.012296*	*Schwarz criterion*	*-3.424288*
Log likelihood	*24.27309*	*F-statistic*	*135.2791*
Durbin-Watson stat	*1.666631*	*Prob(F-statistic)*	*0.000000*

Graph 13: Long run residual (Construction & Buildings)

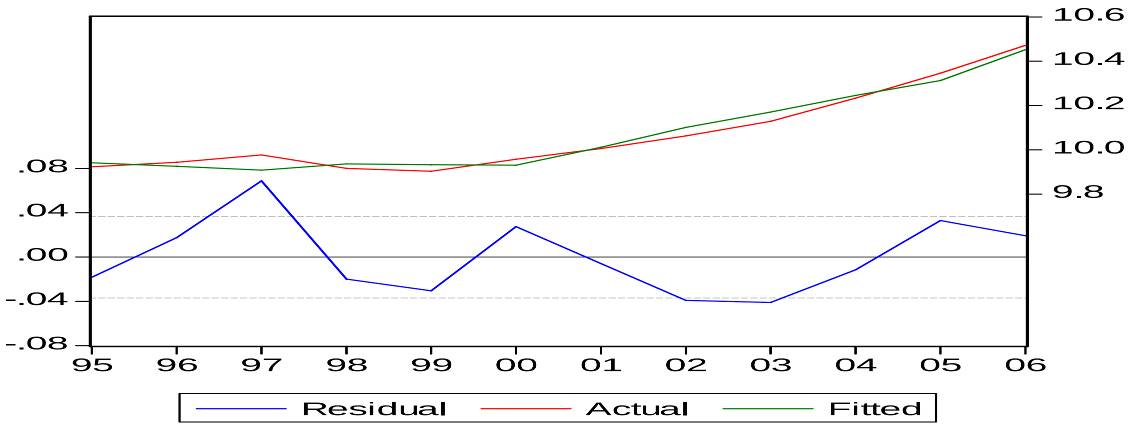


Table 15: Cointegration test

ADF Test Statistic	-3.213112	1% Critical Value*	-4.3260
		5% Critical Value	-3.2195
		10% Critical Value	-2.7557

*MacKinnon critical values for rejection of hypothesis of a unit root.

Table 16: Error correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNYCONSTR(-1))	-0.284763	0.008789	-32.39947	0.0196
D(LNKCONSTR)	0.934876	0.017633	53.01987	0.0120
D(LNKCONSTR(-1))	0.157567	0.010743	14.66754	0.0433
D(LNKCONSTR(-2))	1.363403	0.014705	92.71793	0.0069
D(LNELCONSTR_SM)	-0.120158	0.003464	-34.69203	0.0183
D(LNELCONSTR_SM(-1))	-0.091734	0.002886	-31.78122	0.0200
RESIDCONSTR(-1)	0.123374	0.013700	9.005178	0.0704
C	-0.094840	0.000966	-98.13191	0.0065
R-squared	*0.999996*	*Mean dependent var*		*0.054892*
Adjusted R-squared	*0.999968*	*S.D. dependent var*		*0.060204*
Sum squared resid	*1.17E-07*	*Schwarz criterion*		*-13.36311*
Log likelihood	*68.92291*	*F-statistic*		*35254.85*
Durbin-Watson stat	*2.760296*	*Prob(F-statistic)*		*0.004101*

Graph 14: Actual (YCONSTR) versus Fitted (YCONSTR_F)

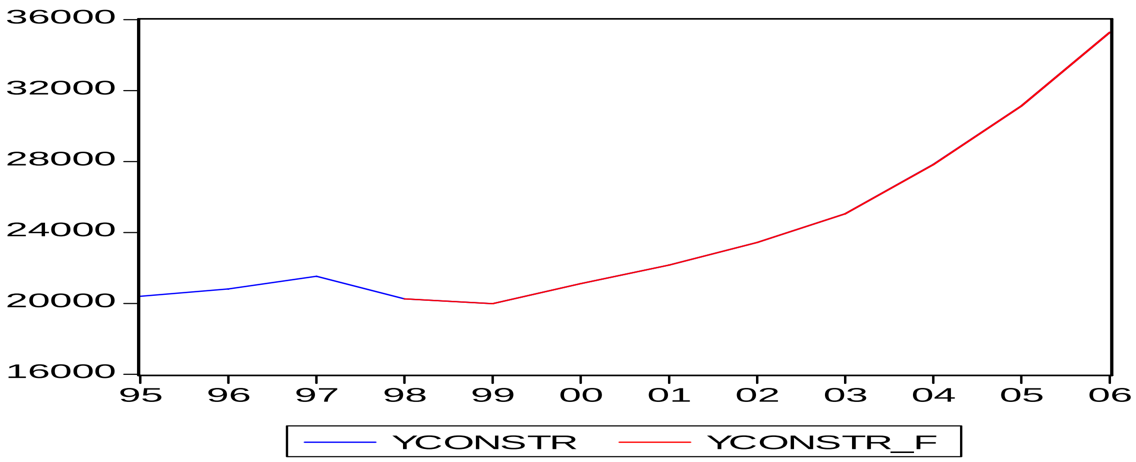


Table 17: Long run regression of LNYCOMTRS (Log of Transport & Communication Output) on capital (LNKCOMTRS) and effective labour (DUMELCOMTRS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNKCOMTRS	2.439538	0.224226	10.87983	0.0000
DUMELCOMTRS	0.006470	0.002751	2.351630	0.0432
C	-19.82394	2.842835	-6.973300	0.0001
R-squared	*0.983899*	*Mean dependent var*		*11.32851*
Adjusted R-squared	*0.980321*	*S.D. dependent var*		*0.224358*
Log likelihood	*26.20209*	*F-statistic*		*274.9807*
Durbin-Watson stat	*1.285933*	*Prob(F-statistic)*		*0.000000*

Graph 15: Long run residual (Transport & Communication)

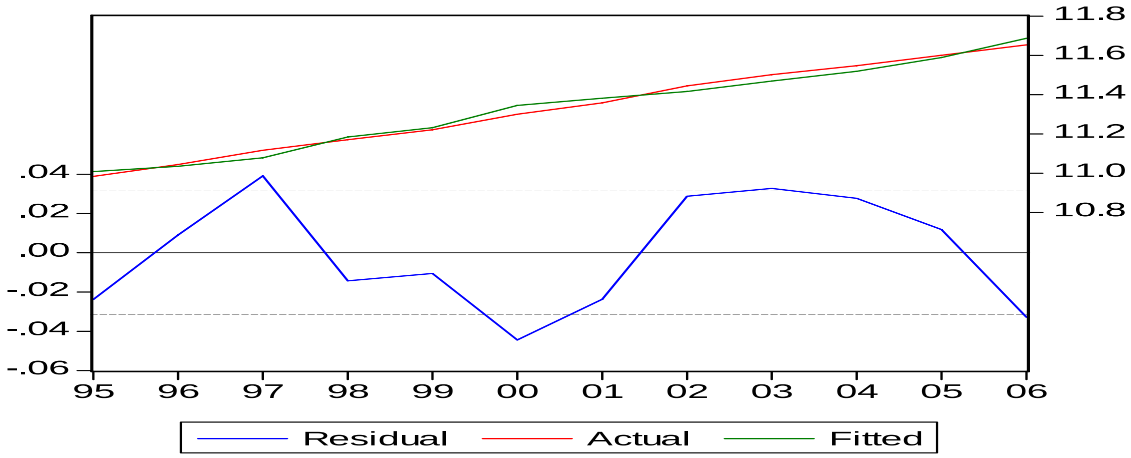


Table 18: Cointegration test

ADF Test Statistic	-2.356290	1% Critical Value*	-4.3260
		5% Critical Value	-3.2195
		10% Critical Value	-2.7557

*MacKinnon critical values for rejection of hypothesis of a unit root.

Table 19: Error correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNKCOMTRS)	0.170938	0.086959	1.965723	0.1208
D(LNKCOMTRS(-1))	-1.121195	0.077685	-14.43263	0.0001
D(DUMELCOMTRS)	0.000420	0.000182	2.304277	0.0825
D(DUMELCOMTRS(-1))	-0.003542	0.000254	-13.93497	0.0002
RESIDCOMTRS(-1)	-0.594360	0.042790	-13.89021	0.0002
C	0.087225	0.002241	38.92403	0.0000
R-squared	*0.991675*	*Mean dependent var*		*0.060991*
Adjusted R-squared	*0.981270*	*S.D. dependent var*		*0.013717*
Log likelihood	*53.17145*	*F-statistic*		*95.30140*
Durbin-Watson stat	*1.386433*	*Prob(F-statistic)*		*0.000301*

Graph 16: Actual (YCOMTRS) versus Fitted (YCOMTRS_F)

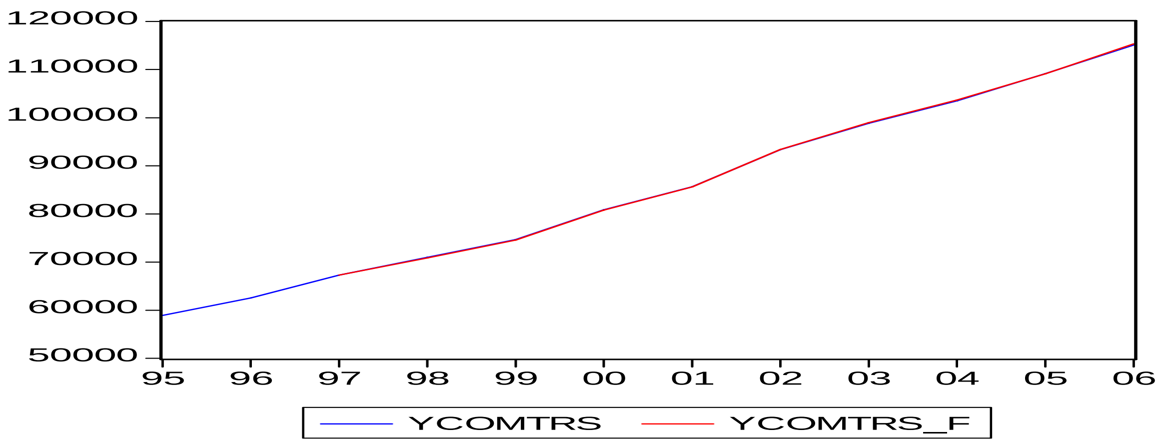


Table 20: Long run regression of LYMAN (Log of Manufacturing Output) on capital (LNKMAM) and effective labour (LNELMAM_SM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNKMAN	0.783062	0.460422	1.700750	0.1232
LNELMAN_SM	0.352829	0.110842	3.183161	0.0111
C	-1.855128	4.719687	-0.393062	0.7034
R-squared	*0.908193*	*Mean dependent var*		*11.98385*
Adjusted R-squared	*0.887792*	*S.D. dependent var*		*0.101936*
Sum squared resid	*0.010494*	*Schwarz criterion*		*-3.582802*
Log likelihood	*25.22417*	*F-statistic*		*44.51591*
Durbin-Watson stat	*1.096677*	*Prob(F-statistic)*		*0.000022*

Graph 17: Long run residual (Manufacturing)

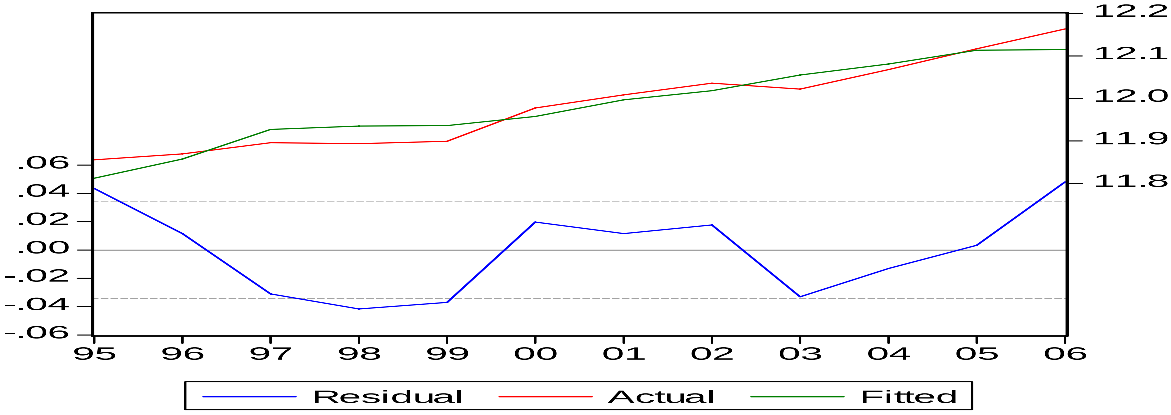


Table 21: Cointegration test

ADF Test Statistic	-2.362856	1% Critical Value*	-4.3260
		5% Critical Value	-3.2195
		10% Critical Value	-2.7557

*MacKinnon critical values for rejection of hypothesis of a unit root.

Table 22: Error correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNKMAN)	-0.586090	0.269826	-2.172106	0.1620
D(LNKMAN(-1))	2.580581	0.402524	6.410996	0.0235
D(LNKMAN(-2))	-3.287029	0.264823	-12.41218	0.0064
D(LNELMAN_SM(-1))	-0.216757	0.024414	-8.878537	0.0124
D(LNELMAN_SM(-2))	-0.384598	0.024378	-15.77668	0.0040
RESIDMAN(-1)	-0.711648	0.061717	-11.53074	0.0074
C	0.074911	0.003101	24.15642	0.0017
R-squared	*0.996434*	*Mean dependent var*		*0.029692*
Adjusted R-squared	*0.985735*	*S.D. dependent var*		*0.029034*
Sum squared resid	*2.41E-05*	*Schwarz criterion*		*-8.285723*
Log likelihood	*44.97604*	*F-statistic*		*93.13303*
Durbin-Watson stat	*2.616651*	*Prob(F-statistic)*		*0.010661*

Graph 18: Actual (YMAN) versus Fitted (YMAN_F)

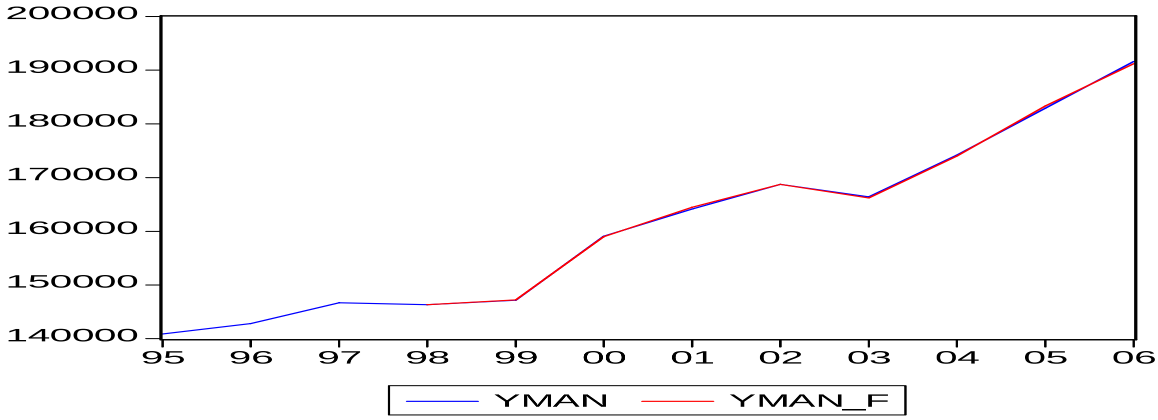


Table 23: Cross-section SUR

Variable	Coefficient	Std. Error	t-Statistic	Prob.
_AGRIC--LNK_AGRIC	-2.641124	0.994132	-2.656714	0.0106
_MAN--LNK_MAN	0.653484	0.051183	12.76773	0.0000
_MIN--LNK_MIN	0.839629	0.035988	23.33086	0.0000
_COMTRS--LNK_COMTRS	1.391167	0.201518	6.903428	0.0000
_CONSTR--LNK_CONSTR	0.683151	0.034240	19.95200	0.0000
_AGRIC--LNEL_AGRIC	2.957131	0.829575	3.564634	0.0008
_MAN--LNEL_MAN	0.332578	0.056233	5.914308	0.0000
_MIN--LNEL_MIN	0.079076	0.033303	2.374452	0.0215
_COMTRS--LNEL_COMTRS	-0.524691	0.210324	-2.494678	0.0160
_CONSTR--LNEL_CONSTR	0.292972	0.025089	11.67714	0.0000
Weighted Statistics				
R-squared	0.999995	Mean dependent var		128.4121
Adjusted R-squared	0.999994	S.D. dependent var		437.1014
S.E. of regression	1.067537	Sum squared resid		56.98173
F-statistic	1099021.	Durbin-Watson stat		1.260427
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.990792	Mean dependent var		10.92981
Sum squared resid	0.297604	Durbin-Watson stat		0.653221

Table 24: Size of the calculated parameters of health ($\alpha\delta$) and schooling ($\alpha\gamma$) on sectoral output growth.

Variable	**Mining**	**Construction**	**Transport & Communication**	**Manufacturing**
Health	0.023 %	0.08566 %	0.00155 %	0.08657 %
Schooling	0.00422 %	0.01549 %	0.00028 %	0.015657 %

Source: Authors

Table 25: Size of α (coefficient of the growth of E)

Sectors	**Mining**	**Construction & Buildings**	**Transport**	**Manufacturing**
Coefficient α	0.094988	0.349187***	0.00647**	0.352829***