Economic Impact of Standards

Table of Contents

List of Figures

List of Tables

Executive summary

At a micro-level, previous research has shown that standards contribute positively to the financial performance of companies and at a macro-level, to total factor productivity, labour productivity and economic growth. In this paper, the South African Bureau of Standards (SABS) mirrors the previously conducted macro-level studies by empirically estimating labour productivity. The results of the SABS' research is in line with the previous studies and prove that standards contribute positively to labour productivity.

1. Introduction

Separating the role of standards and measuring their impact is extremely difficult because standards are an integral component of so many economic activities. On the one hand, their diversity makes it difficult to sensibly aggregate them into a single measure; while on the other hand, the economy-wide, rather than the specific effect of standards, may be the most important.[1]

That being said, national studies have found that the implementation of international standards leads to increased economic efficiency and this generates economic benefits for the supplying industry, through increasing profits. However, users also face economic benefits in the form of lower prices for goods and services. Furthermore, international standards can reduce risks and increase quality of service[2], while standards in general have been shown to increase exports and imports.[3]

Following on from the previously conducted national studies, the South African Bureau of Standards (SABS) has embarked on an investigation to determine the macro-economic impact of standards on South Africa's economy, through modelling labour productivity. Labour productivity is a key determinant of living standards (social development), measured as per capita income and is of significant policy relevance.

---

[1] Centre for International Economics, 2006. *Standards and the economy*. Prepared for Standards Australia, July 2006.
[2] Blind, K. 2011. *The benefits of standards for national economies*. World Standards Cooperation – Newsletter No. 03, October 2011.
[3] Swann, P., Temple, P. & M. Shurmer, 1996. Standards and trade performance: the UK experience. *The Economic Journal*, Vol. 106. Blackwell Publishing.

The paper is structured as follows: Section 2 reviews the previously conducted national studies; Section 3 explains why the SABS chose to model labour productivity; Section 4 constructs a model for South Africa, commencing from the national studies reviewed in Section 2 and Section 5 demonstrates the accuracy of the model; Section 6 interprets the results of the model and Section 7 concludes the report.

2. Literature review

Eight (8) national studies have been conducted and each found that standards have a positive impact on the national economy.

Firstly, the pioneering German study in 2000[4] and the updated 2010[5] study, made use of a standard Cobb-Douglas production function:
$Y(t) = A(t)\{F[K(t), L(t)]\}$, in which A(t) is comprised of the following three factors:

- Technical knowledge generated in Germany,
- Technical knowledge imported from abroad, and
- The diffusion of this technical knowledge.

The equation for their empirical model was specified as:

$$y(t) = a + \propto k(t) + \beta l(t) + \gamma pat(t) + \delta ex(t) + \epsilon std(t) + \zeta dum(t) + u(t) \quad (1)$$

where y(t) is economic growth, k(t) is the gross fixed capital assets (capital), l(t) is the number of persons employed (labour), pat(t) is the number of patents, ex(t) is the licence expenditure and std(t) is the number of standards.

The 2010 study found an economic benefit of 16.77 billion Euros a year. This amount approximately corresponds to the value obtained in 2000 and equates to 0.72% of Germany's GDP.

Secondly and based on the German study, the 2005 UK study estimated:

$$y(t) - l(t) = a + \propto [k(t) - l(t)] + \epsilon std(t) + \lambda t + u(t) \quad (2)$$

[4] Jungmittag, A., Blind, K. & H. Grupp. (1999). *Innovation, standardisation and the long-term production function. A cointegration analysis for Germany 1960–96*. Zeitschrift fu¨r Wirtschafts- und Sozialwissenschaften (ZWS) 119:205–222.

[5] Blind, K., Jungmittag, A. & Mangelsdorf, A. (2010). *The economic benefits of standardization: An update of the study carried out by DIN in 2000*. DIN.

where y(t) – l(t) is labour productivity, k(y) – l(t) is the ratio of capital to employment and the rest are as above.

Using equation 2, the authors find that standards are associated with growth in labour productivity of 0.28% per annum, or about 13% of the recorded growth in productivity between 1948 and 2002. Furthermore, the authors estimate the overall impact of technological change to be about 1.0% per annum over the same period – set against a growth rate of output in the whole economy (GDP) of 2.5%. The contribution of standards to technological change is over 25%.

Thirdly, Australia in 2006 used Total Factor Productivity (TFP) as the dependent variable, with the results indicating a 1% increase in the stock of standards will lead to a 0.17% increase in the level of TFP, although this estimate did range between 0.14 and 0.19.

Fourthly, Danish in 2007 specify the following empirical equation:

$$y_t = \tilde{\propto}_t + \gamma s_t + \alpha k_t + (1-\alpha) l_t \qquad (3)$$

where y(t) is economic growth, s(t) is the stock of standards, k(t) is capital stock and l(t) is the amount of labour employed.

The Danish equation remains the same whether the focus is on the entire economy or on a single industry and so the same fundamental model can be used for both.

The results show that the standards explain approximately 4% of gross value added (GVA) growth in the aggregated analysis and 18% of GVA growth is explained by standards in the disaggregated analysis.

Fifthly, Canadians in 2007 modeled the following: Labour productivity = constant + A*(the existing number of standards) + B*(the capital to labour ratio) + C*(time trend), econometrically specified as:

$$\ln\left(\frac{Q_t}{L_t}\right) = \beta + \propto \ln\left(\frac{K_t}{L_t}\right) + \lambda T_t + \epsilon \ln(STA_t) + u_t \qquad (4)$$

where $\ln(Q_t/L_t)$ is the natural logarithm of labour productivity, $\ln(K_t/L_t)$ is the natural logarithm of the capital-to-labour ratio which captures capital deepening, T_t is a time trend vector, STA_t is the number of standards and u_t is an error term.

On average, the Canadians found that growth in the number of standards contributed 0.246 percentage points to growth in labour productivity and real GDP in each year. Thus, the results suggest that growth in the number of standards accounted for 17% of labour productivity growth and about 9% of growth in real GDP between 1981 and 2004.

Sixthly, the French in 2009 specified the following macroeconomic model:

$$(\dot{y} - \dot{l}) = \dot{a} + (1-\propto)(\dot{k} - \dot{l}) \quad (5)$$

To measure the impact of standards, the following equation is specified:

$$T\dot{F}P_t = c + dkn\dot{o}r_t + ekbr\dot{e}v_{t-2} + \sum_i^n f_i \, x_t + \in_t \quad (6)$$

From this, the French found that the impact of standards on TFP (and consequently on the total growth of the French economy) is 0.81% per year on average between 1950 and 2007.

Lastly, New Zealand in 2011 specified their labour productivity equation as:

$$lnY - lnL = lnA + \alpha(lnK - lnL) + u \quad (7)$$

The results of this study show that over the last 30 years a 1% increase in the number of standards in New Zealand could be related to a 0.1% increase in TFP. Therefore, a 1% increase in the number of standards in New Zealand relates to a 0.056% increase in labour productivity.

3. Why labour productivity

With the previously conducted eight national studies opting to model TFP, economic growth or labour productivity, the SABS chose to model labour productivity for the following reasons.

Firstly, despite there being no unique purpose for or single measure of, productivity, the measurement thereof is a key constituent towards assessing and understanding the development of standards of living. Labour productivity is a measure of far more than just the productivity of individuals in the labour force – it reflects how efficiently labour is combined with other factors of production, how many of these other inputs are available per worker and how rapidly technical change (whether embodied and disembodied) occurs and is, therefore referred to simply as 'productivity' from hereon in. For example, giving a man a bulldozer with which to dig, does not make him more efficient than a man with a shovel; he just has more capital to work with.[6] Moreover, productivity, in particular, is important in the economic analysis of a country because it is a dynamic measure of economic growth, competitiveness and living standards.[7&8] This point is elaborated on in those that follow.

Secondly, due to the law of diminishing marginal returns, sustained growth in a nation's per capita income can only occur if there is a rise in output per unit of input. This is because, as the number of new inputs increases, the marginal product added to output will, at some point, be less than the marginal product of the previous employee. One bulldozer added to a construction project can make a huge difference to productivity but by the time a dozen are on-site, one more will probably not make much of a difference. Therefore, merely increasing the inputs, without an increase in the efficiency with which those inputs are used, cannot result in sustained per capita income increases.[9]

Thirdly, sustained increases in per capita income can be achieved through steady GDP per capita growth, which, in turn, is achieved through productivity. A basic mathematical explanation follows[10]:

- $Income\ per\ capita = \frac{Income\ (Y)}{Population\ (Pop)}$
- $\frac{Y}{Pop} = \frac{Y}{Labour\ (L)} * \frac{L}{Pop}$, with Y/L being labour productivity and L/Pop being the labour to population ratio.
- $Growth\ rate\ of\ \frac{Y}{Pop} = Growth\ rate\ of\ \frac{Y}{L} + Growth\ rate\ of\ \frac{L}{Pop}$
- Therefore, the higher labour productivity is, the higher per capita income is.
- Higher income per capita results in higher consumption per capita and, ultimately, in a higher standard of living, seen in Figure 1 below.

The above mathematical explanation shows that through being more productive, workers can earn more and improve their standard of living, despite working for the same number of hours. This is achieved through, amongst other things[11]:

- More and better private capital – plant and equipment,

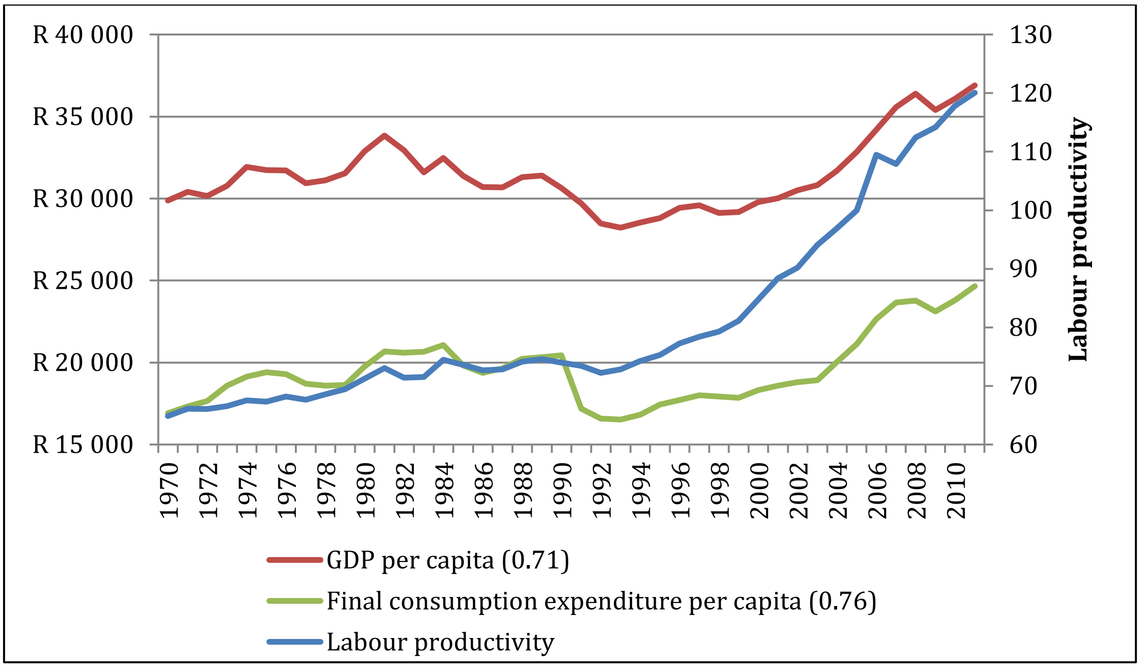
---

6 Krugman, P. 1994. The Myth of Asia's Miracle. *Foreign Affairs*, Vol. 73, No. 6, p62-78.
7 OECD, 2001. Measuring productivity – OECD manual: Measurement of aggregate and industry-level productivity growth.
8 OECD, 2008. Labour productivity indicators: Comparison of two OECD databases, productivity differentials & the Balassa-Samuelson effect.
9 Krugman, P. 1994.
10 Maccini, L. J. 2010. Economic growth and productivity. Johns Hopkins University Lecture.
11 Ibid.

- Technological progress and innovation, and
- More and better "Public Capital" – infrastructure.

Therefore, policies that stimulate labour productivity are a key mechanism of economic growth and social development.

Figure 1: Labour productivity, GDP per capita and consumption per capita



Note: Numbers in brackets are the associated correlations with labour productivity
Source: Eviews 7 and own calculations based on Department of Agriculture, Forestry and Fisheries and SARB data

Lastly, the benefits from productivity increases in South Africa accrue not only to us but to our neighbours: the spill-overs from leader economies to followers are large. If country A's productivity improves because of its own investment level and innovation, it will almost automatically do the same in the long run for country B. That is to say, for nations such as South Africa, a successful productivity-enhancing measure has the nature of a public good. The extent to which our neighbours benefit depends on, in part, product mix and education. Lesotho, for example, which does not manufacture cars, cannot benefit from the invention and adoption of a better car-producing robot in South Africa. Moreover, Lesotho cannot benefit from the factor-price equalisation effect of the accompanying South African investments, since it cannot shift labour force out of its non-existent auto industry. Lack of education and the associated skills prevent both the presence of high-tech industries and the effective imitation/adoption of South African innovation.[12]

Thus, the SABS chose labour productivity above both TFP end economic growth, as the dependent variable because:

- The measurement thereof helps explain the primary economic foundations necessary for economic growth.
- It is a useful measure, relating to the single most important factor of production.
- It is a key determinant of living standards (social development), measured as per capita income and is, therefore, of significant policy relevance.

As a fundamental component of economic policy, be it for growth or social development, productivity is of paramount importance.

4. South Africa's model

Following on from the pioneering German study, the South African specification takes the non-stationarity of the variables into account and estimates a long-term cointegration relationship based on a Cobb-Douglas production function.

The equation for the South African empirical model is specified as:

$$lp(t) = \partial + \propto ave\ \frac{k}{l}(t) + \gamma\ gfcf\ (t) + \beta\ stds(t) + \delta\ open(t)\ + u(t) \qquad (8)$$

where lp(t) is labour productivity (ln_l_productivity), ave k/l(t) is the average ratio of capital to labour (ln_ave_kl_ratio), gfcf(t) is gross fixed capital formation (ln_gfcf), stds(t) is the stock of standards (ln_stds) and open(t) is the degree of openness (ln_open). The variables enter the equation in their natural log forms, as is the norm for Cobb-Douglas specifications.

The variables are sourced from:

- Labour productivity – Quantec[13],
- Average k/l ratio[14] – South African Reserve Bank (SARB),

---

[12] Baumol, W. 1986. Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show. *The American Economic Review*, Vol. 76, No. 5, p1072-1085.

[13] Sourced from Quantec because the SARB only has labour productivity for manufacturing and for the non-agricultural sectors.

[14] The inclusion of the average k/l ratio means that the sum of the production elasticities for K and L is restricted to one. This could not be tested empirically because the K/L variable was not calculated, it was

- Gross fixed capital formation (GFCF) – SARB,
- Stock of standards – SABStan (SABS database),
- Openness – Calculated from SARB data.

According to the process of cointegration, the long-run relationship can be defined as:

$$LP = f(\overset{-ve}{Ave\frac{K}{L}}, \overset{+ve}{GFCF}, \overset{+ve}{Stds}, \overset{-ve}{Open})$$

Table 1: Output coefficients for the long-run cointegrated equation

Dependent Variable:
LN_L_PRODUCTIVITY
Method: Least Squares
Date: 03/14/13 Time: 11:55
Sample: 1970 2011
Included observations: 42

Variable	Coefficient
LN_AVE_KL_RATIO	-0.693099
LN_GFCF	0.457646
LN_STDS	0.112538
LN_OPEN	-0.251129
C	6.077206

Source: EViews 7

The signs and magnitudes of the variables in the long-run equation do not conform to the *a priori* expectations. It is expected that an increase in the average k/l ratio or openness will increase labour productivity. However, with regards to the average k/l ratio in South Africa's case, this can be explained by considering that providing additional capital equipment to a workforce with minimal education and skills, is unlikely to result in significant productivity increases.

Despite this rather controversial argument, there are other reasons why an improved capital labour ratio might not positively contribute to labour productivity:

- Workers are not fully responsible for labour productivity. For example, most of the factors that govern productivity can be influenced to a large extent by management.
- Labour productivity can increase without workers having any role in it,
- Labour productivity can also decrease because of external factors, such as a downswing in the business cycle, and

used as is from the SARB. The SARB calculates the average k/l ratio by dividing the total fixed capital stock by the economically active population of South Africa (a variable not provided by the SARB).

- Similarly to the latter point, productivity is a very elastic concept that changes with the business cycle.

With regards to the negative relationship between openness and labour productivity, standard trade theory associates increases in openness with rising living standards but with the rapid integration of large, low-wage countries like Brazil, China, India and Russia into the world economy, local workers may have become less competitive internationally. These four countries represent 45% of world labour supply and are increasingly open to trade and investment. Over the past 15 years, total trade as a proportion of GDP grew by over 50% in Russia, nearly doubled in China and more than doubled in Brazil and India. Standard trade theory further suggests that this development could be a source of increased job insecurity or downward pressure on wages for low-skilled workers in countries like South Africa, while at the same time, offers a boon for consumers in the form of lower prices.[15]

With increased globalisation comes another novel feature: the rapid adoption of information and communications technology (ICT). ICT technology makes it easier to fragment production and to outsource certain tasks to other countries. Through this "great unbundling", the reach of globalisation has extended to domestic activities where workers were previously sheltered from direct international competition.[16] Although this argument can be extended to further substantiate the negative relationship between labour productivity and openness, we feel the point sufficiently made.

On the other hand, the signs and magnitudes on gross domestic investment and the stock of standards do conform to the *a priori* expectations. An increase in GFCF is likely to increase labour productivity because apart from plant, machinery and equipment purchases, GFCF includes land improvements, the construction of roads, railways, schools, offices, hospitals, private residential dwellings and commercial and industrial buildings.

The output presented in Table 1 suggests that a 1 per cent increase in:

- The average k/l ratio would lead to a 0.69 per cent decrease in labour productivity,
- GFCF would lead to a 0.46 per cent increase in labour productivity,
- The stock of standards would lead to a 0.11 per cent increase in labour productivity, and
- Openness would lead to a 0.25 per cent decrease in labour productivity.

---

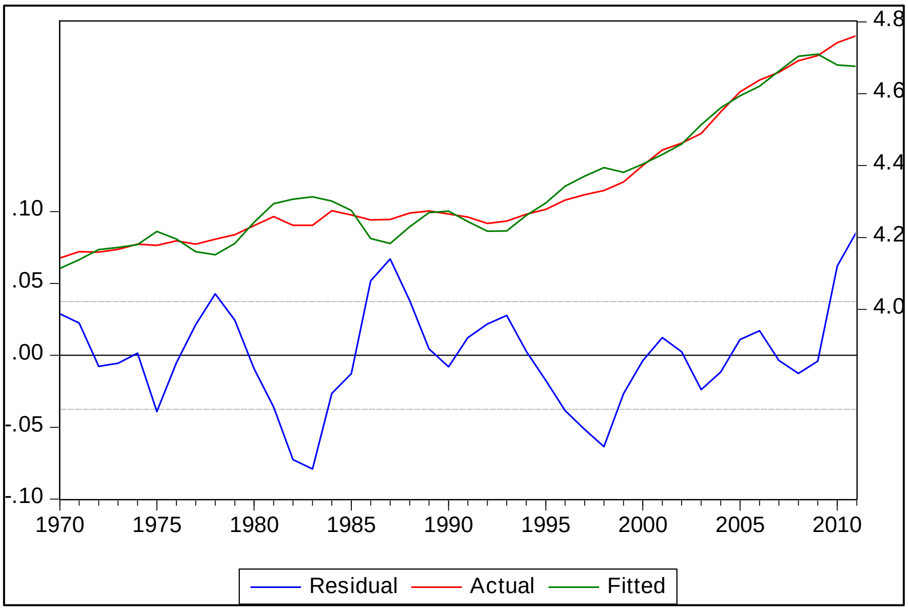
[15] OECD Observer. 2007. *Globalisation, jobs and wages* [Online]. Found at: http://www.oecd.org/els/emp/38796126.pdf. June 2007, Policy Brief.
[16] Ibid.

4.1 Test for cointegration

To get an initial idea of the level of cointegration, Figure 2 is presented below. In the figure, one can see the actual data versus fitted plot, as well as the residual of the cointegrating equation. For cointegration, the residual should fluctuate around the .00 mark in the figure and have no discernible pattern.

In economic parlance, cointegration is when a stationary linear combination of two or more series of non-stationary random variables can be found[17], which appears to be the case in Figure 2 but this still has to be tested econometrically.

Figure 2: Actual versus fitted plot for cointegrating equation



Source: EViews 7

In order to test for cointegration, one tests the null hypothesis (H_0) against the alternate hypothesis (H_1). Ideally, we want to find that H_0 is rejected in favour of H_1, implying no cointegration exists.

[17] Black, J., Hashimzade, N. & G. Myles. 2012. *Oxford dictionary of economics*. Oxford University Press.

Table 2: Testing stationarity of the cointegrating residuals

Null Hypothesis: RESID_LR has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.111027	0.0001
Test critical values:	1% level	-2.624057	
	5% level	-1.949319	
	10% level	-1.611711	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID01)
Method: Least Squares
Date: 03/14/13 Time: 12:33
Sample (adjusted): 1972 2011
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID_LR(-1)	-0.482209	0.117296	-4.111027	0.0002
D(RESID_LR(-1))	0.605599	0.143725	4.213595	0.0001

R-squared	0.383898	Mean dependent var	0.001595
Adjusted R-squared	0.367684	S.D. dependent var	0.027435
S.E. of regression	0.021816	Akaike info criterion	-4.763644
Sum squared resid	0.018086	Schwarz criterion	-4.679200
Log likelihood	97.27288	Hannan-Quinn criter.	-4.733112
Durbin-Watson stat	2.096623		

Source: EViews 7

Table 3: Engle-Granger cointegration test

n	Model	% significance	Lags	ADF : C(p)	Conclusion
4	Constant, no trend	1	0	-4.11 > -5.09	No cointegration
		5	0	-4.11 > -4.37	No cointegration
		10	0	-4.11 < -4.01	Cointegration

Source: Own calculations

Conclusion: From Table 2, we can see that the residuals of the cointegrating equation are stationary and from Table 3 we can see that cointegration exists amongst the variables at a 10% level of statistical significance. We have, thus, successfully shown that there is a stationary linear combination of our non-stationary random variables.

4.2 Error Correction Model

A model incorporating the short-run effects on economic growth corrects the stochastic residuals from the long-run cointegrating regression. The results are shown in Table 4 below.

Table 4: Output for Error Correction Model

Dependent Variable: D(LN_L_PRODUCTIVITY)
Method: Least Squares
Date: 03/14/13 Time: 14:10
Sample (adjusted): 1971 2011
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_GFCF)	0.062489	0.025500	2.450575	0.0196
D(LN_TOT)	0.092831	0.029572	3.139106	0.0035
D(LN_REAL_REMUNER)	0.365245	0.108629	3.362329	0.0019
D(LN_FIXED_K_PRODUCTIVITY)	0.392836	0.077995	5.036691	0.0000
RESID01(-1)	-0.096387	0.052610	-1.832123	0.0757
DUM94	0.007785	0.003827	2.034082	0.0498
C	0.005639	0.002457	2.295412	0.0280

R-squared	0.779638	Mean dependent var	0.015103
Adjusted R-squared	0.740751	S.D. dependent var	0.019259
S.E. of regression	0.009806	Akaike info criterion	-6.257394
Sum squared resid	0.003269	Schwarz criterion	-5.964833
Log likelihood	135.2766	Hannan-Quinn criter.	-6.150860
F-statistic	20.04861	Durbin-Watson stat	1.536077
Prob(F-statistic)	0.000000		

Source: EViews 7

Of the variables included in the ECM, each was integrated of the first order or I(1). Differencing these once transformed them into I(0) series[18]. The error correction coefficient is negative and statistically different from zero. The Adjusted R^2 value indicates that roughly 74 per cent of the variation in labour productivity is explained by the ECM.

[18] See Appendix.

All the perfunctory tests were performed on the ECM, with the following results:

Test	H_0	Test statistic	p-value	Conclusion	Interpretation
Jarque-Bera	Residuals are normally distributed	JB = 1.05	0.59	Cannot reject H_0	Residuals are normally distributed
Ljung-Box Q	No serial correlation in the residuals up to 6th order	LB_Q = 6.25	0.40	Cannot reject H_0	No serial correlation present up to 6th order
Breusch-Godfrey	No serial correlation in the residuals up to 2nd order	nR^2 = 4.62	0.099	H_0 rejected at 10% level of significance	Serial correlation may be a problem
ARCH LM	No autoregressive conditional heteroskedasticity up to 1st order	nR^2 = 3.69	0.05	H_0 rejected at 10% level of significance	Autoregressive conditional heteroskedasticity may be a problem
White	No heteroskedasticity	nR^2 = 11.31	0.08	H_0 rejected at 10% level of significance	Residuals may be homoscedastic
Breusch-Pagan-Godfrey	No heteroskedasticity	nR^2 = 9.31	0.16	Cannot reject H_0	No heteroskedasticity
Ramsey RESET	Model is stable with no specification error	LR = 1.08	0.58	Cannot reject H_0	No misspecification

Thus, given the diagnostic results at a 5 percentage level of significance, it is reasonable to conclude that the residuals do satisfy the assumptions of the classical normal linear regression model.

4.3 Adjustment of the cointegration coefficient and t-values

In order to address the problem of non-stationarity of the time series in the cointegration equation and the t-statistics not being suitable for inference, the coefficients are adjusted using error correction (ECM). The ECM is used via its residuals to adjust the long-run coefficients and their corresponding t-statistics.

4.3.1 Third step adjustment

The Engle-Yoo third step adjustment is performed in order to adjust the long-run (cointegrating) coefficients and associated *t*-statistics for initial bias. This allows for accurate statements regarding the magnitudes (i.e. elasticity interpretations) and statistical evaluation of the long-run coefficients.

Table 5: Results of the Engle-Yoo regression

Dependent Variable: LN_L_PRODUCTIVITY
Method: Least Squares
Date: 03/14/13 Time: 12:29
Sample: 1970 2011
Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_AVE_KL_RATIO	-0.693099	0.142465	-4.865038	0.0000
LN_GFCF	0.457646	0.035979	12.71976	0.0000
LN_STDS	0.112538	0.015467	7.275966	0.0000
LN_OPEN	-0.251129	0.093268	-2.692568	0.0106
C	6.077206	1.392590	4.363958	0.0001

R-squared	0.961573	Mean dependent var	4.340664
Adjusted R-squared	0.957418	S.D. dependent var	0.181120
S.E. of regression	0.037375	Akaike info criterion	-3.624306
Sum squared resid	0.051684	Schwarz criterion	-3.417441
Log likelihood	81.11043	Hannan-Quinn criter.	-3.548482
F-statistic	231.4640	Durbin-Watson stat	0.570732
Prob(F-statistic)	0.000000		

Source: EViews 7

Table 6: Calculated coefficients and adjusted t-statistics

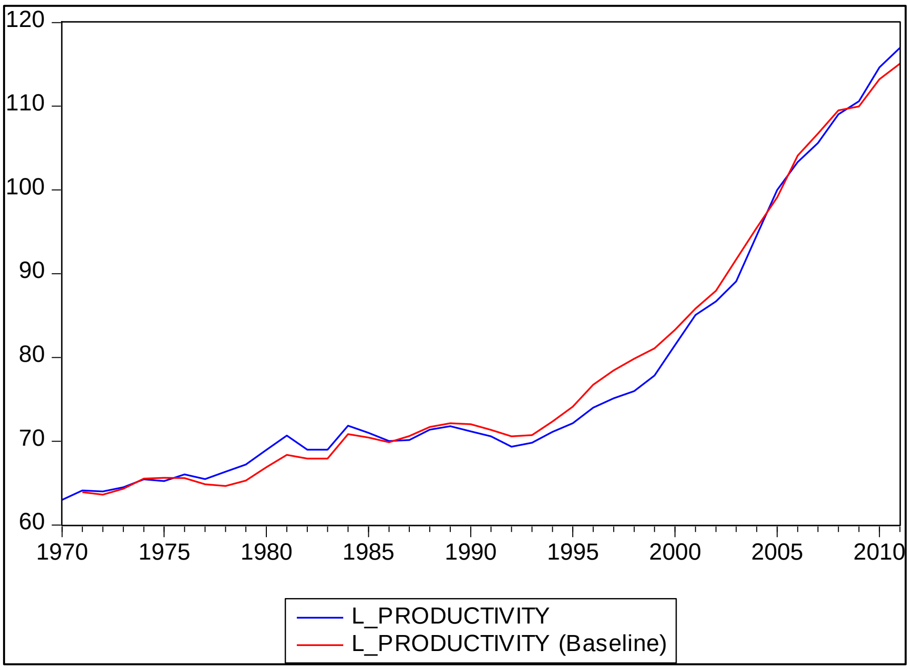
Variable	Adjusted coefficients	Adjusted t-statistic
ln_ave_kl_ratio	-0.693099 – 0.093694 = -0.786793	-5.52
ln_GFCF	0.457646 + 0.122069 = 0.579715	16.11
ln_Stds	0.112538 – 0.047502 = 0.065036	4.20
ln_open	-0.251129 – 0.049274 = -0.300403	-3.22

In the long run, all the adjusted coefficients are highly statistically significant as their respective t-statistics are all larger than 1.96 in absolute value.

5. Dynamic simulation of model

In order to compare the true, non-stationary estimated equation with the actual data series, the equation is written back to its levels and simulated dynamically. The output of this simulation can be seen in Figure 3 below.

Figure 3: **Fit of estimated values to actual values of dependent variable**

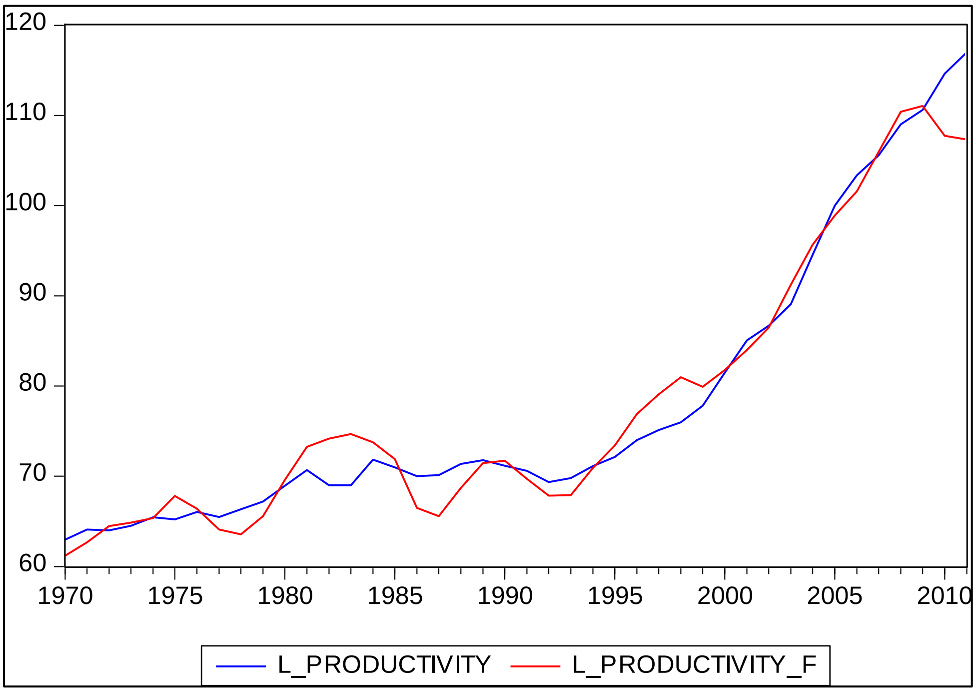


Source: EViews 7

From Figure 3, one can see that the estimated equation for labour productivity compares well to the actual series and thus, the model is a good fit.

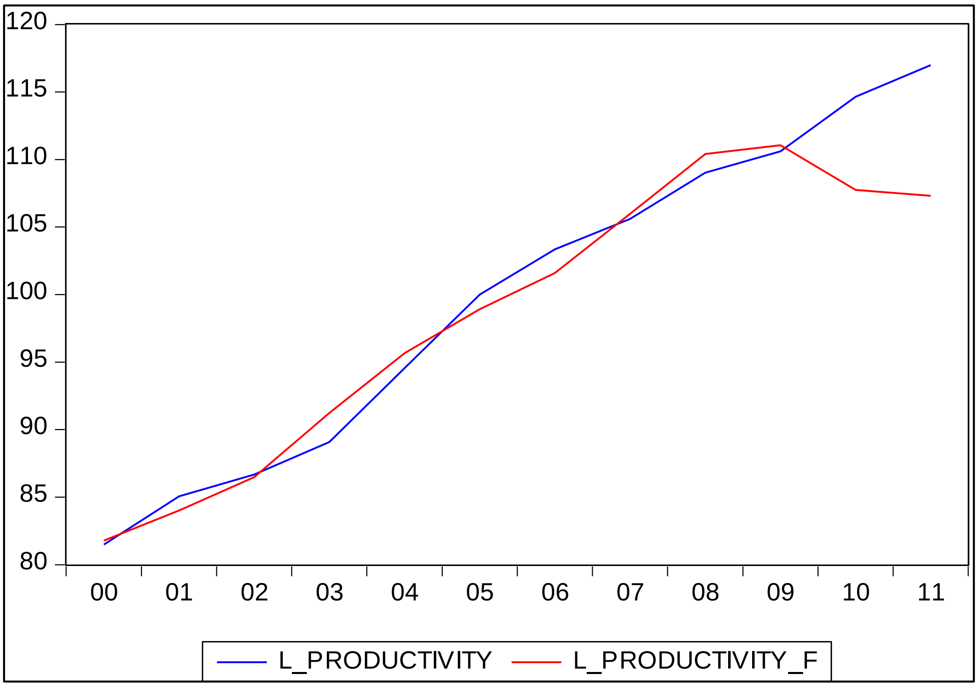
In addition to the dynamic simulation, in-sample forecasting suggests that the long-run equation performs relatively well in predicting movements in labour productivity, as can be seen in Figure 4 below. The forecasted values do diverge from the actual values in 2010 and 2011 and this is displayed more prominently in Figure 5.

Figure 4: **Fit of forecasted values to actual values of dependent variable (1970-2011)**



Source: EViews 7

Figure 5: **Fit of forecasted values to actual values of dependent variable (2000-2011)**



Source: EViews 7

6. Interpretation of findings

From the adjusted coefficients in Table 6, the following is concluded:

- A 1 per cent increase in the average k/l ratio would lead to a 0.79 per cent decrease in labour productivity,
- A 1 per cent increase in GFCF would lead to a 0.58 per cent increase in labour productivity,
- A 1 per cent increase in the stock of standards would lead to a 0.07 per cent increase in labour productivity, and
- A 1 per cent increase in openness would lead to a 0.3 per cent decrease in labour productivity.

Between 1970 and 2011, the stock of standards grew by roughly 941%. This translates into a 65.87% increase in labour productivity for the period or 1.57% per annum.

These results are in line with the previously conducted macro-models of the countries modelling labour productivity. The UK found that the stock of standards translated into a 0.28% increase in labour productivity per annum and Canada found a 0.71% increase. Lastly, New Zealand found that a 1% increase in the stock of standards translates into a 0.056% increase in labour productivity.

7. Conclusion

Standards contribute positively to labour productivity in South Africa and, therefore, contribute positively to economic growth. Furthermore, the findings of Manders and De Vries[19] reiterate the importance of standards in the long run, over the short. The two authors find that: "Organizations aiming at real internal quality improvements gain more than those using ISO 9001 as a "quick fix" in response to quality problems or customer pressure."[20] This suggests that organisations seeking real gains from management standards must do so for reasons stemming from within the organisation itself and have long-term objectives in mind.

Earlier, it was suggested that workers are not fully responsible for labour productivity and that, for example, most of the factors that govern productivity can be influenced to a large extent by

[19] Manders, B. and H. J. de Vries. 2011. *Does ISO 9001 pay?* ISO Focus+, Vol. 3, No. 9, October 2012.
[20] Ibid.

management. Thus, given the findings of Manders and De Vries and those of this paper, one can conclude that internalising standards and taking a long-term view is key to successfully improving labour productivity.

The proposition that the implementation of standards leads to increased economic efficiency[21], thus, appears proved and in line with previous research.

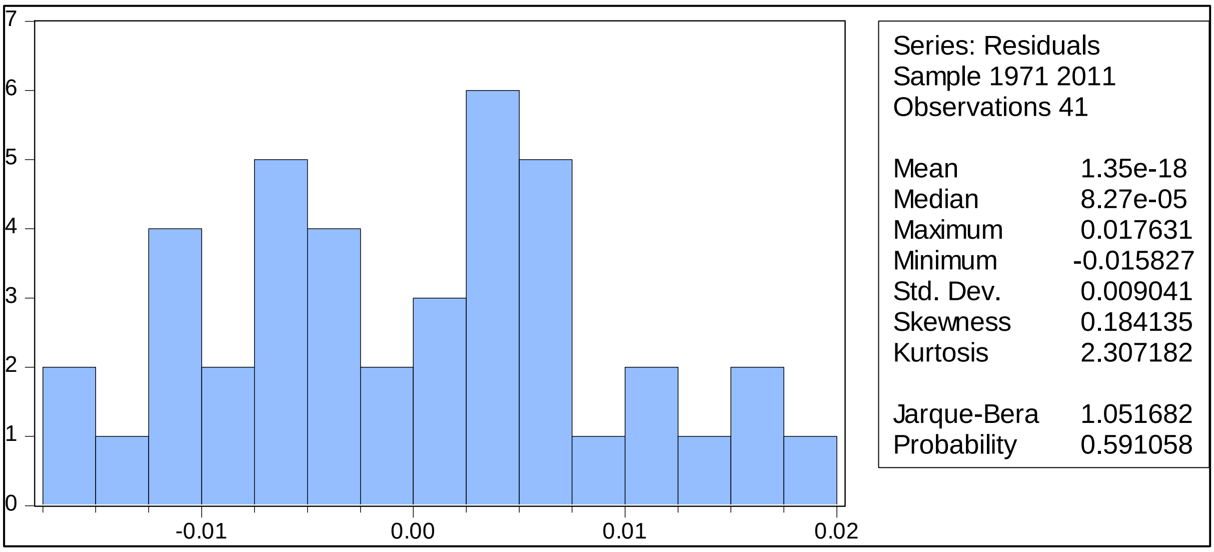
[21] Blind, K. 2011. *The benefits of standards for national economies*. World Standards Cooperation – Newsletter No. 03, October 2011.

Appendix

Series	Model	ADF		Conclusion
		Lags	τ_τ , τ_μ , τ	
ln_l_productivity	τ_τ	0	0.46	Non-stationary
	τ_μ	0	3.45	
	τ	1	2.37	
D(ln_l_productivity)	τ_τ	0	-4.68***	Stationary
	τ_μ	0	-3.69***	
	τ	2	-1.11	
ln_GFCF	τ_τ	2	-0.70	Non-stationary
	τ_μ	2	0.41	
	τ	2	1.80	
D(ln_GFCF)	τ_τ	1	-4.67***	Stationary
	τ_μ	1	-4.49***	
	τ	1	-4.01***	
ln_ToT	τ_τ	0	-2.37	Non-stationary
	τ_μ	1	-3.87***	
	τ	2	0.73	
D(ln_ToT)	τ_τ	1	-5.28***	Stationary
	τ_μ	1	-5.37***	
	τ	1	-5.35***	
ln_real_remuner	τ_τ	0	-1.21	Non-stationary
	τ_μ	0	0.47	
	τ	0	3.97	
D(ln_real_remuner)	τ_τ	0	-6.59***	Stationary
	τ_μ	0	-6.42***	
	τ	0	-5.02***	
ln_fixed_k_productivity	τ_τ	1	-2.57	Non-stationary
	τ_μ	1	-1.81	
	τ	1	-0.22	
D(ln_fixed_k_productivity)	τ_τ	0	-4.03**	Stationary
	τ_μ	0	-3.51**	
	τ	0		

*(**)[***] Statistically significant at a 10(5)[1]% level

Figure 6: Histogram of ECM



Source: EViews 7

Table 7: Ljung-Box Q

Date: 03/14/13 Time: 15:46
Sample: 1971 2011
Included observations: 41

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |** |	. |** |	1	0.226	0.226	2.2526	0.133
.*| . |	**| . |	2	-0.169	-0.232	3.5395	0.170
. | . |	. |*. |	3	-0.024	0.084	3.5658	0.312
. |*. |	. | . |	4	0.109	0.060	4.1271	0.389
. |*. |	. |*. |	5	0.167	0.144	5.4999	0.358
.*| . |	.*| . |	6	-0.122	-0.195	6.2495	0.396

Source: EViews 7

Table 8: Breusch-Godfrey LM test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.033052	Prob. F(2,32)	0.1475
Obs*R-squared	4.622353	Prob. Chi-Square(2)	0.0991

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 03/14/13 Time: 15:48
Sample: 1971 2011
Included observations: 41
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_GFCF)	0.010334	0.025305	0.408398	0.6857
D(LN_TOT)	-0.008172	0.030080	-0.271666	0.7876
D(LN_REAL_REMUNER)	-0.060670	0.111128	-0.545945	0.5889
D(LN_FIXED_K_PRODUCTIVITY)	0.002997	0.075833	0.039516	0.9687
RESID01(-1)	-0.013489	0.055704	-0.242161	0.8102
DUM94	-0.000556	0.003726	-0.149313	0.8822
C	0.000630	0.002420	0.260297	0.7963
RESID(-1)	0.316936	0.188391	1.682328	0.1022
RESID(-2)	-0.243538	0.184266	-1.321668	0.1957

R-squared	0.112740	Mean dependent var	1.35E-18
Adjusted R-squared	-0.109075	S.D. dependent var	0.009041
S.E. of regression	0.009521	Akaike info criterion	-6.279451
Sum squared resid	0.002901	Schwarz criterion	-5.903301
Log likelihood	137.7287	Hannan-Quinn criter.	-6.142478
F-statistic	0.508263	Durbin-Watson stat	1.873739
Prob(F-statistic)	0.841049		

Source: EViews 7

Table 9: ARCH LM test

Heteroskedasticity Test: ARCH

F-statistic	3.858003	Prob. F(1,38)	0.0569
Obs*R-squared	3.686753	Prob. Chi-Square(1)	0.0548

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/14/13 Time: 15:49
Sample (adjusted): 1972 2011
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.69E-05	1.89E-05	3.015848	0.0046
RESID^2(-1)	0.302632	0.154076	1.964180	0.0569

R-squared	0.092169	Mean dependent var	8.15E-05
Adjusted R-squared	0.068279	S.D. dependent var	9.28E-05
S.E. of regression	8.96E-05	Akaike info criterion	-15.75419
Sum squared resid	3.05E-07	Schwarz criterion	-15.66974
Log likelihood	317.0838	Hannan-Quinn criter.	-15.72366
F-statistic	3.858003	Durbin-Watson stat	2.089113
Prob(F-statistic)	0.056855		

Source: EViews 7

Table 10: White's heteroskedasticity test

Heteroskedasticity Test: White

F-statistic	2.158361	Prob. F(6,34)	0.0718
Obs*R-squared	11.30894	Prob. Chi-Square(6)	0.0793
Scaled explained SS	5.082979	Prob. Chi-Square(6)	0.5332

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/14/13 Time: 15:51
Sample: 1971 2011
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.18E-05	3.36E-05	1.839677	0.0746
(D(LN_GFCF))^2	-0.000912	0.001763	-0.517224	0.6083
(D(LN_TOT))^2	-0.003054	0.002481	-1.230792	0.2268
(D(LN_REAL_REMUNER))^2	0.033635	0.023649	1.422262	0.1641
(D(LN_FIXED_K_PRODUCTIVITY))^2	0.013852	0.020383	0.679590	0.5014
RESID01(-1)^2	-0.013279	0.009060	-1.465667	0.1519
DUM94^2	6.18E-05	2.94E-05	2.102875	0.0430

R-squared	0.275828	Mean dependent var	7.97E-05
Adjusted R-squared	0.148033	S.D. dependent var	9.23E-05
S.E. of regression	8.52E-05	Akaike info criterion	-15.74898
Sum squared resid	2.47E-07	Schwarz criterion	-15.45642
Log likelihood	329.8541	Hannan-Quinn criter.	-15.64245
F-statistic	2.158361	Durbin-Watson stat	1.750781
Prob(F-statistic)	0.071795		

Source: EViews 7

Table 11: Breusch-Pagan-Godfrey's heteroskedasticity test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.665840	Prob. F(6,34)	0.1596
Obs*R-squared	9.314609	Prob. Chi-Square(6)	0.1566
Scaled explained SS	4.186595	Prob. Chi-Square(6)	0.6514

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/14/13 Time: 15:52
Sample: 1971 2011
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.44E-05	2.21E-05	2.015276	0.0518
D(LN_GFCF)	3.04E-05	0.000229	0.132743	0.8952
D(LN_TOT)	-5.37E-05	0.000265	-0.202499	0.8407
D(LN_REAL_REMUNER)	0.000874	0.000975	0.895956	0.3766
D(LN_FIXED_K_PRODUCTIVITY)	0.000359	0.000700	0.512519	0.6116
RESID01(-1)	-0.000276	0.000472	-0.585392	0.5621
DUM94	5.83E-05	3.43E-05	1.697954	0.0987

R-squared	0.227186	Mean dependent var	7.97E-05
Adjusted R-squared	0.090807	S.D. dependent var	9.23E-05
S.E. of regression	8.80E-05	Akaike info criterion	-15.68397
Sum squared resid	2.63E-07	Schwarz criterion	-15.39141
Log likelihood	328.5214	Hannan-Quinn criter.	-15.57744
F-statistic	1.665840	Durbin-Watson stat	1.773837
Prob(F-statistic)	0.159623		

Source: EViews 7

Table 12: Ramsey RESET test

Ramsey RESET Test
Equation: ECM_3
Specification: D(LN_L_PRODUCTIVITY) D(LN_GFCF) D(LN_TOT)
D(LN_REAL_REMUNER) D(LN_FIXED_K_PRODUCTIVITY)
RESID01(-1) DUM94 C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.937991	33	0.3551
F-statistic	0.879828	(1, 33)	0.3551
Likelihood ratio	1.078801	1	0.2990

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	8.49E-05	1	8.49E-05
Restricted SSR	0.003269	34	9.62E-05
Unrestricted SSR	0.003184	33	9.65E-05
Unrestricted SSR	0.003184	33	9.65E-05

LR test summary:

	Value	df
Restricted LogL	135.2766	34
Unrestricted LogL	135.8160	33

Unrestricted Test Equation:
Dependent Variable: D(LN_L_PRODUCTIVITY)
Method: Least Squares
Date: 03/14/13 Time: 15:54
Sample: 1971 2011
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_GFCF)	0.068296	0.026284	2.598351	0.0139
D(LN_TOT)	0.115178	0.038016	3.029715	0.0047
D(LN_REAL_REMUNER)	0.455867	0.145520	3.132684	0.0036
D(LN_FIXED_K_PRODUCTIVITY)	0.467309	0.111393	4.195132	0.0002
RESID01(-1)	-0.122583	0.059645	-2.055208	0.0478
DUM94	0.009012	0.004051	2.224580	0.0331
C	0.006741	0.002727	2.471951	0.0188
FITTED^2	-5.692877	6.069221	-0.937991	0.3551

R-squared	0.785361	Mean dependent var	0.015103
Adjusted R-squared	0.739831	S.D. dependent var	0.019259
S.E. of regression	0.009823	Akaike info criterion	-6.234926
Sum squared resid	0.003184	Schwarz criterion	-5.900571
Log likelihood	135.8160	Hannan-Quinn criter.	-6.113172
F-statistic	17.24947	Durbin-Watson stat	1.438465
Prob(F-statistic)	0.000000		

Source: EViews 7