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The role of capital formation and saving in promoting economic growth in Iran

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Abstract

This paper estimates the interdependencies between capital formation, saving and output for Iran. The analysis is complicated because of the conflicting theoretical and empirical findings of their relative roles in other studies, the lack of research on Iran whose turbulent history makes it difficult to disentangle the complex and changing interrelationships between output, saving and investment for the period of our study, 1960 to 2003. The analysis uses Lee and Strazicich (2004) procedure to endogenously determine that structural breaks occurred in 1979 for real output, 1983 for saving and 1977 for investment. These dates coincide with the effect of the Islamic revolution in 1979 and Iran-Iraq war, 1980 to 1988. The relationships were estimated using Johansen's FIML procedure which is appropriate for estimating the effects of non-stationary variables in a simultaneous setting. The estimates indicate a Solow style relationship where a one percent increase in saving will be associated with a 0.55 percent increase in the long run equilibrium level of output. This also implies the share of income that is paid to capital in the form of saving in Iran is higher at 0.55 than the average for developed countries of around 0.35. The role of investment was found to be imprecise in the long run. The short run estimates show that saving has a short run equilibrating effect on output with elasticity −0.13, which further supports the Solow model whereby changes to saving have only transitory effects on the growth in output. The other important result found that investment dynamically Granger causes output growth with a short run elasticity of 0.17, consistent with the endogenous growth explanation. The structural change parameter estimates that the effect on the growth in output fell by around 10 percent after 1979. These findings have two important policy implications for Iran. First, there is scope to reduce the reliance of saving as the domestic source of economic growth. Second, saving needs to be better targeted to the long run strategic provision of capital (including infrastructure) in the structurally transforming economy of Iran.

Keywords

Economic growth, saving, investment, cointegration

Disciplines

Business | Social and Behavioral Sciences

The Role of Capital Formation and Saving in Promoting Economic Growth in Iran

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ABSTRACT

This paper estimates the interdependencies between capital formation, saving and output for Iran. The analysis is complicated because of the conflicting theoretical and empirical findings of their relative roles in other studies, the lack of research on Iran whose turbulent history makes it difficult to disentangle the complex and changing interrelationships between output, saving and investment for the period of our study, 1960 to 2003. The analysis uses Lee and Strazicich (2004) procedure to endogenously determine that structural breaks occurred in 1979 for real output, 1983 for saving and 1977 for investment. These dates coincide with the effect of the Islamic revolution in 1979 and Iran-Iraq war, 1980 to 1988.

The relationships were estimated using Johansen's FIML procedure which is appropriate for estimating the effects of non-stationary variables in a simultaneous setting. The estimates indicate a Solow style relationship where a one percent increase in saving will be associated with a 0.55 percent increase in the long run equilibrium level of output. This also implies the share of income that is paid to capital in the form of saving in Iran is higher at 0.55 than the average for developed countries of around 0.35. The role of investment was found to be imprecise in the long run.

The short run estimates show that saving has a short run equilibrating effect on output with elasticity -0.13, which further supports the Solow model whereby changes to saving have only transitory effects on the growth in output. The other important result found that investment dynamically Granger causes output growth with a short run elasticity of 0.17, consistent with the endogenous growth explanation. The structural change parameter estimates that the effect on the growth in output fell by around 10 percent after 1979.

These findings have two important policy implications for Iran. First, there is scope to reduce the reliance of saving as the domestic source of economic growth. Second, saving needs to be better targeted to the long run strategic provision of capital (including infrastructure) in the structurally transforming economy of Iran.

1. Introduction

This paper investigates how capital formation and saving promote economic growth in Iran. This is a challenging task given the unresolved debate about the roles of investment and saving (both empirically and theoretically) in models of growth and the difficulty of specifying and estimating the relationships for an economy which has experienced profound changes over the past four decades. We believe it is necessary to briefly consider each of these important factors in turn.

Houtakker (1961, 1965), Modigliani (1970) and many others provide empirical evidence of the positive correlation between saving and output for a large number of countries. This direct relationship is often argued as supporting the Solow style model of growth in which a higher saving rate causes transitory growth to a higher steady state level of output. However there is growing evidence that causation may run in the other direction, from growth to saving, called the Carroll-Weil hypothesis.[1] There is further disagreement about the subsequent effect of saving on investment. Whilst Feldstein and Horioka (1980) emphasized the powerful empirical association between saving and investment, no consensus explanation has emerged about this link or its direction.

Levine and Renelt (1992) use cross–country data to show that investment is the only variable that is robustly correlated with the growth in output. Whilst most argue the causal link is from investment to output, there is some evidence that output influences investment through an accelerator effect. The possible complex feedback effects and observed variations in productivity are consistent with the endogenous growth view. Hall and Jones (1999) argue that most cross-sectional variation in per capita output is due to variation in the productivity with which factors are combined, rather than differences in factor accumulation. King and Levine (1994) provide evidence that capital accumulation alone is neither a necessary nor sufficient condition for the "take-off" to rapid growth.

These unresolved issues provide only broad guidance for researchers and policy makers, whose task is made even more difficult when studying developing countries with individual and specific characteristics like that of Iran. To the best of our knowledge, there are few studies which consider the effects of saving and investment on economic growth in the Middle East and even fewer for Iran. Eken, Helbling and Mazarei (1997) show that, for non-oil exporting countries, the share of private investment is positively correlated with economic growth in countries in the MENA region.

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[1] This is most evident in the East Asian economies which had high growth rates long before they had high saving rates. Similarly, Japan had a high income growth in the late 1940s and early 1950s, yet Japan did not exhibit high saving rates until 1960s and 1970s.

However Iran is a major oil exporter and Jalali-Naini (2003) claims the "basic development thinking in Iran since the mid 1950s has been a planning framework in which the oil industry, as the 'leading sector' and the engine of growth supplies surpluses (saving) for investment in other sectors", (p. 18).[2] Indeed, government policies have been very important in Iran's economic performance over the last four decades.[3] Table 1 shows that real gross domestic product (GDP), gross national saving (GNS) and gross fixed capital formation (GFCF) grew strongly and consistently from 1960 to 1978 in line with the growth in the private sector.[4] However the high co-movements in these variables ended when the sharp increase in crude oil prices in 1974 fuelled an economic boom, causing higher inflation which adversely affected economic growth in the late 1970s.

Table 1
Real GDP, Saving and Investment Growth Rates (percent)

Era	Period	GDP	Saving	Investment
Pre- Revolution	1960-78	9.0	16.2	11.4
Post- Revolution	1979-03	2.5	6.2	4.3
- War years	1980-88	-1.5	6.5	-1.5
- First plan	1989-94	7.5	7.7	4.6
- Second plan	1995-99	3.2	5.2	10.1

Sources: National Accounts, Central Bank of Iran (2001), Hakimian (1999).

The boom ended with the Islamic revolution in 1979, which introduced significant changes to economic policies. There was extensive nationalization and greater state control of prices in regard to large-scale modern industries, the banking and insurance sectors as well as foreign trade. Jalali-Naini (2003) notes that these policies (together with economic mismanagement, institutional and public sector inefficiency) caused high levels of uncertainty and misallocation of resource.

Even more devastating to the economy was the eight-year war with Iraq, which assured that inappropriate government interventionist policies would continue. During the war years (1980-88) Iran experienced low investment and productivity with negative growth in output.[5] The physical damage of the war has been estimated to be around 30,811 billion Rials (Mazarei, 1996). Another adverse effect in this period occurred with the oil

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[2]   He also finds that total factor productivity (TFP) has not contributed to economic growth in Iran for the period 1959 to 2000.

[3]   Bahmani-Oskooee (1993) analyses the effects of official exchange control via the black market exchange rate effects on purchasing power parity.

[4]   The strong growth (although there was a dip in GNS in 1974-75) was due to a combination of low inflation, an increase in the demand for domestic money and a stable exchange rate .

[5]   Direct war expenditures comprised on average 16.9 percent of total Iranian government expenditure between 1981 and 1986.

crisis in 1986 and the sharp drop in foreign exchange receipts from oil revenue which led to the 1986-88 recession. According to Mazarei (1996), the difficulty in importing intermediate and capital goods due to the lack of foreign exchange was one of the causes of serious problems on the supply side of the Iranian economy at this time.

A new period of reconstruction began with the end of the war in late 1988 and economic adjustment policies were implemented under the First Five-Year Development Plan (FYDP). During 1989-1994, real GDP increased by 7.5 percent, while saving and investment increased by 7.7 and 4.6 percent respectively. Pesaran (2000) attributes this growth to the liberalization of trade and foreign exchange markets together with the utilization of previously unused capacity in the economy. Jalali-Naini (2003) refers to other relevant factors like the loosening of some government controls, partial correction of the prices system and a move towards privatization which were part of the government's 'structural adjustment policies'. Investment responded by increasing at a rate of 10.1 percent during the Second Five-Year Development Plan, 1995-99, whilst the growth in saving was only half of this at 5.2 percent.

This brief review of Iran's economy shows the difficulty in disentangling the complex and changing interrelationships between output, saving and investment for the period of our study, 1960 to 2003. It is essential that structural change in a growth setting is explicitly incorporated into the simultaneous analysis of these interdependencies. The next section therefore tests for structural change and non-stationarity in the variables, which are then incorporated into the simultaneous estimation of their dependencies in the Section 3. Section 4 summarises the key findings and brings out some policy implications.

2. Unit Root Tests with Structural Breaks

It is well known that if potential structural breaks are not allowed for in testing for unit roots in time series, the tests may be biased towards a mistaken non-rejection of the non-stationarity hypothesis (Perron (1989, 1997), Leybourne and Newbold (2003) Pahlavani et al. (2006). Given Iran's experience, it is surprising that very few studies of the Iranian economy have considered the issue of structural breaks. An exception is Bahmani-Oskooee (1993) who assumed a structural break occurred in 1979 when examining the effects of the black market exchange rate on relative prices.

Perron's (1989) unit root test, which includes dummy variables to allow for one known, or exogenous, structural break was criticized by Christiano (1992) and others who argued that this invalidates the distribution theory underlying conventional testing (Vogelsang and Perron, (1998)). In response, a number of studies proposed different ways of

estimating the time of the break endogenously which lessen the bias in the usual unit root tests.

These studies included Zivot and Andrews (1992), Perron (1997), Lumsdaine and Papell (1997) and Vogelsang and Perron (1998). However, the endogenous break unit root tests assume no break(s) under the unit root null and derive their critical values accordingly. Nunes *et al* (1997) show that this assumption leads to size distortions in the presence of a unit root with a break. Furthermore Lee and Strazicich (2003) demonstrate that when utilizing these endogenous break unit root tests, researchers might conclude that the time series is trend stationary when in fact the series is nonstationary with break(s). In this regard 'spurious rejections' may occur.

We therefore use the minimum Lagrange Multiplier (LM) unit root test proposed by Lee and Strazicich (2004) which not only endogenously determines a structural break but also avoids the above problems of bias and spurious rejections. Furthermore, the Lee and Strazicich (2004) procedure corresponds to Perron's (1989) exogenous structural break (Model C) with one change in the level and the trend.

The one break LM unit root test statistics according to the LM (score) principle, are obtained from the following regression:

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + u_t \tag{1}$$

where $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}$ $(t = 2,...T)$ and Z_t is a vector of exogenous variables defined by the data generating process; $\tilde{\delta}$ is the vector of coefficients in the regression of Δy_t on ΔZ_t respectively with Δ the difference operator; and $\widehat{\psi}_x = y_1 - Z_1 \tilde{\delta}$, with y_1 and Z_1 the first observations of y_t and Z_t respectively.

Equivalent to Perron's (1989) Model C, with allows for a shift in intercept and change in trend slope under the null hypothesis and is described as $Z_t = [1, t, D_t, DT_t]'$, where $DT_t = t - T_B$ for $t > T_B + 1$, and zero otherwise. It is important to note here that testing regression (1) involves using ΔZ_t instead of Z_t. ΔZ_t is described by $[1, B_t D_t]'$ where $B_t = \Delta D_t$ and $D_t = \Delta DT_t$. Thus, B_t and D_t correspond to a change in the intercept and trend under the alternative and to a one period jump and (permanent) change in drift under the null hypothesis, respectively.

The unit root null hypothesis is described in (1) by $\phi = 0$ and the LM *t*-test is given by $\tilde{\tau}$; where $\tilde{\tau} = t$-statistic for the null hypothesis $\phi = 0$. The augmented terms $\Delta \tilde{S}_{t-j}$, $j = 1,...k$, terms are included to correct for serial correlation. The value of *k* is determined by the general to

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specific search procedure.[6] To endogenously determine the location of the break (T_B), the LM unit root searches for all possible break points for the minimum (the most negative) unit root t–test statistic as follows:

$$Inf\ \widetilde{\tau}(\widetilde{\lambda}) = Inf_\lambda\widetilde{\tau}(\lambda)\ ;\ \text{where}\ \ \lambda = T_B/T\ . \tag{2}$$

Table 2
Lee and Strazicich (2004) Minimum LM Unit Root Test Results
Break in Both Intercept and Trend

	Symbol	$\hat{T}_B$	$\hat{k}$	Test statistic	Inference
Real GDP (lnGDP)	Y	1979	2	-3.84	Unit Root I(1)
Real gross national saving (lnGNS)	S	1983	4	-4.48	Unit Root I(1)
Real total investment (lnGFCF)	I	1977	1	-3.85	Unit Root I(1)

Notes: Critical values taken from Lee and Strazicich (2004) were derived in sample size of T=100.

The critical values depend somewhat on the location of the break, ($\lambda = T_B/T$). The critical values for λ =0.4 (for Y and I) and 0.5 (for S) are -4.50 and -4.51 at the 5 percent level of significance.

Due to the small sample here, the maximum number of k was chosen as 4.

Source: The data for these variables have been collected from Central Bank of Iran (2001; 2004).

Table 2 summarises the Lee and Strazicich (2004) test results for the sample 1960 to 2003. The test results reveal that all of the variables under investigation are non-stationary, I(1) with a break. Table 2 shows the time of the most significant structural break (T_B) is 1979 for real GDP, 1983 for GNS and 1977 for GFCF. It is interesting to note that the structural breaks in these variables coincide with major real events including the Islamic Revolution of 1979 and the beginning of the Iran-Iraq war in 1980. Because of the closeness of these years, we will select the start year of 1979 as the representative break date.

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[6] General to specific procedure begins with the maximum number of lagged first differenced terms max k =8 and then examine the last term to see if it is significantly different from zero. If insignificant, the maximum lagged term is dropped and then estimated at k =7 terms and so on, till the maximum is found or k =0.

3. Estimation of the Relationships

In order to test for the interdependent effects that the variables have on each other, it is necessary to use the Johansen's (1991, 1995) method.[7] The procedure is appropriate because it includes the specification and estimation of the simultaneous effects between the non-stationary variables.

The VAR for the vector of variables, $\underline{X}_t' = \{Y_t, S_t, I_t\}$ is:

$$\underline{X}_t = \underline{\kappa} + \sum_{i=1}^{l} \Phi_i \underline{X}_{t-i} + \delta D_t + \upsilon_t \;, \qquad t = 1, 2, ..., n \qquad (3)$$

with unrestricted intercepts $\underline{\kappa}$ and D_t the I(0) dummy variable taking value for 1979 to 2003 and zero otherwise.

The model was estimated over the sample period, 1960 to 2003 for the optimum lag length, l, over the range of one to four lags. The model selection criteria and test statistics reported in Table 3 show possible optimum lags of 1, 2 and 3. Whilst there is supporting evidence of a lag of one according to the Schwarz Bayesian Criterion (SBC) and the Adjusted Likelihood Ratio (LR) test, it was decided to accept the lag of two since it is in the middle of the possible range, consistent with the Akaike Information Criterion (AIC) and allows for testing of Granger causality using the VECM (with reduced lag, $l-1=1$).

Table 3
Selection of the Optimum Lag Length (l)

Lag (l)	AIC	SBC	LR Test	Adjusted LR
4	87.71	52.25	–	–
3	87.08	59.21	**19.28*****	12.53
2	**87.77**	67.50	35.89	23.33
1	86.20	**73.53**	57.03	**37.07****
0	3.39	−1.68	240.65	156.42

Notes: *AIC* represents the Akaike Information Criterion: *SBC* represents the Schwarz Bayesian Criterion: *LR* represents the Likelihood Ratio test: *** Significant at the 1 percent level: ** 5 percent level: * 10 percent level.

The first order cointegrating VAR (with unrestricted intercept and no trend) gives the estimated eigenvalues:

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[7] See also Johansen and Julius (1992) and Pesaran and Pesaran (1997).

$$\lambda_1 = 0.3552, \quad \lambda_2 = 0.2418, \quad \lambda_3 = 0.0906 \quad \text{for} \quad \Pi = \sum_{i=1}^{\kappa} \Phi_i - \mathbf{I} \quad \text{having}$$

possible rank, $0 \leq r \leq 3$.[8] The smallest eigenvalue is close to zero and so the rank must be a maximum of two. However, the remaining values are also low, allowing the possibility of a rank of zero. The Likelihood Ratio tests and model selection criteria are shown in Table 4.

The maximal eigenvalue and trace tests do not reject the null hypothesis of $r = 1$ and $r = 2$ respectively, at the five percent levels of significance. All of the model selection criteria indicate a maximum rank of 3 which implies the system of three non-stationary variables is jointly stationary. It is likely that the lack of the degrees of freedom is affecting these criteria, which have relatively flat surfaces over the higher ranks. Since $r = 0$ implies no cointegration between the variables, it is sensible to not reject the null hypothesis, H_0: $r \leq 1$ according to the *LR* test based on the trace of the stochastic matrix. This is consistent with selecting the largest of the (low) estimated eigenvalues, $\lambda_1 = 0.3552$.

Table 4
Selection of the Optimum Rank (*r*) of the Π Matrix
Likelihood Ratio (LR) Tests [1]

H₀	*H_A*	*Max λ*	*H_A*	*Trace*
$r = 0$	$r = 1$	**18.43****	$r \geq 1$	34.05
$r \leq 1$	$r = 2$	11.63	$r \geq 2$	**15.62****
$r \leq 2$	$r = 3$	3.99	$r = 3$	3.99
Model Selection Criteria [2]				
Rank	*Max LL*	*AIC*	*SBC*	*HQC*
$r = 0$	100.71	85.70	72.67	80.93
$r = 1$	109.92	89.92	72.54	83.55
$r = 2$	115.73	92.73	72.75	85.41
$r = 3$	**117.73**	**93.73**	**72.88**	**86.09**

Notes: [1] *Max λ* represents the LR test based on the maximal eigenvalue of the stochastic matrix: *Trace* represents the LR test based on the trace of the stochastic matrix:
*** Significant at the 1 percent level: ** 5 percent level:
[2] *Max LL* represents the maximum log of the likelihood function: *AIC* represents the Akaike Information Criterion: *SBC* represents the Schwarz Bayesian Criterion: *HQC* represents the Hann-Quinn Criterion.

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[8] If $r = 0$ then there is no cointegrating relationship between the variables and if $r = 3$ then the three variables are jointly stationary. The rank should therefore be within the range $1 \leq r \leq 2$.

The benefit of a rank of one is that we have only one cointegrating vector, $\underline{\beta}'\underline{X}_t$ from the decomposition, $\Pi = \underline{\alpha}\underline{\beta}'$. This reduces the required number of identifying restrictions on the cointegrating vector, $\{\beta_Y Y + \beta_S S + \beta_I I\}$ $I(0)$ to a simple, single normalisation.[9] This is sufficient to identify the long run equilibrium relationship between the variables. The question becomes, which is the appropriate variable, $\{Y_t, S_t, I_t\}$ to be used to normalise the vector? All three possible cases are considered and the estimated long run elasticities are reported in Table 5. Since they all have the same maximised log-likelihood value of 109.92 (subject to the single exactly identifying restriction) the size, sign and significance of the estimates will be used to select only one relationship.

Table 5
Estimated Long Run Elasticities

Dependent Variable [1]	Explanatory Variables [2]		
	Y	*S*	*I*
Y	–	0.547*** (0.212)	0.154 (0.249)
S	1.827*** (0.707)	–	−0.282 (0.561)
I	6.478 (10.459)	−3.547 (7.059)	–

Notes: [1] The cointegrating vector was identified by normalising the explanatory variable as the dependent variable.
[2] Standard errors are shown in parentheses and tests of significance are reported assuming normality:
*** Significant at the 1 percent level: ** 5 percent level:

The long run relationships between saving and output in the first and second equations are striking. Consistent with the Solow model of economic growth, there is a unique equilibrium relationship between the level of saving and output. The first equation shows a one percent increase in saving is consistent with a 0.55 percent increase in output in long run equilibrium. This estimate is significant at the one percent level (under the assumption of normality). Compare this estimated value with Romer's

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[9] Since the variables are in logs, normalising on Y gives the elasticities $\hat{\varepsilon}_{Y,S} = -\hat{\beta}_S/\hat{\beta}_Y$ and $\hat{\varepsilon}_{Y,I} = -\hat{\beta}_I/\hat{\beta}_Y$, whilst normalising on S_t gives, $\hat{\varepsilon}_{S,Y} = -\hat{\beta}_Y/\hat{\beta}_S$ and $\hat{\varepsilon}_{S,I} = -\hat{\beta}_I/\hat{\beta}_S$, and on I_t gives $\hat{\varepsilon}_{I,Y} = -\hat{\beta}_Y/\hat{\beta}_I$ and $\hat{\varepsilon}_{I,S} = -\hat{\beta}_S/\hat{\beta}_I$.

(2006; pp. 22-24) estimate of the elasticity of output with respect to the saving rate:

$$\varepsilon_{Y,s} = \frac{\Delta Y}{Y} \bigg/ \frac{\Delta s}{s} = \frac{\eta}{1-\eta}$$

where $s = S/Y$ is the average saving rate (*aps*) and η is the share of income that is paid to capital. Given that for most countries, the average share of income paid to capital is around one-third $\left(\eta \quad 0.35\right)$ then the elasticity should be approximately one-half. The estimate of the elasticity in the first normalisation of Table 5 can be modified to incorporate the saving rate, s:

$$Y = 0.55S = 0.55\left(sY\right) = 0.55\left(s + Y\right) = \frac{0.55}{1-0.55}s$$

since s and Y are in logs. The elasticity estimate of $\varepsilon_{Y,s} = \dfrac{0.55}{1-0.55} = 1.2\dot{2}$

shows the share of income paid to capital on the long run balanced growth path is higher for Iran with $\eta = 0.55$.

The second possible normalisation with saving as the dependent variable in Table 5 gives the inverse elasticity of 1.82. [10] Whilst the direction of the effect of output influencing saving supports the Carroll-Weil hypothesis, the elastic value is large. Inspection of Table 5 clearly shows that investment has no significant long relationship with output and saving. Indeed the determination of investment in the third identified vector is very imprecise, reflecting the variability of investment relative to saving. These results lend strong support for the selection of a rank of one for the system, reflecting the singular, close relationship between output and saving. The first normalisation of output in the first row of Table 5 is selected as the best representation of the long run equilibrium relationship.

The associated short run error correction is therefore:

$$\Delta X_t = -\alpha_X \left(Y_{t-1} - 0.547 S_{t-1} - 0.154 I_{t-1}\right) + \kappa_X + \delta_X D_t + \sum_{X \in (Y,S,I)} \gamma_X \Delta X_{t-1} + \nu_{X,t} \qquad (4)$$

where $X \in \{Y, S, I\}$. The results of the estimation of the VECM are summarised in Table 6 and we will focus on ΔY_t. The estimated error correction coefficient $\left(\alpha_Y\right)$ has the correct sign and is significant at the one percent level. The magnitude of 0.228 reflects the inertia inherent in the

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[10] This elasticity is simply given by, $1/0.547 = 1.827$, which must also be significant because the ratios of the coefficients to standard errors must be the same, $0.547/0.212 = 1.827/0.707 = 2.58$.

evolution of annual real GDP, with nearly 25 percent of disequilibrium eliminated in the first year. Importantly, the inclusion of the saving variable (with significant coefficient at the one percent level) in the error correction means that saving has a short run equilibrating effect on output. The size of the short run elasticity is $-0.125 = 0.228 \times (-0.547)$. This further supports the Solow model whereby changes to saving have only transitory effects on the growth in output.

Table 6
Short Run Error Correction Elasticities of Explanatory Variables [1]

	$\alpha_X (ecm)$	κ_X	δ_X	$\gamma_Y (\Delta Y_{t-1})$	$\gamma_S (\Delta S_{t-1})$	$\gamma_I (\Delta I_{t-1})$
ΔY_t	0.228	−0.894	−0.102	−0.022	−0.025	0.174
	(0.072)***	(0.298)***	(0.031)***	(0.238)	(0.044)	(0.071)**
	$R^2 = 0.50$		$DW = 2.03$		$F_{1,35}(\text{RESET}) = 0.04$	
	$F_{5,36} = 7.32***$		$F_{1,35}(\rho = 0) = 0.04$		$F_{1,40}(\bar{\sigma}^2) = 2.37$	
ΔS_t	−1.289	−5.237	−0.489	−0.639	−0.060	0.376
	(0.309)***	(1.274)***	(0.131)***	(1.021)	(0.187)	(0.304)
	$R^2 = 0.42$		$DW = 2.23$		$F_{1,35}(\text{RESET}) = 0.02$	
	$F_{5,36} = 5.28***$		$F_{1,35}(\rho=0) = 4.42**$		$F_{1,40}(\bar{\sigma}^2) = 2.06$	
ΔI_t	−0.211	−0.849	−0.089	0.624	0.054	0.129
	(0.209)	(0.862)	(0.089)	(0.691)	(0.127)	(0.206)
	$R^2 = 0.26$		$DW = 1.78$		$F_{1,35}(\text{RESET}) = 0.44$	
	$F_{5,36} = 2.47**$		$F_{1,35}(\rho = 0) = 2.30$		$F_{1,40}(\bar{\sigma}^2) = 0.02$	

Notes: [1] Standard errors are shown in parentheses and tests of significance are reported assuming normality:

*** Significant at the 1 percent level: ** 5 percent level: * 10 percent level.

$F_{1,35}(\rho = 0)$ represents the Lagrange multiplier test for serial correlation: $F_{1,35}(\text{RESET})$ represents Ramsey's test using the square of the fitted values: $F_{1,40}(\bar{\sigma}^2)$ represents the test for heteroscedasticity.

The coefficients on the intercept (κ_Y) and dummy variable (δ_Y) are also significant at the one percent level. The dummy variable coefficient of −0.102 implies that the average growth in output (measured as the first difference in logs, ΔY_t) after 1979 was around ten percent per annum lower than for the period prior to this.

Importantly, the short run Granger causality test of the lagged dependent variables $\gamma_s \Delta S_{t-1}$ and $\gamma_I \Delta I_{t-1}$ on ΔY_t shows the growth in

investment increases the growth in output with the elasticity of 0.174, which is significant at the five percent level. The inclusion of the error correction in the test is important because its exclusion would mispecify the relationship and invalidate the test of short run Granger causality. Note that investment is not important in equilibrating output via the error correction mechanism, because the estimate of 0.154 in the normalised cointegrating vector is not significant. If this was significant then it would support the Solow model of growth, which states that increases in capital only lead to transitory growth in output. In contrast, the estimated Granger causing short run dynamic elasticity of 17.4 percent is consistent with the endogenous growth model whereby increases in capital contribute to sustained growth in output.

The summary statistics show the VECM for the growth in output passes the test for serial correlation (with the DW statistic and the Lagrange multiplier test), Ramsey's RESET test for correct functional form, and the test for heteroscedasticity. Fifty percent of the growth in output is explained by the first VECM and whilst the factors summarised in our introduction explain the other institutional and economic determinants to economic growth in Iran.

4. Conclusions and Policy Implications

This paper attempts to estimate the interdependencies between capital formation, saving and output for Iran which is complicated for two reasons. The first is the theoretical models and conflicting empirical findings of the relative roles of these important aggregates do not provide clear guidance as to the appropriate specifications. Second, Iran's turbulent history makes it difficult to disentangle the complex and changing interrelationships between output, saving and investment for the period of our study, 1960 to 2003. It is important that structural change in the variables is explicitly incorporated into the simultaneous estimation in a non-stationary growth setting.

The methodology adopted follows the work by Pahlavani (2005) on the causes of economic growth in Iran and uses the procedures adopted by Verma and Wilson (2005) and Chaudhri and Wilson (2000). The Lee and Strazicich (2004) procedure was used to determine that all three variables were non-stationary, I(1) in the presence of structural change. The endogenously determined time of the most significant structural breaks were 1979 for output, 1983 for saving and 1977 for investment. These years coincide with the effect of the Islamic revolution in 1979 and Iran-Iraq war 1980 to 1988.

The relationships were estimated using Johansen's (1991, 1995) FIML procedure which is appropriate for estimating the effects of non-stationary variables in a simultaneous setting. The cointegrating vector estimates indicate a long run elasticity of output with respect to saving of 0.55. That is, a one percent increase in saving will be associated with a 0.55

percent increase in the long run equilibrium level of output, which describes a Solow style relationship. This also implies the share of income that is paid to capital in the form of saving in Iran is higher at 0.55 than the average for developed countries of around 0.35. These findings show the importance of saving in promoting higher levels of output and income in Iran. However, whilst they explain a higher long run steady state, they do not explain the causes of economic growth. The role of investment was found to be imprecise in the long run.

The results of the estimation of the short run error correction show that saving has a short run equilibrating effect on output with elasticity of −0.125. This further supports the Solow model whereby changes to saving have only transitory effects on the growth in output. The other important result found that investment dynamically Granger causes the growth in output with a short run elasticity of 0.17, which is significant at the five percent level. This estimate is correctly specified because of the inclusion of the error correction term and the result is consistent with the endogenous growth explanation of growth.

Output is found to return to the equilibrium growth path relatively rapidly, with elasticity indicating around 23 percent of disequilibrium is eliminated in the first year. The structural change parameter in the VCEM estimates that the effect on the growth in output fell by around 10 percent after 1979. This validates the explanation in the introduction that economic growth in Iran slowed significantly after the revolution and war periods.

In summary, the explicit modelling and estimation of endogenously determined structural change in the non-stationary and interdependent measures of output, saving and capital formation have two important policy implications for Iran. First, whilst relatively high domestic saving is found to be an important determinant of economic growth in the short run and long run, there appears to be scope to reduce the reliance on this domestic source (with the possible use of overseas saving). Second, saving should be used to improve the effectiveness of capital accumulation which was found to be important in promoting economic growth in the short run only. The use of saving in the strategic provision of capital, including infrastructure, is essential for the promotion of long run economic growth in the structurally transforming economy of Iran.

REFERENCES

Bahmani-Oskooee, M. (1993), 'Black Market Exchange Rate Versus Official Exchange Rates In Testing Purchasing Power Parity: An Examination of the Iranian Rial', *Applied Economics*, 25 (4), 465-72.

Bai, J. and P. Perron, (2003), 'Computation and Analysis of Multiple Structural Changes Models,' *Journal of Applied Econometrics*, 18, 1-22.

Carroll, C. and D. Weil (1994), 'Saving and Growth: A Reinterpretation', *Carnegie-Rochester Conference Series on Public Policy,* 40, 133-192.

Carroll, C., Overland. J and D. Weil (2000), 'Saving and Growth with Habit Formation', *American Economic Review,* 90, 341-355.

Central Bank of Iran. (2001, 2004) *Iran's National Accounts*, Tehran: Bureau of Economic Accounts, Central Bank of Iran.

Chaudhri, D. P. and E. J. Wilson, (2000), 'Savings, Investment, Productivity and Economic Growth of Australia 1861-1990: Some Explorations', *The Economic Record*, 76, 55-73.

Christiano, L.J. (1992), 'Searching for a Break in GNP', *Journal of Business and Economic Statistics* 10, 237-49.

Eken, S., Helbling, T. and A. Mazarei (1997), 'Fiscal Policy and Growth in the Middle East and North Africa Region', *IMF Working Paper*, WP/97/101, Washington DC.

Hakimian, H (1999), 'Institutional Changes and Macroeconomic Performance in Iran: Two Decades after the Revolution (1979-1999)', *ERF Working Paper,* No. 9909.

Hall, R. E. and C. I .Jones (1999), 'Why Do Some Countries Produce So Much More Output per Worker Than Others?', Q*uarterly Journal of Economics,* CXIV, 83-116.

Houtakker, H.S. (1961), 'An International Comparison of Personal Saving', *Bulletin of the International Statistical Institute,* 38, 55-60.

Houtakker, H. S. (1965), 'On Some Determinants of Savings in Developed and Underdeveloped Countries', in *Problems in Economic Development,* E. Robinson (ed.), MacMillan, London.

Jalali-Naini, A (2003), 'Economic Growth in Iran: 1950-2000', *ERF Working Paper*, January, Mimeo.

Johansen, S. (1991), 'Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Vector Autoregressive Models ', *Econometrica,* 59, 1551-1580.

Johansen, S. (1995), *Likelihood Based Inference on Cointegration in the Vector Autoregressive Model*, Oxford University Press, Melbourne.

King, R. and R. Levine (1994), 'Capital Fundamentalism, Economic Development and Economic Growth' *Carnegie-Rochester Conference Series on Public Policy,* 40, 259-292, June.

Lee, J. and M. C. Strazicich (2003), 'Minimum LM Unit Root Test with Two Structural Breaks', *Review of Economics and Statistics* 63, 1082-1089.

Lee, J. and M. C. Strazicich (2004), 'Minimum LM Unit Root Test with One Structural Break', *Working Paper*, Department of Economics, Appalachain State University.

Leybourne, S. J and P. Newbold, (2003), 'Spurious Rejections by Cointegration Tests Induced by Structural Breaks', *Applied Economics*, 35 (9), 1117-21.

Levine, R.E. and D. Renelt (1992), 'A Sensitivity Analysis of Cross-Country Growth Regressions', *American Economic Review*, 82, 942-963.

Lumsdaine, R. L. and D. H. Papell (1997), 'Multiple Trend Breaks and the Unit Root Hypothesis', *Review of Economics and Statistics*, 79 (2), 212-218.

Mazarei, A. (1996), 'The Iranian Economy Under Islamic Republic: Institutional Change and Macroeconomic Performance (1979-1990)', *Cambridge Journal of Economics*, 20 (3), 289-314.

Modigliani, F. (1970), 'The Life Cycle Hypothesis of Savings and Inter-Country Differences in the Savings Ratio', in *Induction, Growth and Trade: Essays in Honour of Sir Roy Harrod,* W.A.Eltis (ed.), Claredon Press, London.

Nunes, L., Newbold, P. and C.Kuan (1997), 'Testing for Unit Roots with Breaks: Evidence on the Great Crash and the Unit Root Hypothesis Reconsidered', *Oxford Bulletin of Economics and Statistics*, 59, 435-448.

Pahlavani, M. (2005), 'Sources of Economic Growth in Iran: A Cointegration analysis in the presence of structural Breaks', *Applied Econometrics and International Development*, 5 (4), 83-94.

Pahlavani, M., Valadkhani, A. and A. Worthington (2005), 'The Impact of Financial Deregulation on Monetary Aggregates and Interest Rates in Australia', *Applied Financial Economics Letters*, 1 (3), 157-63.

Pahlavani, M., Wilson, E. and A. Valadkhani (2006), 'Identifying Major Structural Breaks in the Iranian Macroeconomic Variables', *International Journal of Applied Business and Economic Research*, 4 (2), forthcoming.

Perron, P. (1989), 'The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis', *Econometrica*, 57 (6), 1361–1401.

Perron, P. (1997), 'Further Evidence on Breaking Trend Functions in Macroeconomic Variables, *Journal of Econometrics*, 80 (2), 355-85.

Peseran, M. H. and B. Peseran (1997), *Working with Microfit 4: Interactive Econometric Analysis*, Oxford University Press, Oxford.

Pesaran, M.H (2000), 'Economic Trends and Macroeconomic Policies in Post-Revolutionary Iran', *Journal of Money and Banking*, 1 (2), 26-66.

Romer, D. (2006), *Advanced Macroeconomics*, 3rd ed., McGraw-Hill Irwin, Sydney.

Solow, R. (1970) *Growth Theory: An Exposition*, Clarendon Press, Oxford.

Vogelsang, T. and P. Perron (1998), 'Additional Tests for a Unit Root Allowing for a Break in the Trend Function at Unknown Time', *International Economic Review*, 39 (4), 1073-1100.

Verma, R. and E. J. Wilson (2005), 'Multivariate Analysis of Savings, Investment, and Growth in India', paper presented to the *Monetary Policy Workshop,* Reserve Bank of India, Mumbai, June.

Zivot, E. and K. Andrew (1992), 'Further Evidence On The Great Crash, The Oil Price Shock, and The Unit Root Hypothesis', *Journal of Business and Economic Statistics*, 10 (10), 251–70.