2004

What determine private investment in Iran?

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Publication Details
This article was originally published as Valadkhani, A, What Determine Private Investment in Iran?, International Journal of Social Economics, 31(5/6), 2004, 457-68.
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Disciplines
Business | Social and Behavioral Sciences

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This journal article is available at Research Online: http://ro.uow.edu.au/commpapers/394
What determine private investment in Iran?

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Abstract Iran’s Third Five-Year Development (2000/01-2004/05) has considered a pivotal role for private investment in creating seven to eight hundred thousand jobs per annum to stabilise the rate of unemployment. This paper examines the long- and short-run determinants of the private investment function by employing the Johansen multivariate cointegration technique and a short-run dynamic model. Using annual data for the period 1960-2000, this paper finds, inter alia, that private investment is cointegrated with non-oil GDP, and the rate of inflation. It is found that a one per cent increase in inflation in the long-run can immediately result in a one per cent decline in investment in the short-run.
Introduction

According to the Central Bank (2002), Iran’s total population was 63.9 million in 2000. Unlike the previous two development plans conducted after the 1979 Islamic revolution, the most important concern of the recent Third Five-Year Development Plan (2000/01-2004/05) pertains to a growing rate of unemployment among youth. As a totally inappropriate policy, population growth was zealously encouraged after the 1979 revolution by political and religious leaders, particularly in the 1980s. This population policy was abandoned during the last decade but population continues to grow due to its momentum and dynamic nature. As a result, population growth reduced from 3.9 per cent in 1986 to 1.7 per cent in 2000.

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 why the population pyramid in Iran can be literally referred to as a “time bomb”. During the period 1996-2000 on average each year only 296,250 new jobs created, whereas over the same period on average 692,750 new job seekers entered the labour market (Management and Planning Organisation, MPO, 2000, p.21). According to the third Plan it is predicted that over the next five years on average every year between 750,000 to 800,000 people will be seeking employment but if the economy continues like its past five years, each year approximately half a million people will be added to the total unemployed population (Valadkhani, 2001).

According to the third Plan, GDP should grow at least six per cent per annum in order to keep the rate of unemployment constant. Real GDP at factor price on average grew only 3.5 per cent per annum over the last five years (1996-2000) or even during the
last decade (1991-2000) in which Iran exported $US 150.5 billion (MPO, 2000). The major objective of the Iranian government in the third Plan is to achieve a minimum of six per cent annual growth in GDP through heavy reliance on the private sector. This paper examines the long- and short-run determinants of private investment which is expected to play a decisive role in Iran.

The structure of the paper is as follows. In the next section a theoretical model is postulated which captures the long-run private investment function by adopting the Johansen multivariate cointegration technique. In the penultimate section of the paper the unit-root results using the Augmented Dickey-Fuller (ADF) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are presented. The empirical econometric results for the long- and short-run demand for money, as well as policy implications of the study are also discussed in this section. The last section provides some concluding remarks.

**Theoretical Framework**

There are several theoretical hypotheses for investment behaviour which are the accelerator theory, liquidity theory, expected profits theory and neoclassical theory. The review of these theories is beyond the scope of this study; however, they are briefly outlined here. For a comprehensive survey of investment functions in developing countries, see Blejer and Khan (1984) and for a detailed discussion of different investment hypotheses see Bischoff (1971), Wallis (1973), Jorgenson (1974), Clark (1979) and Branson (1989).

The simple accelerator principle asserts that the relationship between the desired capital stock and the expected output remains constant. But the flexible accelerator, developed by Goodwin (1951) and Chenery (1952), uses a partial adjustment mechanism.
This theory estimates the speed of adjustment at which firms invest so as to move toward the desired capital stock. In this approach, investment depends on the difference between the actual and desired stock of capital. In other words, when the existing capital stock is less than the desirable stock, net investment is positive and vice versa.

In order to implement this theory, modellers generally include the lagged value of the capital stock, with an expected negative sign, the current value of real output, with an expected positive sign, and the lagged value of investment, with an expected positive sign, as explanatory variables in the investment function. For an empirical example applied to a multi-country model, see Fair (1994).

The liquidity theory is associated with the inter-related concepts of the cost of capital and the supply of fund. This theory argues that the supply of funds schedule is horizontal up to the point where internal funds are depleted and then it becomes vertical. The foremost sources of funding are depreciation allowances, net profits, fixed interest borrowing, preference shares, and equity shares (Oshikoya, 1990, p.46).

The main premise underlying the expected profits theory is that the desired capital stock relies on the stock market valuation of the firm. In this regard, Tobin's q-theory reformulates the flexible accelerator theory in order to take adjustment costs and expectations into the account. Tobin emphasises financial markets and uncertainty in the sense that investors have a choice between investment in real assets, i.e. adding to the stock of physical capital, and investment in financial assets such as purchasing shares, stocks etc (Branson, 1989). The neoclassical investment theory specifies the investment equation as a function of the relative price of capital. In the light of this theory, Jorgenson (1971) estimates an investment function which is positively related to real output and negatively to the rental cost of capital.
At the initial stages of the modelling, the computed capital stock was used to test the flexible accelerator hypothesis for the private investment function in Iran but the results were not satisfactory. Therefore, a new specification with particular attention to the specific structure of the Iranian economy has been adopted for private investment function.

Private investment in this study is specified as follows:

\[
\ln(I_t) = \beta_0 + \beta_1 \ln(Y_{nt}) + \beta_2 R_t + \varepsilon
\]  

(1)

where \( I \) is real private investment, \( Y_{nt} \) denotes the real non-oil GDP, and \( R \) is the rate of inflation proxied by \( \ln(P_t) - \ln(P_{t-1}) \).

Some theoretical justification for this specification is necessary. First, there is no rate of interest in the Islamic banking system of Iran. There are some types of "profit rates" introduced after the 1979 revolution which are not compatible with the pre-revolution data on interest rates. The justification for the inclusion of the growth of the GDP price deflator is that under inflationary circumstances when the value of money deteriorates continuously, there is little incentive for people to deposit their funds in the banking system. This is the case particularly in Iran since nominal interest rates "profit rates" for term deposits and saving accounts are kept artificially low. Simultaneously with the existence of negative or zero returns from the banking system, the black market for foreign currency, cars, gold coin etc. provides people with higher returns in short periods. Therefore, an increase in the growth of the consumer price index under these circumstances is conjectured to produce a decline in the propensity to save as measured by funds flowing through financial intermediaries. This leads to a reduction in the funds available for investment purposes through the banking system. The rate of inflation has also been used as a proxy for the nominal interest rate by Pesaran (1995) in his estimation.
of the real money balances for Iran. The use of an appropriate price index as a proxy for
the rate of interest has also been highlighted by Khayum (1991, p.61) in the context of
developing countries.

Second, instead of GDP, non-oil GDP has been chosen as the explanatory variable.
This is because the oil sector value added is directly regulated by the government and it
does not have a “direct” impact on private sector investment. The indirect but very
important contribution of the oil sector to private investment is captured through two
channels: a) the oil sector affects non-oil GDP because the oil sector generates petrodollars
which substantially impact on the economy’s capacity to import capital and intermediate
goods for production in the non-oil sectors; b) the oil sector and its output are totally
exogenous as oil prices are determined in the world oil market and the quantity of Iranian
oil export is set by the OPEC. Therefore, one should separate this exogenous component
from GDP in the VAR system and then capture its exogenous impact on private
investment through the VEC (Vector Error Correction) model as follows:

Let us consider the following VAR of order q:

\[ y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_q y_{t-q} + Bx_t + w_t \]  
(2)

where \( y_t \) is a \( k \)-vector of I(1) variables (e.g. in this study \( k=3 \) and the variables are \( \ln(I) \),
\( \ln(Y_n) \), and \( R \)), and \( x_t \) is a \( d \)-vector of exogenous variables (e.g. in this study we have only
one exogenous variable and that is \( \Delta Y_o \)), \( Y_o \) is the real value added in the oil sector, and \( w_t \)
is a vector of white noise residuals. Following Johansen (1991, 1995), equation (2) can
also be rewritten as:

\[ \Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{q-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \]  
(3)

where \( \Pi = \sum_{i=1}^{q} A_i - I \), and \( \Gamma_i = -\sum_{j=i+1}^{q} A_j \)
The rank ($r$) of $\Pi$ determines the number of cointegrating vectors. If $\Pi$ has a reduced rank (i.e. $r<k$), then there exist $k \times r$ matrices $\alpha$ and $\beta$ each with rank $r$, where $\Pi = \alpha \beta'$ and $\beta'y_i$ is stationary. The elements of $\alpha$ represent the adjustment parameters and each column of $\beta$ in the literature is referred to as the cointegrating vector. Thus the important issue is how to determine the number cointegrating vectors (or $r$). In this paper both the trace statistics and the maximum eigenvalue statistics will determine $r$. The trace statistics test the null hypothesis of $r$ cointegrating relations against the alternative of $k$ cointegrating equations. On the other hand, the maximum eigenvalue statistics test the null of $r$ cointegrating vectors versus the alternative of $r+1$ cointegrating relations. For more details see Johansen (1991, 1995).

An important step before using the Johansen multivariate technique is to determine the time series properties of the data. This is an important 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 ADF test, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS, 1992) test, have been adopted to examine the stationarity, or otherwise, of the time series data. In this paper the lowest value of the Schwarz Information Criterion (SIC) has been used as a guide to determine the optimal lag length in the ADF regression. These lags augment the ADF regression to ensure that the error term is white noise and free of serial correlation.

In addition to the ADF test, a KPSS test statistic has been calculated for all the variables. Unlike the ADF test, the KPSS test has the null of stationarity, and the alternative indicates the existence of a unit root. The KPSS test simply assumes that a time series variable (say $y_i$) can be decomposed into the sum of a deterministic trend, a
random walk, and a stationary error term in the following way:
\[ y_t = \beta t + \xi_t + \varepsilon_t \]  
(4)

where \( w_t \) (a random walk) is given by \( \xi_t = \xi_{t-1} + u_t \).

One can now test for the stationarity of \( y_t \) by testing \( \sigma_u^2 = 0 \). This test involves two steps: first one should run an auxiliary regression of \( y_t \) on an intercept and a time trend \( t \) and save the OLS residuals (say \( e_t \)) and compute the partial sums \( S_t = \sum_{i=1}^{t} e_i \); and second, compute the following KPSS statistic:

\[ \text{KPSS} = T^{-1} \sum_{t=1}^{T} S_t^2 / s^2 \]  
(5)

where \( s^2(l) = T^{-1} \sum_{t=1}^{T} e_t^2 + 2T^{-1} \sum_{s=1}^{l} w(s,l) \cdot \sum_{t=s+1}^{T} e_t e_{t-s} \). Following KPSS, the Bartlett window, where \( w(s, l) = 1-s/(l+1) \), has been used to correct for heteroscedasticity and serial correlation. Given the use of annual data, a maximum of 1 lag was chosen for the lag truncation parameter \( l \) in the testing procedure.

**Empirical results and policy implications**

The annual average share of private investment in GDP did not change significantly from the period 1959-1979 to the period 1980-2000. On average, this share was around 11 percent in both pre- and post-revolutionary eras. The share of private investment in GDP (nominal value) shows a very moderate increase after the 1988 Iraqi war but it can be stated that during the last 4 decades this share has been fluctuating around a mean of 11 per cent, whereas private consumption has shown an overall upward trend in the post-revolutionary period. It is interesting to note that since 1983 the share of the private sector investment has been always higher than that of the government sector due to a significant
drop in oil exports. During the two periods of 1959-2000 and 1983-2000 private investment constituted about 56 and 57 per cent of total investment, respectively. The sources of data in this study are Tabibian et al. (2000) and the Central Bank (2002).

Prior to undertaking an empirical investigation of the determinants of private investment, it is essential to determine the time series properties of the data. In order to make robust conclusions about stationarity or otherwise of the data, the ADF and the KPSS tests are utilised. The empirical results of the ADF and KPSS tests for level and trend stationarity are summarised in Table I. The ADF and KPSS tests for unit roots support the view that all the variables appearing in equation (1) are I(1).

“take in Table I about here”

Therefore, the Johansen (1991, 1995) multivariate cointegration technique can now be used to test the existence of a long-run equilibrium relationship for private investment. The first important step in conducting this test is to determine the optimal lag length (q) in equation (3). Allowing for an upper band of 2 lags, the SIC has been employed to determine q. Based on the SIC (not reported here but available from the author upon request), the optimum lag length is q=1. Both the intercept and trend have been included in the cointegrating vector(s) but in the VEC models only an intercept is allowed. According to Lewis and MacDonald (2002), it is more appropriate to include both an unrestricted trend and an intercept in the cointegrating vector(s) in the initial stage of testing and if the trend variable turned out to be insignificant, it can be excluded at the next stage using a restricted model. Various diagnostic tests have also employed and the test results indicate that the system of equations with 1 lag is well-behaved. It is very important to note that $\Delta Y_{ot-1}$ (as an exogenous variable) has also been included in equation (3).
Table II reports the results of the Johansen multivariate cointegration test on the private investment function as formulated in equation (1). As seen, the trace and max.eigenvalue test statistics provide robust evidence of one cointegrating vector at the 1 and 5 per cent levels, respectively.

“take in Table II about here”

From Table III the long-run parameters are seen to be of consistent sign and orders of magnitude and highly significant. It should be noted that the eigenvalue associated with the first vector (0.55) is considerably higher than those corresponding to the other vectors, thereby validating that there exists a unique cointegrating vector in the system. Consistent with theoretical postulates discussed in the previous section, private investment is positively related to non-oil GDP ($Y_n$) and negatively to the rate of inflation (R). The cointegrating vector has also been presented below.

$$\ln(I_t) = 1.43\ln(Y_{nt}) - 1.01R_t - 0.022T - 5.34$$

As seen from equation (6), ceteris paribus, a 10 per cent increase in real non-oil GDP stimulates private investment by 14.3 per cent. According to the projections made in the third Plan, private investment should grow at 8.5 per cent per annum to materialise a 6 per cent GDP growth. It is very important to note that these policy objectives are consistent with the results obtained in this study. As seen from equation (6), the long-run elasticity of private investment with respect to non-oil GDP is about 1.43. Therefore, ceteris paribus, a 6 per cent growth in GDP should be accommodated by 8.58 (6 per cent times 1.43) per cent increase in private investment which is very close to the targeted growth rate specified in the third Plan.

“take in Table III about here”
Table III and equation (6) show that there is also an inverse one-to-one relationship between inflation and private investment, meaning that a 10 per cent rise in inflation can reduce private investment by almost the same magnitude. The results support the view that higher inflation rates can easily dishearten investors to acquire real assets, thus higher growth of investment is not possible unless the government curbs inflation. Otherwise agents may engage themselves in directly unproductive activities such as buying/selling foreign currencies, gold coins, cars, money laundering etc using a very large sum of liquidity in the economy. It is interesting to recognise that liquidity (defined as M2) increased prodigiously from 54 billion rials in 1960 to 249,111 billion rials in 2000 (a 4622 fold increase!), whereas real GDP recorded only a 7.4 fold increase during the same period.

Table III also shows the estimated adjusted coefficients ($\alpha$s) which can be used to test for weak exogeneity. The adjustment coefficients contain weights with which cointegrating vector(s) enter short-run dynamics. Given that this study finds only one cointegrating vector, Table III presents the first column of the $\alpha$ matrix. These coefficients measure the speed of the short-run response to disequilibrium occurring in the system. Before proceeding any further, it is essential to test for weak exogeneity of the two variables on the right hand side of equation (1) with respect to $ln(I)$. The Johansen method enables analysts to test for weak exogeneity by imposing zero restrictions on the weighting coefficients of $\alpha_Y$ and $\alpha_R$. One should note that the $ec$ term is significant and correctly signed (-0.89) in the VEC equation for $ln(I)$, indicating a very high speed of adjustment in the private investment function.

Table IV, *inter alia*, presents the test results for separate and joint restrictions on
the weighting coefficients. As can be seen, using separate zero restrictions on the corresponding $\alpha$s, the $ec$ term, while highly significant for $\Delta \ln(I)$, is not significant in the short-run dynamic equations for $\Delta \ln(Y)$, and $\Delta R$. The weak exogeneity test, by imposing the joint zero restriction of $\alpha_Y=\alpha_R=0$, reveals that the null cannot be rejected at the 1 per cent level as $\chi^2(2)=4.28$ [probability=0.12]. Therefore, on the basis of imposing separate and joint restrictions on the adjustment coefficients, one can conclude that both $\ln(Y)$ and $R$ are weakly exogenous with respect to $\ln(I)$ and hence OLS and a single-equation can be used to model short-run dynamics of $\Delta \ln(I)$.

"take in Table IV about here"

Using the resulting residuals (the $ec$ term) from the long-run relationship in equation (6), one can estimate a VEC model which captures the short-run dynamics of the private investment function. That is:

$$\Delta \ln(I_t) = \varphi_0 + \sum_{i=0}^{q_1} \varphi_{i1} \Delta \ln(Y_{t-i}) + \sum_{i=1}^{q_2} \varphi_{i2} \Delta R_{t-i} + \sum_{i=1}^{q_3} \varphi_{i3} \Delta \ln(I_{t-i}) + \sum_{i=1}^{q_4} \varphi_{i4} \Delta \ln(Y_{t-i}) + \theta ec_{t-i} + \nu_t \quad (7)$$

where $\varphi_{ij}$ are the estimated short-term coefficients; $\theta$ is the feedback effect or the speed of adjustment, whereby short-term dynamics converge to the long-term equilibrium path; and the lagged dependent variables are added to ensure that $\nu_t$ (or the residual) is white noise. See Hendry, Pagan and Sargan (1984) for a concise discussion of dynamic specification.

Starting with a maximum lag of two for $q_1$ to $q_4$, the general-to-specific methodology is now used to omit the insignificant variables in equation (7) on the basis of a battery of maximum likelihood tests.

Using I(0) variables in the estimating procedure, joint zero restrictions are imposed on explanatory variables in the general model or equation (7) to obtain the most parsimonious and robust estimators. The empirical results for the parsimonious
model capturing short-run dynamics for money demand are presented in Table V. As can be seen, the estimated equation for short-run dynamics passes each and every diagnostic test.

“take in Table V about here”

The estimated coefficients have been sensibly signed, with the current and lagged non-oil GDP growth rates being the only short-run determinants of the growth of private investment. The feedback coefficient for the ec term is highly significant, validating the significance of the cointegration relationship in the short-run model for private investment. The magnitude of the estimated coefficient for ec indicates that the divergence from the equilibrium path is eliminated with a high speed of 74 per cent per year. All the other variables appearing in equation (7) but not reported in Table V were insignificant and consequently they have been excluded from the parsimonious model.

The short-run model for the growth of real private investment performs quite well in terms of goodness of fit statistics. Figure 1 (see panel a defined below) clearly indicates that the parsimonious short-run dynamic model demonstrates a very good tracking performance, by capturing all turning points without even using a single dummy variable.

One problem associated with the analysis of the private investment function is non-constancy problem or instability of estimated coefficients which can create economic and econometric complications in deriving any inference from the empirical model. Given various political and economic events and regime shifts such as the 1974 “oil booms”, the 1979 Islamic revolution, and the 1980-1988 Iraqi war during the sample period, parameter constancy is pivotal in modelling private investment which has an inherent unstable nature. Therefore, the estimated short-run model has been
evaluated by a number of recursive stability tests which are displayed in Figure 1 in the following order: $egin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$

“take in Figure 1 about here”

where panel (a) displays the tracking performance of the model; panel (b) shows the recursive residuals; panel (c) depicts the CUSUM test; panel (d) illustrates the CUSUM of squares; panel (e) displays the N-step recursive residuals; and panels (f) to (i) present the recursively estimated four coefficients during the period 1966-2002 in the same order that these coefficients appear in Table V (from top to bottom). These evaluative tests are useful in assessing stability of a model, as recursive algorithms avoid arbitrary splitting of the sample. Overall, the graphical tests for stability reported in Figure 1 reveal that aside from a few minor and insignificant outliers around the 1970s and one in 1990, the test results point to the in-sample constancy of the estimated equation. In particular, the recursively estimated coefficients have remained relatively stable since 1980.

Attention is now directed to a non-quantifiable obstacle facing the Iranian government in relation to private investment. As mentioned earlier, the third Plan expects the private investment to grow at 8.5 per cent while the private sector in Iran’s constitution has been treated as “residuals”. Article 44 of Iran’s constitution states that:

“The economy of the Islamic Republic of Iran is to consist of three sectors: state, cooperative, and private, and is to be based on systematic and sound planning. The state sector is to include all large-scale and mother industries, foreign trade, major minerals, banking, insurance, power generation, dams, and large-scale irrigation networks, radio and television, post, telegraph and telephone services, aviation,
shipping, roads, railroads and the like; all these will be publicly owned and administered by the State. The cooperative sector is to include cooperative companies and enterprises concerned with production and distribution, in urban and rural areas, in accordance with Islamic criteria. The private sector consists of those activities concerned with agriculture, animal husbandry, industry, trade, and services that supplement the economic activities of the state and cooperative sectors. ...The scope of each of these sectors as well as the regulations and conditions governing their operation, will be specified by law” (source: http://www.uni-wuerzburg.de/law/ir00000_.html#A044_)

The constitution does not allow the private sector to play an active role in the economy and this is in stark contrast with the high expectation of the third Plan from the private sector. Table V indicates that in the short-run 1 per cent increase in the growth of non-oil GDP can lead to a 2.9 (2.001+0.892) per cent in the growth of private investment. But one should also note that in the long-run one per cent additional increase in inflation results in a one per cent reduction in private investment. Given a very high speed of adjustment (-0.74), inflation can rapidly and adversely affect the short-run growth of private investment.

President Khatami cannot succeed in the third Plan within the boundaries of the present constitution without overhauling labour law and introducing a comprehensive tax reform that does not discriminate between rent-seeking bonyads (revolutionary foundations supported by the government and the leader) and non-bonyad economic activities. Since the 1979 Islamic revolution these foundations and a large number of state-owned enterprises have been exempt and/or have benefited from various types of government subsidies. As a result, an enormous pressure has been placed on the
government budget. Given that the major source of financing government budget deficit in Iran is through borrowing from the central bank, a substantial increase in the monetary base and liquidity would be unavoidable. This policy resulted in high rates of inflation and thereby a reduction in investment.

Conclusion

After briefly reviewing the relevant literature on the investment function, this paper determines the long- and short-run drivers of private investment in Iran using annual time series data from 1960 to 2000. The ADF and KPSS tests for unit roots support the view that all the variables appearing on a standard private investment function are I(1). Therefore, the Johansen cointegration test has been employed to determine the number of the cointegrating vector(s). Cointegration tests clearly indicate that there is a unique cointegrating vector, linking private investment with real non-oil GDP and the rate of inflation. The estimated long-run non-oil GDP and the rate of inflation (as a proxy for the nominal rate of interest) elasticities with respect to real private investment are 1.43 and -1.01, respectively.

This paper also presents an error correction model capturing short-run dynamics of the real growth of private investment. The estimated coefficients in this model are only significant for the lagged and current growth rates of non-oil GDP, suggesting that in the short-run the growth of non-oil GDP and an error correction term are the main determinants of the growth of private investment in Iran. The parsimonious short-run dynamic model of private investment shows no sign of misspecification or instability and passes a battery of diagnostic tests. The results obtained in this study show that if inflation is not curbed, the reversal of the present conditions and stimulating a 8.5 per cent
sustainable growth of private investment is enormously difficult, if not impossible.

Furthermore, creating 750,000 jobs per annum is an enormous task which cannot be fulfilled without amending the constitution and curbing soaring inflation. The performance of the third Plan in its first year shows that the economy may grow at 5.8 per cent as a result of rising oil prices and/or ongoing economic reforms. However, without addressing major predicaments which are deeply rooted in the Iranian economy, attaining sustainable long-run growth and prosperity will be easier said than done, particularly if the structure of the economy is such that a one per cent rise in inflation can immediately translate to a one percent decline in investment.

<table>
<thead>
<tr>
<th>Variable</th>
<th>C (constant) and T (trend) in the equation</th>
<th>ADF test</th>
<th>KPSS Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(I) )</td>
<td>C &amp; T</td>
<td>-2.07</td>
<td>0</td>
</tr>
<tr>
<td>( \Delta \ln(I) )</td>
<td>C</td>
<td>-5.5*</td>
<td>0</td>
</tr>
<tr>
<td>( \ln(Y_c) )</td>
<td>C &amp; T</td>
<td>-1.79</td>
<td>1</td>
</tr>
<tr>
<td>( \Delta \ln(Y_c) )</td>
<td>C</td>
<td>-3.18**</td>
<td>0</td>
</tr>
<tr>
<td>( \ln(Y_o) )</td>
<td>C &amp; T</td>
<td>-2.13</td>
<td>0</td>
</tr>
<tr>
<td>( \Delta \ln(Y_o) )</td>
<td>C</td>
<td>-4.85*</td>
<td>0</td>
</tr>
<tr>
<td>( R=\Delta \ln(P) )</td>
<td>C</td>
<td>-2.45</td>
<td>0</td>
</tr>
<tr>
<td>( \Delta R=\Delta \ln(P) )</td>
<td>C</td>
<td>-6.59</td>
<td>1</td>
</tr>
</tbody>
</table>

**Note:** * and ** indicate that, based on the MacKinnon, and the Kwiatkowski-Phillips-Schmidt-Shin critical values, the corresponding null hypothesis is rejected at the 5 and 10% significance levels, respectively.

**Table I.**
ADF test results
<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace statistic</th>
<th>1% critical value</th>
<th>Max. Eigenvalue statistic</th>
<th>5% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.548</td>
<td>51.4*</td>
<td>48.5</td>
<td>30.2**</td>
<td>25.5</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.374</td>
<td>21.2</td>
<td>30.5</td>
<td>17.8</td>
<td>19.0</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.085</td>
<td>3.39</td>
<td>16.3</td>
<td>3.4</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Note: * and ** indicate that the corresponding null hypothesis is rejected at 1 and 5% significance levels, respectively.

Table II.
Johansen test for cointegration
<table>
<thead>
<tr>
<th>Cointegrating Eq</th>
<th>β Coefficients</th>
<th>t ratio</th>
<th>VEC equation</th>
<th>α Coefficients</th>
<th>t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(I) )</td>
<td>1</td>
<td>-</td>
<td>( \Delta \ln(I) )</td>
<td>( \alpha_{\ln(I)} = -0.89 )</td>
<td>-4.3</td>
</tr>
<tr>
<td>( \ln(Y) )</td>
<td>-1.432</td>
<td>-14.1</td>
<td>( \Delta \ln(Y_n) )</td>
<td>( \alpha_{\ln(Y_n)} = -0.07 )</td>
<td>-0.9</td>
</tr>
<tr>
<td>( R = \Delta \ln(P) )</td>
<td>1.014</td>
<td>2.6</td>
<td>( \Delta R )</td>
<td>( \alpha_R = -0.20 )</td>
<td>-2.0</td>
</tr>
<tr>
<td>( T )</td>
<td>0.022</td>
<td>4.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{Constant} )</td>
<td>5.337</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table III.**
Standardized cointegrating vector and the corresponding adjustment coefficients

<table>
<thead>
<tr>
<th>The null hypothesis</th>
<th>Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_{\ln(I)} = 0 )</td>
<td>( \chi^2(1) = 8.9 )</td>
<td>0.003</td>
</tr>
<tr>
<td>( \alpha_{\ln(Y)} = 0 )</td>
<td>( \chi^2(1) = 0.82 )</td>
<td>0.367</td>
</tr>
<tr>
<td>( \alpha_R = 0 )</td>
<td>( \chi^2(1) = 2.3 )</td>
<td>0.130</td>
</tr>
<tr>
<td>( \alpha_{\ln(Y)} = \alpha_R = 0 )</td>
<td>( \chi^2(2) = 4.2 )</td>
<td>0.120</td>
</tr>
</tbody>
</table>

**Table IV.**
Testing for weak exogeneity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated coefficients</th>
<th>t-statistics*</th>
<th>Prob.</th>
<th>Expected signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Constant} )</td>
<td>-7.992</td>
<td>5.8</td>
<td>[0.00]</td>
<td>+/-</td>
</tr>
<tr>
<td>( \Delta \ln Y_n )</td>
<td>2.001</td>
<td>5.9</td>
<td>[0.00]</td>
<td>+</td>
</tr>
<tr>
<td>( \Delta \ln Y_{n-1} )</td>
<td>0.892</td>
<td>2.4</td>
<td>[0.02]</td>
<td>+</td>
</tr>
<tr>
<td>( e_{\text{res}} )</td>
<td>-0.738</td>
<td>-5.7</td>
<td>[0.00]</td>
<td>-</td>
</tr>
</tbody>
</table>

Order of integration of stochastic residuals: I(0)
\( R^2 = 0.744 \) solved for \( \Delta \ln(I)_t \)
\( R^2 = 0.959 \) solved for \( \ln(I)_t \)
Diagnostic tests:
\( DW \) 1.96
\( AR 1-2 \) \( F(2,32) = 0.17 \) [0.84]
\( ARCH 1-1 \) \( F(1,32) = 0.15 \) [0.70]
Normality \( \chi^2(2) = 2.90 \) [0.23]
White heteroskedasticity \( F(6,27) = 1.07 \) [0.40]
\( RESET \) \( F(1,33) = 0.40 \) [0.53]

**Table V.**
Empirical results for the short-run private investment function, \( \Delta \ln(I)_t \)
Figure 1.
Tracking performance and graphical tests for stability of the short-run model
Reference


Central Bank (2002), Nemagarhayeh Eghtesadi (Economic Indicators), Department of Economic Accounts, Central Bank, Tehran.


