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This study presents a model capturing sources of Iranian aggregate labour productivity using annual time series data from 1960 to 2002. Labour productivity in this model is determined by real net capital stock, information technology and telecommunications (ITT) and trade openness. Empirical estimates indicate that policies aimed at promoting various types of investment and trade openness, which generates technology spillovers, can improve labour productivity. A substantial rise in productivity can not be achieved unless the economy increases its stock of capital in both ITT and non-ITT sectors, and industrial protectionist policies are reversed.

Keywords: Labour productivity, Economic growth, Iran.

JEL Classifications: C22, N15, O47

## 1. Introduction

There is a consensus among economists that productivity growth plays a substantial role in enhancing standards of living and international competitiveness. For instance, according to econometric studies based on growth-accounting models, increased productivity over the last three decades has contributed to two-thirds of the 80 per cent rise in per capita income in Australia (Industry Commission, 1997). As higher productivity translates into higher per capita income, individuals benefit from higher standards of health care, better education and public welfare.

Romer (1990) demonstrates the way in which public and private resources devoted to the development of new ideas and new products can accelerate economic growth and productivity. On the other hand, the neo-Schumpeterian models of Aghion and Howitt (1998) analyse the economic impact of research into product improvement rather than product diversity. Nevertheless their overall conclusions are the same as those of Romer. That is, increases in productivity, brought about by new or improved products and processes, such as information and communications technologies (ICTs), will directly and indirectly result in increased returns to capital investment and consequently lead to a sustained level of growth of GDP. Therefore, it can be stated that the estimates based on growth-accounting procedures underestimate the true contribution of productivity growth.

In order to address this theoretical pitfall, new growth theories identify the channels through which economic institutions and reform processes can stimulate the rate of investment in physical capital, human capital, technological know-how and knowledge capital. These factors exert a sustained and positive effect on the long-run growth of the economy (Rebelo, 1991). Unlike the traditional neo-classical growth models of Swan (1956) and Solow (1956), in the new endogenous growth models institutions and policy arrangements do matter and can impact not only on the level of economic activity but also on its long-run growth path. Undoubtedly higher productivity

growth leads to more sustainable long-term economic prosperity, but the main issue is “how can productivity be stimulated in a developing country like Iran?”

According to Greenstein and Spiller (1995), Karunaratne (1995), Parham *et al.* (2001), investment in information technology and telecommunications (ITT) should also be regarded as an important stimulant of productivity. They demonstrate that investment in ITT results in curtailing transport and transactions costs, facilitating the process of technological diffusion, accelerating the diffusion of knowledge and providing better marketing information.

Furthermore, Dowrick (1994) finds that increased openness to trade stimulates productivity growth through increased competition, specialisation and transfer of knowledge. Jbili, Kramarenko and Bailén (2004, p.5) also provide some evidence that “trade openness generates technology spillovers and provides the economy with access to specialized inputs from abroad”. Roy and Van den Berg (2000) have found that oil exports can be regarded as an engine for economic growth in five oil exporting countries including Iran. In a comprehensive study with a neoclassical approach Dellalifar and Khalilzadeh-Shirazi (1979) have examined the dynamics of GDP growth in Iran during the period 1959-1973 but this study is now outdated.

Microeconomic reforms can also substantially contribute to increased productivity by reducing institutional and regulatory barriers to the flow of foreign goods and providing businesses with greater flexibility to adjust to a more competitive environment. Moreover, these reforms have been pivotal in the uptake of ICTs. The degree of trade openness, and the uptake of ICTs as quantifiable proxy variables, can reflect, in part, the impacts of the Iranian microeconomic reforms.

The structure of this paper is as follows. In Section 2 a theoretical model is postulated which explains the long-term and short-term factors affecting Iran’s labour productivity since 1960. Section 3 discusses the types and sources of the data employed in this study. In this section two unit root tests are utilised to determine the time series properties of the data. This section also presents the empirical econometric results for the short and long-term labour productivity models, as well as policy implications of the study. Section 4 provides some concluding remarks.

## 2. Methodology

As seen from the previous section there is an existing research literature on the sources of labour productivity. The supply side approach of Aschauer (1989) and Romer (1990) is used to specify a production function for aggregate output per unit of labour, *viz.*

$$\ln\left(\frac{Y}{L}\right)_t = \lambda_0 + \beta_1 \ln\left(\frac{K}{L}\right)_t + \beta_2 \ln\left(\frac{TEL}{L}\right)_t + \beta_3 \ln\left(\frac{T}{L}\right)_t + e_t \quad (1)$$

Where  $Y$  is real GDP (billion rials in 1982 constant prices),  $L$  is total number of labour force in the economy (in person),  $K$  is real stock of capital (billion rials in 1982 constant prices)<sup>1</sup>,  $TEL$  is the total number of telephone lines as a proxy for measuring the ITT stock of capital<sup>2</sup>,  $T$  is trade or total real exports plus total real imports (billion rials in

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1 Real net capital stock of capital ( $K$ ) is calculated by  $K_t = K_{t-1} - \phi_t + I_t$ , where  $\phi_t$  denotes the depreciation of capital in year  $t$  (published by Central Bank, 2003),  $I_t$  is real gross fixed capital formation in year  $t$  (obtained from Tabibian *et al.*, 2000 and World Bank, 2004).  $K$  in 1960 (the base year) is calculated by assuming that ICOR=2.5 (where ICOR is an acronym for incremental capital-output ratio). According to Shahshahani (1978), Iran’s ICOR was 2.5 around 1960.

2 Previous studies (*e.g.* Madden and Savage, 1998) have also used total number of telephone lines as a proxy to capture the impact of ITT on labour productivity.

1982 constant prices),  $\ln$  denotes the natural logarithm, and  $\beta_i$  are elasticities to be estimated.

In light of endogenous new growth theories, human capital could have also been considered as an important explanatory variable in the model but due to the lack of consistent and reliable time series data for the period under investigation this variable is excluded from the model. According to Jbili, Kramarenko and Bailén (2004, p.6) “it is difficult to determine precisely the magnitude of the contribution of investment in education to growth due to the lack of data to measure the effect of education attainment on productivity”. They have recently constructed a new proxy variable (*i.e.* average years of schooling) to capture the effect of human capital on productivity in their growth accounting model. However, the inclusion of this variable, which is subject to skepticism, resulted in the contribution of TFP (total factor productivity) to growth being negative. One may argue that the exclusion of human capital may result in the misspecification of the model. As shown later in this paper, despite the exclusion of human capital, the diagnostic test results reported later in this paper do not suggest any sign of misspecification in model. Although the important role of human capital in labour productivity is undeniable, at an empirical level the estimated models in this study appear to be acceptable in that it determines three major deriviers of productivity. For a discussion of the direct and indirect effects of human capital on economic growth see Hosseini-Nasab (2003).

In equation (1) let us now assume that: a) the dependent and all independent variables are integrated of order 1; b) the resulting residuals ( $e_t$ ) are white noise or I(0) and; and c) all the explanatory variables on the right hand side are weakly exogenous with respect to the dependent variable. If these assumptions hold, according to the Engle-Granger representation theorem (Engle and Granger, 1987), it can be argued that equation (1) is cointegrated capturing a long-term relationship between labour productivity, and its major determinants namely: 1) the real stock of capital (buildings, machinery, tools, etc.) per unit of labour, or  $K/L$ ; 2) the real stock of ITT capital per unit of labour, or  $TEL/L$ ; and 3) trade openness or total real exports plus total real imports per unit of labour, or  $T/L$ . It is theoretically expected that if  $K/L$ ,  $TEL/L$ , and  $T/L$  increase, labour productivity will rise. In other words, it is expected that  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  will have positive signs (for the theoretical justification of  $\beta_i$  see Section 1).

An important step before estimating the productivity model is to determine the time series properties of the data. This is a crucial issue since the use of non-stationary data in the absence of cointegration can result in spurious regression results. To this end, two unit root tests, *i.e.* the Augmented Dickey-Fuller (ADF) test and the GLS-detrended Dickey-Fuller (Elliot, Rothenberg, and Stock, ERS, 1996) test, have been adopted to examine the stationarity, or otherwise, of the time series data. In this paper the lowest value of the Akaike Information Criterion (AIC) has been used as a guide to determine the optimal lag length in the ADF regression. These lags are added to the ADF regression to ensure that the error term is white noise. A brief description of the ERS unit root test is provided below.

Assume that we want to examine the time series properties of  $y_t$ . First of all, the following regression, which regresses the quasi-differenced data  $d(y_t | \alpha)$  on the quasi-differenced  $d(x_t | \alpha)$  is used in the ERS point optimal test:

$$d(y_t | \alpha) = d(x_t | \alpha)' \delta(a) + \eta_t \quad (2)$$

where  $x$  could be a constant or both a constant and a trend, and  $\hat{\delta}(a)$  denotes the OLS estimators in this regression. According to ERS, the value of  $a = \bar{a}$  is determined as follows:

$$\bar{\alpha} = \begin{cases} 1-7/T & \text{if } x_t = \{1\} \\ 1-13.5/T & \text{if } x_t = \{1,t\} \end{cases} \quad (3)$$

Second, the resulting residuals should be obtained from equation (2) as follows:

$$\eta_t(\alpha) = d(y_t | \alpha) - d(x_t | \alpha)' \hat{\delta}(a) \quad (4)$$

Based on this equation, the sum-of-squared residuals function is estimated. That is:

$$SSR(\alpha) = \sum_{t=1}^T \hat{\eta}_t^2(a) \quad (5)$$

Finally, one needs to calculate the following ERS point optimal test statistic ( $P_T$ ), which basically tests the null hypothesis that  $\alpha = 1$  versus the alternative that  $\alpha = \bar{\alpha}$ :

$$P_T = \frac{SSR(\bar{\alpha}) - \bar{\alpha}SSR(1)}{f_0} \quad (6)$$

Where the denominator ( $f_0$ ) is an estimator of the residual spectrum at frequency zero. Critical values for the ERS test statistic are from ERS (1996, Table 1, p. 825). Given that there are only 43 annual observations for the variables studied in this paper, the unit root test results should be considered cautiously as all these tests are appropriate for large samples.

Let us assume that all the variables in equation (1) are I(1) and the resulting residuals are I(0). According to Engle and Granger (1987), it can then be stated that there exists a corresponding error-correction mechanism (ECM or  $e_{-1}$ ) model of the following form:

$$\Delta \ln \left( \frac{Y}{L} \right)_t = \gamma_0 + \sum_{i=0}^{p-2} \gamma_{1i} \Delta \ln \left( \frac{K}{L} \right)_{t-i} + \sum_{i=0}^{p-2} \gamma_{2i} \Delta \ln \left( \frac{TEL}{L} \right)_{t-i} + \sum_{i=0}^{p-2} \gamma_{3i} \Delta \ln \left( \frac{T}{L} \right)_{t-i} + \sum_{i=1}^{p-2} \delta_i \Delta \ln \left( \frac{Y}{L} \right)_{t-i} + \theta e_{t-1} + v_t \quad (7)$$

where  $\gamma_{ji}$  are the estimated short-term coefficients;  $\theta$  represents the feedback effect or the speed of adjustment whereby short-term dynamics converge to the long-term equilibrium path indicated in equation (1);  $\delta_i$  denotes the estimated coefficients of the lagged dependent variable to ensure that  $v_t$  or the disturbance term is white noise;  $e$  or ECM is obtained from equation (1), and  $\Delta$  indicates the first-difference operator.

The general-to-specific methodology can be used to omit insignificant variables in equation (7) on the basis of a battery of maximum likelihood tests. In this method, joint zero restrictions are imposed on explanatory variables in the unrestricted (general) model to obtain the most parsimonious and robust equation in the estimation process.

One may argue that according to Hamilton (1994, p.590), when there are more than two variables (say  $y_{1t}, y_{2t}, y_{3t}, \dots, y_{nt}$ ), the OLS Engle-Granger estimation of the long-term relationship can not provide a consistent estimate of the cointegrating vector unless the resulting residuals from  $y_{1t} = f(y_{2t}, y_{3t}, \dots, y_{nt})$  are not correlated with any other non-stationary linear combinations of  $(y_{2t}, y_{3t}, \dots, y_{nt})$ . In order to address this important issue the  $\beta$  coefficients in equation (1) are estimated by the dynamic least square (DLS) technique.

As mentioned earlier, assuming that all variables in equation (1) are integrated of order one, then the DLS technique is used to generate optimal multivariate estimators of the cointegrating parameters in the following manner:

$$\ln\left(\frac{Y}{L}\right)_t = \lambda_0 + \beta_1 \ln\left(\frac{K}{L}\right)_t + \beta_2 \ln\left(\frac{TEL}{L}\right)_t + \beta_3 \ln\left(\frac{T}{L}\right)_t + \sum_{i=1}^{k+1} \pi_{1i} \Delta \ln\left(\frac{K}{L}\right)_{t-i} + \sum_{i=1}^{k+1} \pi_{2i} \Delta \ln\left(\frac{TEL}{L}\right)_{t-i} + \sum_{i=1}^{k+1} \pi_{3i} \Delta \ln\left(\frac{T}{L}\right)_{t-i} + e_t \quad (8)$$

It is argued that OLS can be used to estimate equation (8) and the resulting DLS coefficients would provide a consistent estimate of the cointegrating parameters ( $\beta_i$ ) presented in equation (1). The lags and leads of the first difference of the independent variable augment a standard OLS regression, such as equation (1), to remove the effects of regressor endogeneity on the distribution of the OLS estimator. The DLS estimators will be consistent in spite of the fact the residual term in equation (8) could be correlated with the right hand side variables. It is worth noting that “OLS estimators of the cointegrating parameters are “superconsistent”, converging to the true parameter values at a rate proportional to the sample size  $T$  rather than proportional to  $\sqrt{T}$  as in ordinary applications” (Lettau and Ludvigson, 2001, p.823). For a more detailed account of the DLS see Stock (1987) and Stock and Watson (1993).

### 3. Empirical Results and Policy Implications

Table 1 presents the sources and descriptions of the data employed as well as the computed summary statistics using annual time series data from 1960 to 2002. Labour productivity has exhibited an interesting trend during the last four decades in the Iranian economy. Figure 1 shows the time series graphs of the data employed in this paper. At constant 1982 prices, the output per unit of labour increased persistently from 359,091 rials in 1960 to 1,291,482 rials in 1976. The bulk of this spectacular growth can be contributed to the rising price of crude oil in the period under investigation. In fact during 1960–76, Iran had the fastest growth rates in the world (Jbili, Kramarenko and Bailén, 2004).

After 1977 labour productivity exhibited a sharp decline reaching an all time record low of 699,578 rials in 1988 during the post-revolutionary period. Since 1988, when the eight-year war with the belligerent Iraqi regime came to an end, labour productivity has shown a gradual recovery. It is argued that the exchange rate unification, trade liberalization, the opening up to foreign direct investment, financial sector liberalization, high oil prices and expansionary fiscal and monetary policies have contributed to the recent higher growth rates and increased productivity (Jbili, Kramarenko and Bailén, 2004).

It should be noted that real output per unit of labour in the year 2002 stood at 98,1099 rials which is roughly equivalent to a similar figure in 1979 when the Shah was overthrown. In other words, comparing labour productivity in 2002 and 1979 reveals that the Iranian economy has not made any progress. To some extent this phenomenon can be explained by capital dilution, reflecting a substantial fall in investment, as well as a sharp expansion of labour force. There are many factors contributing to the declining rate of capital formation such as the upheavals consequential to the 1979 Islamic Revolution, the destructive eight-year war with Iraq, the freezing of the country's foreign assets, a volatile international oil market, the increased state dominance of the economy, and the plummeting in oil output and revenue, economic sanctions, and international economic isolation.

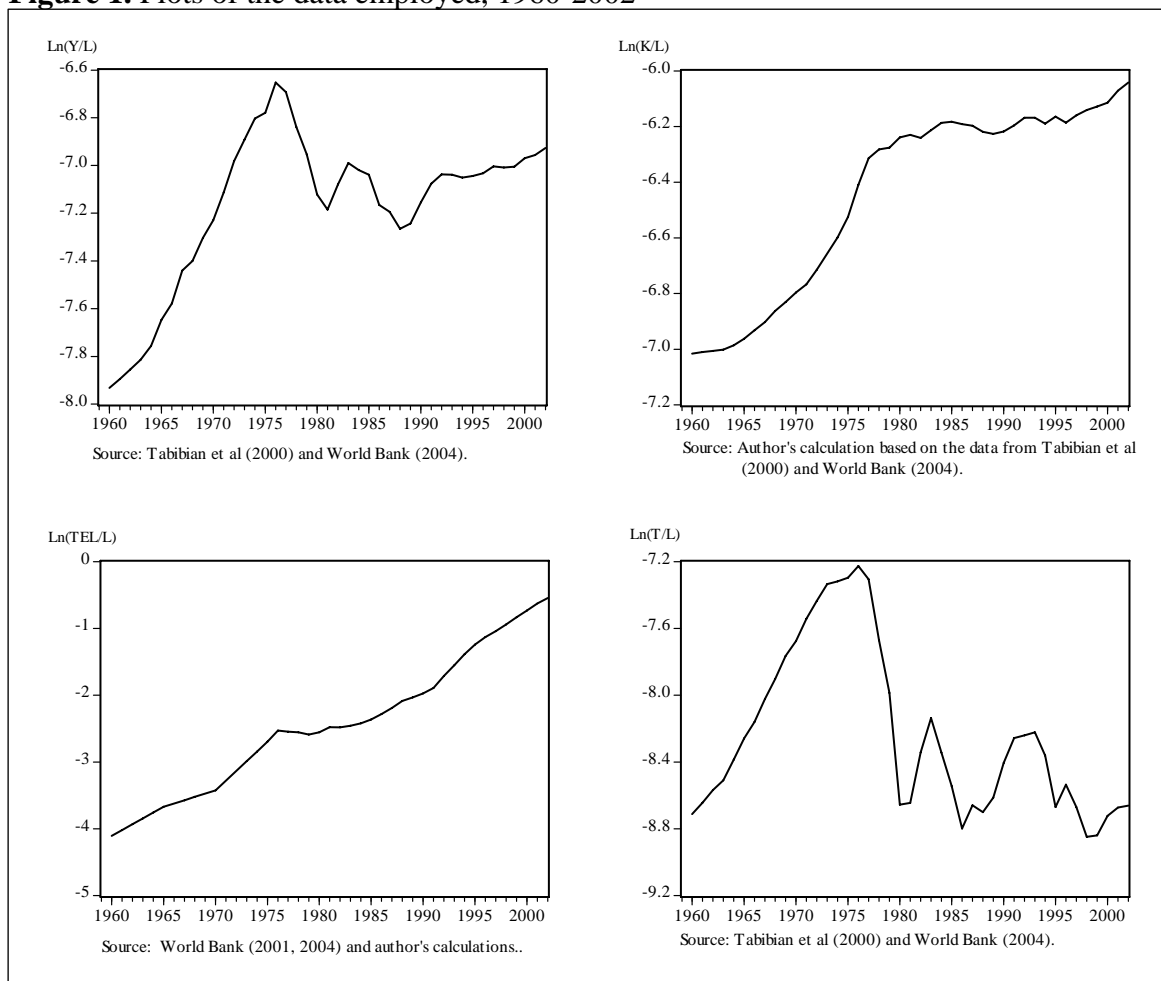
**Table 1.** Summary statistics and description of the data employed

Variable	Description	Source	Mean	Maximum	Minimum	Standard Deviation
$Y$	GDP (1982 billion rials)	Tabibian, <i>et al.</i> (2000) and World Bank (2004)	10934	20686	2683	4813
$L$	Labour (person)	World Bank (2004)	12916415	21084218	7202013	4232454
$K$	Net capital stock (1982 billion rials)	Based on Tabibian, <i>et al.</i> (2000), World Bank (2004) and Central Bank (2003)	23754	50112	6499	12919
$(Y/L)*10^8$	Real output per worker (1982 rials)		818525	1291482	372479	216593
$TEL$	Number of telephone lines	World Bank (2004, 2001) and author's calculations	2447237	12232292	129573	3157816
$T$	Total exports and imports (1982 billion rials)	Tabibian, <i>et al.</i> (2000) and World Bank (2004)	3577	7545	1270	1560
$\Delta \ln(Y/L)$	Labour productivity growth rate (fraction)	Author's calculations	0.024	0.138	-0.169	0.075
$\Delta \ln(K/L)$	Growth rate of real net capital stock per unit of labour (fraction)	Author's calculations	0.023	0.116	-0.022	0.029
$\Delta \ln(T/L)$	Growth rate of trade openness (fraction)	Author's calculations	0.001	0.301	-0.668	0.186
$\Delta \ln(TEL/L)$	A proxy for the growth rate of ITT (fraction)	Author's calculations	0.085	0.179	-0.034	0.052

On the other hand, according to the 1996 census, more than 50 per cent of Iran's population were below 19 years of age. The population pyramid in Iran is such that a large proportion of population will seek employment within the next five years or so because the economy has one of the youngest populations in the world with approximately 40 per cent under 15 years of age (Amuzegar, 2000). That is the reason why the population pyramid in Iran is literally referred to as a "time bomb. To some extent, large labour force growth rates can be attributed to the influx of approximately two million Afghan and one million Iraqi refugees (Karshenas and Pesaran, 1995).

Given such a massive pool of growing labour force and other idle resources, such a lacklustre growth of productivity does not appear to be counterintuitive. The degree of capital utilisation was about 40 per cent at the end of the 1980s (Amuzegar, 1992, p. 420). It should also be noted, that a considerable number of seemingly employed people in large cities have been engaged in "unproductive" activities in various service sectors. This portion of the labour force is largely involved in small retail and itinerant petty trade which is termed "rent-seeking" by Karshenas and Pesaran (1995) and Farzin (1995). This does not imply that rent-seeking cannot exist in other sectors such as the civil service and nationalised industries.

**Figure 1.** Plots of the data employed, 1960-2002



What are the sources of variation of labour productivity? Figure 1 shows the plots of labour productivity and its major determinants as far back as the data were available. A cursory or informal inspection of these graphs reveals some interesting facts which are consistent with the earlier theoretical postulates and findings in the literature outlined in section 1. During the period 1960-1976 labour productivity ( $Y/L$ ) rose sharply and at the same time  $K/L$  and  $TEL/L$  and  $T/L$  have demonstrated a pronounced and persistent upward trend. It is also interesting to note that after 1976  $K/L$  showed a meager growth and trade openness in fact showed an overall declining trend with an unstable behaviour and marked fluctuations in the post-revolutionary period (*i.e.* 1979-2002).

Prior to undertaking a thorough empirical investigation of the sources of the Iranian labour productivity growth, it is essential to determine the time series properties of the data. As mentioned above, in order to make some conclusions about stationarity or otherwise of the data the ADF and the ERS point optimal tests are utilised. The empirical results of the ADF and ERS unit root tests are summarised in Table 2. According to both tests, all of the four variables employed in equation (1) are integrated of order one,  $I(1)$  at 5 per cent significance level, and they become stationary after first differencing. Given that there are only 43 annual observations for the various variables studied in this paper, the unit root test results should be taken with a pinch of salt as all these tests are appropriate for large samples.

**Table 2.** Unit Root Test Results

Variable	Augmented Dickey-Fuller test		Elliott-Rothenberg-Stock DF-GLS test	
	ADF statistic	Optimum lag length*	DF-GLS statistic	Optimum lag length*
$\ln(Y/L)$	-2.60	1	-1.04	1
$\Delta \ln(Y/L)$	-3.11*	0	-3.13*	0
$\ln(K/L)$	-1.53	1	-0.24	1
$\Delta \ln(K/L)$	-2.83**	0	-2.74*	0
$\ln(TEL/L)$	0.22	1	0.41	1
$\Delta \ln(TEL/L)$	-2.82**	0	-2.86*	0
$\ln(T/L)$	-1.95	1	-1.77**	1
$\Delta \ln(T/L)$	-3.92*	0	-3.90*	0

\* Akaike information criterion (AIC) has been used to determine the optimal lag length. \* and \*\* indicate the corresponding null hypothesis is rejected at 5 and 10 %, respectively.

Since all the variables in equation (1) are I(1), the DLS method and annual time series data from 1960 to 2002 are used to estimate the long-run productivity model in equation (8). The estimation results are presented below (for compactness the coefficients estimates on the first lagged and lead differences are not shown below but they are available from the authors upon request):

$$\ln\left(\frac{Y}{L}\right)_t = 0.487 + 0.627 \ln\left(\frac{K}{L}\right)_t + 0.101 \ln\left(\frac{TEL}{L}\right)_t + 0.411 \ln\left(\frac{T}{L}\right)_t$$

t: (0.92) (6.76) (2.82) (7.25) (9)

$\bar{R}^2 = 0.958$  ADF(residuals) = -3.86

The optimal long-run coefficients are seen to be of consistent sign and are highly significant. This equation performs very well in terms of goodness-of-fit (adjusted  $R^2 = 0.958$ ) and it generates white noise residuals. Based on these results one can argue that real net capital stock, information technology and trade openness have been the major determinants of labour productivity in the long run.

In terms of the magnitude of the estimated elasticities, equation (9) shows that if the real capita stock per unit of labour,  $TEL/L$  and trade openness increase by 10 per cent, the labour productivity will rise by 6.3 per cent, 1.0 per cent and 4.1 per cent, respectively. As can be seen, the productivity elasticity for ITT is quite low and this finding is consistent with the results reported in other studies (see *e.g* Valadkhani, 2003).

Since the estimated residuals from the long-term productivity model are I(0), one can use the Engle and Granger representation theorem to estimate the short-term productivity model, or equation (7). Table 3 presents the results for the vector error correction model which captures the short-term dynamics of the labour productivity model. The general-to-specific methodology have been adopted in estimating equation (7) by omitting insignificant lagged variables and undertaking a battery of maximum likelihood tests. Joint zero restrictions have been imposed on insignificant explanatory variables in the unrestricted (or general model) to obtain the most parsimonious and robust equation in the estimation process. The parsimonious short-term model of

productivity includes all of the long-term determinants of labour productivity except for  $TEL/L$ . In other words, the results reported in Table 3 indicate that the short-term sources of productivity are the capital stock per unit of labour and trade openness. All the estimated coefficients are statistically significant at least at the 10 per cent level and have the expected signs. In terms of goodness-of-fit statistics, though expressed in  $\Delta \ln$ , with an adjusted  $R^2$  of 0.803, this equation performs extremely well. In addition, this equation passes each and every diagnostic test. Table 3 also reveals that the feed-back coefficient (or adjustment speed) is as low as  $-0.18$  meaning that in every year only 18 per cent of the divergence between the short-term productivity from its long-term path is eliminated.

**Table 3.** Empirical results for the short-term productivity growth,  $\Delta \ln(Y/L)_t$ , model

Variable	Estimated elasticities	<i>t</i> -statistics	Prob.	Expected signs
Intercept	0.011	1.53	[0.13]	
$\Delta \ln (K_t/L_t)_t$ 1.145	0.545	3.91	[0.00]	+
$\Delta \ln (K/L)_{t-1}$ -0.600		-2.29	[0.03]	+
$\Delta \ln (T/L)_t$	0.290	8.93	[0.00]	+
$\Delta \ln(Y/L)_{t-1}$	0.162	1.67	[0.10]	+
ECM <sub>t-1</sub>	-0.182	-1.79	[0.08]	-
Order of integration of stochastic residuals: I(0)				
Goodness-of-fit statistics:				
Adjusted $R^2=0.803$				
Overall <i>F</i> statistic $F(5,35) = 33.6$				
Diagnostic tests:				
DW	2.03			
AR 1-2	$F(2, 33) = 2.17$		[0.13]	
ARCH 1	$F(1, 33) = 0.34$		[0.57]	
Normality	$\chi^2(2) = 0.24$		[0.89]	
White $\chi^2$	$F(10, 24) = 0.76$		[0.66]	
RESET	$F(1, 34) = 0.004$		[0.95]	

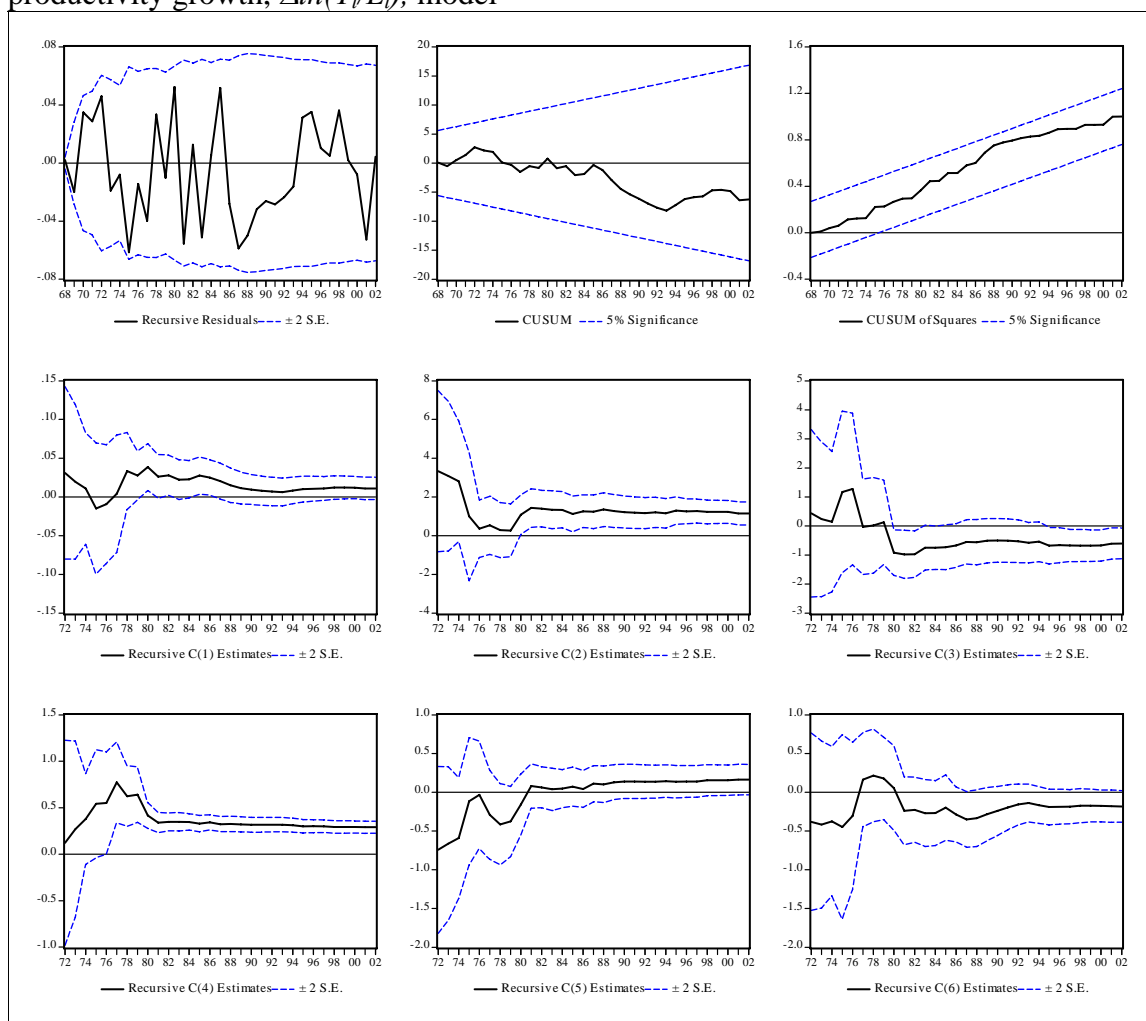
Notes: Figures in square brackets show the corresponding probabilities

One problem associated with any econometric analysis is non-constancy of estimated coefficients which can create economic and econometric complications in deriving any inference from the empirical model, particularly for a country such as Iran that has been subject to so many socio-economic changes through time. Therefore, the estimated short-run model has been evaluated by a number of recursive diagnostic tests

which are displayed in Figure 2 in the following order:  $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$

where panel (a) displays the recursive residuals; panel (b) depicts the CUSUM test; panel (c) shows the CUSUM of squares; and panels (d) to (i) present the recursively estimated 6 coefficients over the period 1968-2002 or 1972-2002 in the same order that these coefficients appear in Table 3 (from top to bottom). These evaluative tests are useful in assessing the parameter constancy of the model, as recursive algorithms avoid arbitrary splitting of the sample.

**Figure 2.** Graphical recursive tests for parameter constancy of the short-run productivity growth,  $\Delta \ln(Y_t/L_t)$ , model



Overall, the graphical tests reported in Figure 2 reveal that aside from a few minor and insignificant outliers before 1980, the test results point to the in-sample constancy of the estimated coefficients. In particular, the recursively estimated coefficients have remained relatively stable since 1980.

As seen from Table 3, Iran's labour productivity growth in the short-term is mainly determined by the growth rate of the real stock of capital and trade openness as well as an error correction mechanism. However, the long-term productivity performance depends, not only on these short-term determinants, but also on the stock of ITT capital (proxied by the total number of telephone lines per each worker). Therefore, the inward-looking protectionist stance will impede Iranian productivity performance in both the short- and long-run.

In sum, if Iran is to reverse the stagnation of labour productivity, the economy should invest more in physical and ITT capital. Microeconomic reforms can also make the economy more adaptable and less vulnerable to any external shocks. The reduction of trade barriers can pave the way for a long-term sustainable growth of productivity. The prevailing economic malaise in Iran in terms of productivity is mainly associated with, and/or intensified, by inappropriate economic policies. For example, inefficient industries have been supported by means of exorbitantly high trade tariffs, low-interest credits from the banking system and the unbridled supply of petrodollars. These

measures have substantially upset the trade openness index. Most of Iran's industries could not exist without government protection.

Rather than providing shelter behind the tariff protection barrier, an alternative policy would be to expose such industries to the international competitive environment so as to develop competitive capacity. With excessive government support they have remained internationally uncompetitive for an unreasonable long time. Some of these industries simply import raw materials and intermediate goods at an artificially over-valued exchange rate. Then, after some limited manufacturing processes they set prices for their finished products on the basis of the black market exchange rate (Farzin, 1995). Given such industrialisation policies, it becomes clear that petrodollars accruing to the government are potential targets for rent-seeking activities. A significant rise in productivity can not be achieved unless export of high value-added manufactured goods is promoted and industrial protectionist policies are reversed. It should be noted that "despite recent reductions in import taxes and non-tax barriers, Iran's trade regime is very restrictive: the average (unweighted) tariff rate in 2002 was 30 percent, the 11<sup>th</sup> highest tariff rate out of 193 surveyed countries" by the IMF (Jbili, Kramarenko and Bailén, 2004, p.16).

#### **4. Conclusion**

In this paper the short-term and the long-term drivers of Iranian labour productivity have been examined by using consistent annual time series data from 1960 to 2002. The Engle-Granger two-step procedure and the DLS estimation technique are employed to estimate and validate empirically the short- and long-term productivity models. It is found that in the long-term policies aimed at accelerating various types of investments in physical capital and ITT and promoting trade liberalization will improve labour productivity.

For example, *inter alia*, it is also found that an increase of say 10 per cent in trade openness, *ceteris paribus*, can boost productivity by 2.9 per cent in the short run and 4.1 per cent in the long run. Given that Iran's import taxes and non-tax barriers are very high, there is a great opportunity to increase labour productivity by various microeconomic reforms aimed at removing the existing trade barriers which are mostly unnecessary and unjustifiable. It is also argued that meager productivity growth rates can be explained by capital dilution, sharp expansion of labour, and stifling trade restrictions in the economy.

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