Public and Private Investment in Saudi Economy: Evidence from Weak Exogeneity and Bound Cointegration Tests

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Abstract

This paper investigates the long-run equilibrium relationship between the real private and total public investment disaggregated into government and public enterprises investment in Saudi Arabia by using the weak exogeneity and ARDL cointegration tests after using Engle-Granger and Perron-Rodriguez cointegration tests. The results show the stable long-run relation between private and total public investment. The public investment crowds out the private investment, while this latter is crowding in by infrastructure government investment. The absence of financial accelerator mechanism indicates that the private enterprises could be in vicious loan-credit cycle. The finding indicate that long-run exceeds short-run crowding-out, since the public sector still dominates the economic activities and attracts more capital resources. But the disequilibrium of private investment is widely corrected and converges back, with a high speed of adjustment, to its long-run equilibrium.

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1. Introduction

This article analyses the long and short run effects of total public investment on private investment based on empirical data of KSA. Many papers examine the crowding effects using an aggregated measure of public investment. The idea is to test these effects considering that total public investment is decomposed into infrastructure government investment and investment in public enterprises. The demand approach permits to evaluate the effect of demand expectation (accelerator's principle) and considers the user cost of capital (Jorgenson 1971) via the irreversible investment theory. The assumption of adjustment costs in the investment process would appear to be more appropriate for modeling private investment (Dixit & Pindyck 1994). We postulate that an adjustment process to the equilibrium relationship exists between public and private investment. The reduction in private investment is not only due to the uncertainty increasing but also to the public enterprises investment crowding out effect. Nevertheless the infrastructure government investment would motivate the private investment decisions.

Aschauer's model, based on supply theory, concludes that infrastructure public investment crowds in the private investment through the productivity effects of public capital (Aschauer 1989; Argimon et *al*. 1997). The public investment may crowd out private investment if the additional government investment is financed locally by public bonds, which leads to an increase in the interest rate, credit rationing and a tax burden for future generations (Rossiter 2002). This crowding effect could occur in the short run when the economy operates below full employment level.

Based on the demand theory of investment, the hypothesis considered is that the effects of public investment variations occur in short and long run (Aschauer 1989; Erenberg 1993; Pereria 2001). To test these effects, the reduced-form private investment function is specified assuming a logarithmic linear function. The ARDL cointegration leads to investigate the short and long run relationship without imposing that the variables have the same order of integration. This methodology seems to be more reliable in our empirical study. Many articles do not verify hitherto a required condition of weak exogeneity test. The contribution of this paper is to implement this test as a prerequisite in the bounds cointegration testing framework.

Many empirical evidence shows that there are mixed evidence of crowding out and crowding in effects of public investment in developing countries (Atukeren 2005; Erden & Holcombe 2006). The findings of Mitra (2006) for India using SVAR model suggest that government investment crowds out private investment, though the government investment had a positive impact on the economy in the long run. Chakraborty (2007) analyzes for India the economic and financial crowding out through infrastructure and non-infrastructure investments using VAR model. He exhibits that there is no evidence for economic crowding out effect on private capital. The study of Looney (1992), based on the period 1960-1992, indicates that there is no crowding effect between government and private investment. But since1990s, the Saudi government measures enhance the investment environment and promote the initiatives in private sector. It is expected in Saudi Arabia that the public enterprises investment could crowd out the private investment, while the infrastructure government investment would have a positive effect even if the government has a huge budget for expenditures. Although the net effect of total public investment remains ambiguous, so the result depends on which one of the two effects dominates.

This article is organized as follows; the second section describes theoretical backgrounds. The economic reform process in Saudi Arabia is briefly presented in the third section. The ARDL cointegration approach is treated in fourth section. The empirical results are exhibited in the fifth section. The sixth section shows conclusions and policy recommendations.

2. The model of investment

There are two theoretical concepts of crowding out effect: economic and financial. The economic effect occurs when the increase in public investment crowds out the private investment through fiscal and economic policies, irrespective of the mode of financing the fiscal deficit (Blinder & Solow 1973). The financial effect arises when the interest rate is increased, because the public enterprises and government are borrowing heavily while the private business and individuals encounter some restrictions loans. Using an augmented accelerator model of investment (Wang 2005), the behavior of private investment can be explained by the implicit reduced-form function $f(\cdot)$ as follows:

$$IPR = f\left(IPR_{-1}, IPU, IBG, Y^{*}, CRE, rir\right) \quad \text{with} \quad \frac{\partial IPR}{\partial IPR_{-1}} > 0 \quad \frac{\partial IPR}{\partial IPU} \lesseqgtr 0 \quad \frac{\partial IPR}{\partial IBG} > 0 \qquad (1)$$

where the variables *IPR*, *IPU*, *IBG*, Y^{*} and *CRE* design private investment, investment of public enterprises, infrastructure government investment, expected demand (approximated by real GDP) and credits to private sector, respectively. The variable *rir* shows a real interest rate as a proxy of user cost of capital defined by $rir_t = Ln[(1 + r_t)/(1 + \pi_t)]$ where r_t and π_t denote nominal interest rate and inflation rate, respectively (Neely & Rapach 2008). The positive coefficient of lagged private investment reflects the irreversibility of investment. The total public investment can have either a negative effect (substitution) or a positive effect (complementarity) (Khan & Kumar 1997; Cruz & Teixeira 1999). So the infrastructure government investment could reduce investment uncertainty in the private sector by tumbling costs, raising productivity and increasing returns.

The flexible accelerator model suggests that the private investment is affected positively by the expected demand. The effect of credits on private investment is expected to be positive. Generally credit policies affect private investment via the stock of credits available to firms that have access to preferential interest rates. If the real interest rate has a negative effect, this endows with Jorgenson's theory (1971). But a very small value of this effect would endow with the theory of irreversible investment in conditions of macroeconomic uncertainty.

Bearing the above arguments in mind, the long run equation of private investment is assumed to be given by the following natural logarithmic form:

$$ipr_t = \beta_1 \pm \beta_2 ipu_t + \beta_3 ibg_t + \beta_4 gdp_t + \beta_5 cre_t - \beta_6 rir_t + u_t \qquad (2)$$

where u_t represents the error term which is an indicator for macroeconomic instability. The elasticity parameters β_2 and β_3 are related to real crowding effect, while the parameter β_6 is more attached to financial crowding effect. The variables defined in Eq.2 with small letters are the natural logarithmic of the variables defined with capital letters in Eq.1 except for the variable *rir* which remains the same. If the relationship in Eq.2 is stable, that is, cointegrated with appropriate adjustment, the crowding-out effect is checked (Shafik 1992; Ramirez 2000; Ahmed & Miller 2000; Naqvi 2002). The assumption considered is that the adjustment would be hold in short and long run following different processes of accelerator and cost of capital effects. The adjustment mechanisms can be operated through the public investment and the central bank. The former could be more or less rigid vis-à-vis the discrepancies and the latter has different preferences regarding deviations from the long run equilibrium.

3. Economic reform process in Saudi Arabia

The government has established many public companies such Arab and American Company of Oil (ARAMCO), Saudi Arabian Mining Company (MAADEN), Saudi Basic Industries Corporation (SABIC) in petrochemical sectors, Saudi Electricity Company (SECO), Saline Water Conversion Corporation (SWCC) and Saudi Telephone Company (STC). But to absorb the burgeoning unemployed manpower, the government would stimulate the private sector using a very moderate tax policy. The economic strategy is focused on the diversification of income sources by developing non-oil sectors. It is expected that such sectors would generate more job opportunities in the society improving incomes and enhancing the quality of life.

The private sector would expand progressively the role of national and foreign investors. Also the banking sector has a substantial role to play by financing various economic activities and providing more capital to investors. The financial private sector could attract Saudi capital to flow back to the domestic and regional securities markets. The private sector role could reduce the government debt burden on the public budget, and generate non-oil revenues for the government budget (Table 1A). The development of a rather opened business environment would rationalize the economic development and lead to increase the efficiency. The Supreme Economic Council in 1999 (SEC) and the Saudi Arabian General Investment Authority in 2000 (SAGIA) have been established to observe the performance of private sector and eliminate at least the institutional barriers to investment such the abolition of local sponsorship of foreign investors and the free capital flows.

During the 1990s, the Saudi government has planned to boost the private non oil sector. So since 1990, the Saudi Arabia's basic infrastructure was viewed as largely completed and could support further private economic activities. Thus, the private investment expanded his capacity of production and supported long run economic growth. The ratio of private investment to GDP tended to increase, while the ratio of public investment decreased. Since 1998 the gap between private and public investment was persistently being reduced, but the ratio of private investment remains higher to the ratio of the public investment. Also the rise in oil prices since 1998, close to 72 dollars per barrel in 2006, led to a huge increase of public sector investment, and seems to crowds out the private investment (Figure 1, Table 1B).

Figure 1 KSA private and public investment as % of *GDP*

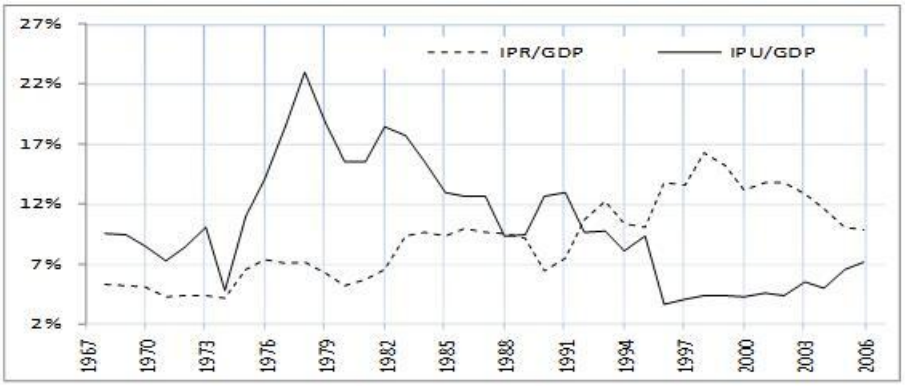


Table 1A Sources of government revenues as % of GDP

	1998-99	2000-04	2005-06	2005	2006	2007	2008
Oil revenues	16.0	28.9	44.0	42.7	45.3	39.1	56.1
Other revenues	9.2	6.7	5.1	5.1	5.2	5.6	6.7
Ratio of deficit or surplus	-7.4	2.5	19.7	18.4	21.0	12.3	33.1

Author's calculation-Source: Central Department of Statistics & Information, Ministry of Economy & Planning, 2009

Table 1B Share of investments by type of capital assets (% of GDP)

	1998-99	2000-04	2005-06	2005	2006	2007	2008
All types	20.1	17.8	17.0	16.5	17.5	19.9	17.7
Government & oil sector	4.3	4.8	7.1	6.5	7.7	10.2	9.3
Non oil private sector	15.8	13.0	9.9	10.0	9.7	9.8	8.4

Author's calculation-Source: Central Department of Statistics & Information, Ministry of Economy & Planning, 2009

The ratio of bank credits to GDP is increased in average during the second half of the 2000s mainly to finance private enterprises investment, whereas the bank investment in securities is decreased and remains oriented to public sector (Table 1C). Therefore the bank claims allocation in Saudi Arabia did not generate financial crowding out effects.

Table 1C Bank claims in Saudi Arabia (% of GDP)

	1997-99	2000-04	2005-06	2005	2006	2007	2008
Bank investments in securities	16.8	18.8	11.2	12.1	10.3	11.5	13.2
Public sector	15.6	17.6	10.0	10.8	9.2	10.0	12.0
Private sector	1.2	1.2	1.2	1.3	1.0	1.4	1.2
Bank credits	28.1	29.6	37.7	38.3	37.2	41.4	42.5
Public sector	3.4	2.3	2.6	2.7	2.6	2.6	1.8
Private sector	24.8	27.3	35.1	35.6	34.6	38.8	40.6

Author's calculation-Source: SAMA Annual Economic Reports and Bulletins 44, 2009

4. ARDL cointegration test

The most commonly used methods for conducting cointegration test include the residual based on Engle-Granger test with single equation (1987), the maximum likelihood based on Johansen-Juselius (1990) and Johansen test with multivariate VAR model (1992, 1995). The existence of any long-run relation among a vector $z_t' = (y_t, x_{1t}, x_{2t})$ of variables can be tested by the ARDL or bound testing cointegration procedure. The main advantage of ARDL modeling lies in its flexibility. Firstly, the variables can have different order of integration. Secondly, the model takes sufficient lags to capture the Data Generating Process (DGP) in General-To-Specific (GETS) modeling approach. Thirdly, the ECM, which integrates short-run dynamics and long-run equilibrium, can be derived from ARDL through a simple linear transformation (Banerjee et *al*. 1993). The ARDL approach uses the following unrestricted Vector Error Correction Model (VECM) (Pesaran-Shin 1999; Pesaran-Shin-Smith 2001):

$$\Delta z_t = c_0 + \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \varepsilon_t \qquad (3)$$

called equilibrium correction model, where c_0 is the drift, Π and Γ contain the long-run multipliers and short-run dynamic coefficients, respectively. The matrix Π has a reduced rank and can be decomposed as $\Pi = \alpha\beta'$ where α and β are matrices containing speed of adjustments towards equilibrium and cointegration vectors, respectively. The vector of errors is assumed to be identically distributed: $\varepsilon_t \sim ID(0;\Omega)$ where Ω is positive definite. By assuming conformable partitionings of relevant variables, vectors and matrices as:

$$z_t = \begin{pmatrix} y_t \\ x_t \end{pmatrix}, \Pi = \begin{pmatrix} \pi_y \\ \Pi_x \end{pmatrix} = \begin{pmatrix} \pi_{yy} & \pi_{yx} \\ \pi_{xy} & \Pi_{xx} \end{pmatrix}, \alpha = \begin{pmatrix} \alpha_y \\ \alpha_x \end{pmatrix},\ \Gamma_i = \begin{pmatrix} \gamma_{y_i} \\ \Gamma_{x_i} \end{pmatrix},\ \varepsilon_t = \begin{pmatrix} \varepsilon_{y_t} \\ \varepsilon_{x_t} \end{pmatrix},\ \Omega = \begin{pmatrix} \omega_{yy} & \omega_{yx} \\ \omega_{xy} & \Omega_{xx} \end{pmatrix}$$

if $\alpha_x = 0$ (or $\pi_{xy} = 0$ and $\Pi_{xx} = 0$), then x_t is weakly exogenous for the parameters (π_{yy}, π_{yx}) and valid inference can be implemented in the conditional model of y_t given x_t and the past of appropriate variables (Case III, unrestricted intercept and no trend in Pesaran et *al*. 2001):

$$\Delta y_t = c_0 + \pi_{yy} y_{t-1} + \pi_{yx} x_{t-1} + \sum_{i=1}^{p-1} \psi_i' \ \Delta z_{t-i} + \omega' \Delta x_t + u_t \tag{4a}$$

$$\Delta y_t = c_0 + \alpha_y \beta' \ z_{t-1} + \sum_{i=1}^{p-1} \psi_i' \ \Delta z_{t-i} + \omega' \Delta x_t + u_t \tag{4b}$$

called conditional or partial model, where $\omega = \Omega_{xx}^{-1} \omega_{xy}$, $\psi_i' = \gamma_{y_i} - \omega' \Gamma_{x_i}$, $u_t := \varepsilon_{y_t} - \omega_{yx} \Omega_{xx}^{-1} \varepsilon_{x_t}$ (Johansen 1995, Pesaran et *al*. 2001 and Jacobs & Wallis 2010). Assuming that a unique long-run relationship exists between the variables and x_t is weakly exogenous, the conditional VEC Model from (3) can be written as an ARDL model:

$$\Delta y_t = c_{01} + \lambda_1 y_{t-1} + \lambda_2 x_{1,t-1} + \lambda_3 x_{2,t-1} + \sum_{i=1}^{p} \gamma_{1i} \Delta y_{t-i} + \sum_{i=0}^{q_1} \gamma_{2i} \Delta x_{1,t-i} + \sum_{i=0}^{q_2} \gamma_{3i} \Delta x_{2,t-i} + u_t \tag{4c}$$

with $|\lambda_1| < 1$. The disturbances u_t are supposed uncorrelated. By construction Δx_t are no correlated to u_t, and due to the unrestricted nature of the lag distribution of Eq.(4c), this equation is identified and will be estimated consistently by least square method. Pesaran and Shin (1999) suggest using a more parsimonious specification with ARDL approach.

Three main steps are required to implement the Bounds Testing Procedure. For convenience, these steps are stated with selecting the order of the VAR (using AIC and BIC criteria) and testing for weak exogeneity. The *first step* consists to estimate the Eq.(4c) in order to test for the existence of long-run relationship among specified variables. This test is realized by calculating a standard F-test for the joint significance of the lagged levels of the variables: $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = 0$ against $H_1 : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq 0$. When a long-run relationship exists between the variables in Eq.(4c), the F-test indicates which variable should be normalized. The normalization gives the statistic $F_y(y/x)$ where y is the dependant variable. Following Pesaran et *al*. (2001), the F test has a non-standard distribution; they provide two asymptotic critical values bounds to testing for cointegration when the explanatory variables are different order of integration I(1) and I(0).[2] When the cointegration is confirmed involving the stationary of estimated error e_t, the *second step* consists to estimate the following level relationship defined by long-run ARDL$\left(p, q_1, q_2\right)$ sub-model:

$$y_t = c_{01} + \sum_{i=1}^{p} \lambda_{1i} y_{t-i} + \sum_{i=0}^{q_1} \lambda_{2i} x_{1,t-i} + \sum_{i=0}^{q_2} \lambda_{3i} x_{2,t-i} + \nu_{y_t} \tag{5}$$

where λ_{ji} represents the conditional long-run multiplier. This conditional ARDL equation involves selecting the optimal orders of p and q by using AIC or SIC criterion. With the annual data, the maximum number of lags is expected to be inferior or equal to 2. With the lagged error-correction term $\left(ect_{t-1} := \nu_{y_t}\right)$, deduced from Eq.(5), the *final step* consists to obtain the short-run dynamic coefficients from ECM as following:

$$\Delta y_t = \mu + \sum_{i=1}^{p} \varphi_{1i} \Delta y_{t-i} + \sum_{i=0}^{q_1} \varphi_{2i} \Delta x_{1,t-i} + \sum_{i=0}^{q_2} \varphi_{3i} \Delta x_{2,t-i} + \theta \, ect_{t-1} + \nu_{\Delta y_t} \tag{6}$$

where $\left(\varphi_{1i}, \varphi_{2i}, \varphi_{3i}\right)$ are the short-run dynamic coefficients and θ is the speed of adjustment to the long-run equilibrium.

5. Data and results

5.1 *Data and unit root tests*

The annual data are from 1968 to 2006 and extracted from the annual reports of Saudi Arabia Monetary Agency (SAMA, report 43, 2007). The national accounts statistics break down the Gross Fixed Capital Formation (GFCF) into private (*IPR*) and public investment (*IPU*) realized by state-owned enterprises, each one includes local and foreign investment. The infrastructure investment (*IBG*) is from government budget. The Data on real *GDP* are calculated straightforwardly by implicit *GDP* deflator (base 1999). All data are taken in real terms (1999 prices) with the appropriate deflators and they are not seasonally adjusted. A plot of the variables over time indicates the presence of trend in the variables.

[2] A lower value of F-statistic assumes that the variable is I(0) and its upper value supposes that the variable is I(1). If F-statistic is above the upper critical value, then the null hypothesis of no cointegration could be rejected. This null hypothesis could be accepted if the F-statistic is below the lower critical value.

The Dickey-Fuller Generalized Least Square (DF-GLS) de-trending test proposed by Elliott et *al*. (1996) and the Ng-Perron test (MZ-GLS) following Ng & Perron (2001) have been implemented for their reliability in small samples and less sensitivity to the lag choice. They use a modified information criteria (MIC) which takes into account the fact that the bias in the sum of the autoregressive coefficients is highly dependent on lags number. The results (Table 2) of ADF-GLS and MZ-GLS unit root tests for the null hypothesis I(1) indicate mixed order of integration, so the first difference of the variables *ipr*, *cre*, *rir* reject the unit root hypothesis at 1%, while this latter is accepted for *ipu*, *ibg* and *gdp*. To check for possible size distortions for ADF-type tests, we chose the lag order employing the data dependent method (top-down testing) proposed by Ng & Perron (1995). The two unit root tests show mix I(1) and I(0) variables, these results have significant implications for the cointegration analysis frame. Then the ARDL's approach is more appropriate in our empirical work, and the long run private investment Eq.(2) can be justified by using the bounds test approach.

Table 2 Unit root tests with only constant [3]

	Δipr	Δipu	Δibg	Δgdp	Δcre	Δrir
ADF^{GLS}	-4.249**	-1.780*	-2.211*	-2.065*	-4.209**	-3.113**
$\overline{MZ}_{\alpha}^{GLS}$	-16.301**	-4.906	-6.476†	-6.874†	-16.212**	-37.658**

5.2 *Weak exogeneity test*

The weak exogeneity assumptions influence the dynamic properties of the conditional VECM i.e. Eq.(4) and must be tested in the full system framework (Johansen 1992). The government investment (ibg_t) can be treated as an exogenous I(1) variable, so the infrastructure investment is considered one of the economic policy instruments. Considering $x_t = (ipu_t, gdp_t, cre_t, rir_t)'$ weakly exogenous, the parameters of the conditional Eq.(4) of

[3] In all Tables of results **, *, † indicate significance at the 1%, 5% and 10%, respectively. The Akaike Information Criterion (AIC) has better theoretical and empirical properties. In the ADF-GLS test: one-sided (lower-tail) test of the null hypothesis that the variable is non-stationary; at 1%, 5% and 10% asymptotic critical values equal -3.46, -2.91 and -2.59, respectively when the model includes a constant and trend ; and equal -2.58, -1.98 and -1.62, respectively when the model includes only a constant (Rapach & Weber, 2004). For the Modified Phillips-Perron test: one-sided (lower-tail) test of the null hypothesis that the variable is non-stationary; at 1%, 5% and 10% asymptotic critical values equal -19.95, -17.30 and -11.16, respectively when the model includes a constant and trend ; and equal -13.80, -8.10 and -5.70, respectively when the model includes only a constant (Ng & Perron 2001).

$y_t := ipr_t$ can be meaningfully estimated independently to the marginal distribution of x_t (Johansen 1995; Pesaran & Shin & Smith 2001). Under the concept of Granger causality, the block exogeneity Wald test is used to test whether all endogenous variables could be considered as exogenous. From the underlying VAR model, the result $\hat{\chi}^2(4) = 28.458$ with P-value 1.01*E*-05 indicates that all level variables are globally exogenous.

When $\Pi_{xy} = 0$ and $\Pi_{xx} = 0$, then x_t is weakly exogenous for $\pi_{yy} := \lambda_1$ and $\pi_{yx,x} = \pi_{yx} := (\lambda_2, \lambda_3)$ in Eq.(4). Given that Π can be written as $\Pi = \alpha\beta'$. Then, the test of weak exogeneity consists to test restrictions of nullity on the α matrix i.e. coefficients associated to error correction terms (Johansen 1992, 1995; Brüggemann 2002).[4] From an unrestricted VAR, the Π matrix can be estimated using the Johansen's method; the use of standard likelihood ratio consists to test whether the restrictions implied by the reduced rank of Π could be rejected. Assuming there is only one cointegrating relation in VEC model, to test whether the endogenous variables are weakly exogenous with respect to the parameters of VEC framework, the constraint $\alpha_x = 0$, with no other restrictions on the parameters, would be tested by solving a modified eigenvalue problem as described in Johansen (1995). This implies that efficient inference can be constructed on π_{yy} and $\pi_{yx,x}$ in the conditional model (4). The corresponding LR statistic is computed as follows:

$$LR = T\sum_{i=1}^{r} Ln\left(\frac{1-\tilde{\varphi}_i}{1-\hat{\varphi}_i}\right)$$

where $\tilde{\varphi}_i$ and $\hat{\varphi}_i$ are the calculated eigenvalues with and without restrictions, respectively. The statistic LR is asymptotically distributed with $\chi^2(df)$ where df is the degree of overidentification. The results in Table 3 show that public investment can be considered as strong exogenous in Eq.(4), and the weak exogeneity to the system is rejected only for the real interest rate.[5] By using the Granger causality test in the VAR framework, the variables *ipu*

[4] The exogeneity test gives more convenience and allows efficient inference on the cointegration coefficients in partial model (Jacob & Wallis 2010). So, this latter gives some arguments for the interpretation of economic implications in the short and long run.

[5] Also, if x_t is weakly exogenous and y_{t-1} does not Granger-cause x_t, then x_t will be strongly exogenous.

and *gdp* seem to be strong exogenous for the parameters π_{yy} and π_{yx} in the conditional model (4a), but the variable *cre* remains weak exogenous. These outcomes provide evidence for the underlying economic theory that crowding-out effect could be tested in the ARDL cointegration framework.

Table 3 Weak exogeneity tests via Likelihood Ratio

	α_{ipu}	α_{gdp}	α_{cre}	α_{rir}
χ_1^2	2.0983	0.2341	0.6338	5.1816
P-value	0.1475	0.6285	0.4259	0.0228

5.3 *Cointegration tests*

The existence of the long-run relationship, between private and public investment, is tested using different tests of cointegration Engle-Granger (1987), Perron-Rodriguez (2001) and Pesaran-Shin-Smith (1999, 2001). We don't apply the maximum likelihood approach of Johansen-Juselius (1990), because the same order of integration is required. If this equilibrium relationship holds, it would imply that fiscal and monetary policies could influence fluctuations in private investment and flows of credit to private sector.

Each cointegration test includes constant and trend as deterministic components, so the visualizing data do support this basic specification. For the estimation of u_t (from Eq.4c), the lag order is chosen by AIC and t-sig. This lag is selected appropriately to reduce residual serial correlation and avoid over-parameterization of Eq.(4c), the lag structure test gives $p = 2$. From two first columns of Table 4, the null hypothesis of no cointegration using the ADF cointegration test cannot be rejected. Thus, there is no evidence of cointegration at the 5% significance level using conventional Engle & Granger ADF test (1987). Furthermore, we employ the Perron & Rodriguez (2001) cointegration tests with good size and power. The null hypothesis of no cointegration is rejected at 5%. The contrast between the results in Table 4 suggests that the rejection using EG test entails a Type II error.

Table 4 Cointegration tests (dependent variable: *ipr*) [6]

	EG		PR=EG^{GLS}	
	AIC	t-sig	AIC	t-sig
ρ	-0.0758	-0.0708	-0.5043*	-0.6769*
τ_{ρ}	(-1.513)	(-1.515)	(-3.015)	(-3.123)

Considering in the underlying VAR model the lag values from 1 to 2 of p and q for each Eq.(4c), so $(2+1)^6 = 729$ regressions can be running using Microfit 5.0 (Pesaran & Pesaran 2009), the specification that minimize the AIC value is chosen. The bound cointegration test is based on F-statistic which distribution under the null hypothesis depends on the integration order of variables in Eq.(4c) and lag choice of order p. The critical value bounds are computed by stochastic simulations using 2000 replications implemented in Microfit. If all variables are I(0), the bootstrapping critical value at 5% is 2.98, and if they are I(1), the critical value is 4.39. For cases in which some series are I(0) and others are I(1), the bootstrapping critical value falls in the interval [2.98; 4.39].

Table 5A Bounds cointegration tests from Eq.(4c)

	ipr	*ipu*	*ibg*	*gdp*	*cre*	*rir*
$F_{.}$(./X)	8.906**	1.131	1.555	3.731	0.849	2.421

The Eq.(4c) postulates that the crowding effects exist in short and long run. The bounds cointegration test clearly rejects at 5% the null hypothesis of no cointegration for the private investment equation (Table 5A). This result implies long-run cointegration relationship amongst the variables when the regression is normalized on private investment. For *gdp* equation, the test is inconclusive because the F-value falls within the bounds.

The bound cointegration test needs to be checked by usual diagnostic tests.[7] The results show that the models haven't serial correlation and heteroskedasticity except for *rir* model

[6] In EG's test: one-sided (lower-tail) test of the null hypothesis that the variables are not cointegrated; at the 1%, 5% and 10% asymptotic critical values equal -4.02, -3.40 and -3.09, respectively (Rapach & Weber 2004). In the PR's test: one-sided (lower-tail) test of the null hypothesis that the variables are not cointegrated; at the 1%, 5% and 10% asymptotic critical values equal -3.33, -2.76 and -2.47, respectively (Perron & Rodriguez 2001).

[7] The diagnostic tests for ARDL model concern Lagrange Multiplier (LM) for the null hypothesis H_0 of no residual serial correlation, White Heteroscedasticity (WH) for H_0 of no residual heteroskedasticity, Jarque-Bera (JB) for H_0 of residual normality and Ramsey's RESET for H_0 of no stable specification or no Functional Form (FF) misspecification. In LM test, the lag length is 2 according to AIC for all variables except for *ipu* (lag=3).

(Table 5B). The ARDL model is robust against specification form except for *rir* model. All models accept the null hypothesis of a normality distribution except the main model *ipr* which has light leptokurtic distribution (Kurtosis=4.3). This can be attributed to a relative jump component in the error term, which reflects news, events or information released by policy government or private firms' strategies.

Table 5B Diagnostic for Bounds cointegration tests (Eq.4c)

	ipr	*ipu*	*ibg*	*gdp*	*cre*	*rir*
LM	1.453	2.005	0.382	0.954	0.658	3.803
P-value	(0.26)	(0.15)	(0.69)	(0.40)	(0.53)	(0.04)
WH	0.400	2.166	0.606	1.256	1.896	3.890
P-value	(0.97)	(0.10)	(0.85)	(0.37)	(0.13)	(0.02)
JB	10.441	1.435	2.907	1.131	4.215	0.158
P-value	(0.01)	(0.49)	(0.23)	(0.57)	(0.12)	(0.92)
FF_2	2.003	1.078	1.290	0.859	1.166	9.586
P-value	(0.16)	(0.36)	(0.30)	(0.44)	(0.33)	(0.001)

The existence of a long-run cointegration relationship allows to estimate Eq.(5) using the ARDL(1,0,0,1,2,1) specification. Due to the difference in integration orders, the long-run ARDL relation exhibits complicated dynamics between the private investment and their main determinants.[8] To derive the long-run coefficients (Table 6), Eq.(5) is then re-parameterized by normalization on *ipr*.

Table 6 ARDL long-run estimation of *ipr* (Eq.5)

	1	*ipu*	*ibg*	*gdp*	*cre*	*rir*
Coefficient	-17.385	-0.913	0.421	2.773	-0.241	-1.999
Std. Error	1.83	0.09	0.06	0.23	0.06	0.30
Prob.	0.0004	0.0005	0.01	0.0000	0.13	0.009

The finding indicate that public investment affects negatively and significantly the private investment with a crowding-out coefficient -0.913, whereas the infrastructure government investment improves its investment efforts with a crowding-in coefficient 0.421. Thus, the net result indicates that a net crowding effect is estimated close to -0.492, and shows that total

[8] This estimated conditional ECM equation has one of complex roots with modulus 0.4091; the complex root is $0.3004 \pm 0.2777\,i$ where $i = \sqrt{-1}$, which suggests the presence of cyclical real private investment process that quickly converges towards the equilibrium target i.e. Eq.5.

public investment crowds out private investment. The crowding out effect is then moderated because the government spending expands, through the multiplier-accelerator mechanism, the private sector activities, and hence stimulates the private investment. Also the private investment is affected significantly and positively by the real GDP as it is predicted, but the normalization leads to an unusual high coefficient.

The crowding out effect is verified in Saudi Arabia economy, but it does not signify the unavailability of capital. The Saudi financial sector does not suffer from shortage of funds, but in the long run there is some mismatching between fund needs of private enterprises and loanable funds of banks. The no fixed maturity and no fixed financing cost could reduce these mismatch problems. Also, this dilemma in crowding out effect could be explained by the fact that local international banks encourage abroad investments and securities in international markets. The international market affects domestic banking markets by attracting the Saudi liquidity and reduces the loanable funds available for local investors (Claessens et *al*. 2001).

However, the credits to private sector have an insignificant negative coefficient at 5% level in short and long run. In such case the private enterprises could be in vicious loan-credit cycle named a financial accelerator, and the credit flows do not exhibit a positive role in private investment process (Bernanke et *al*. 1999). The real interest rate still is a strong constraint to the private investments in short and long run. Two arguments could explain this result, inversely to public sector the private sector prefers largely external to internal finance (Table 1C), and the policy rate reacts to the real loan-credit cycle by increasing nominal interest rate. These findings exhibit the absence of financial accelerator mechanism, but it remains that the increase of external finance premium reduces the private investment.

The results of Eq.6 indicate the absence of any instability of the coefficients.[9] Figure 2 exhibits that both the associated cumulative sum and the cumulative sum of squares of recursive residuals plots lie within the 5% critical bounds. The significant coefficient of error correction term indicates that the disequilibrium is widely corrected and converges back to the

[9] The regression of Eq.6 fits reasonably well and passes the diagnostic tests against misspecification, heteroskedasticity, serial correlation and non normal errors. These tests could have lower power mainly against important breaks. Overall, the conditional ECM of private investment growth equation has a number of desirable features. The shift in the trend occurring at 1974 accounts a structural break due to unexpected growth of oil revenues.

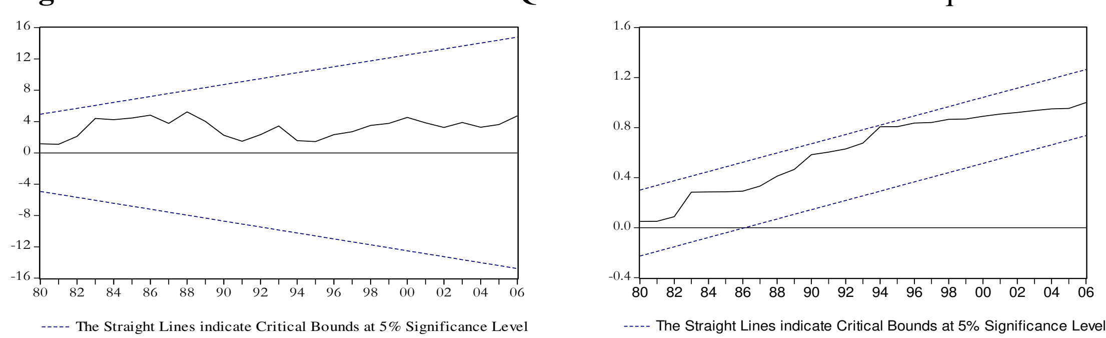
equilibrium in one year and four months with a high adjustment speed at 75% a year. The deviations from the equilibrium would be corrected either by private investment or public investment processes. The short-run auto-adjustment of investment attains only nearly a quarter; this inertia factor shows slow evolution in private investment. The estimated net crowding-out effect in short-run is 0.209 i.e. -0.347+0.138; thus as in the long-run, total public investment crowds out private investment. The dynamics between short and long-run crowding-out effects are related to government policies and private investment strategies, and would reduce the long-run crowding-out. But the results show that long-run crowding-out exceeds short-run crowding-out, because the public sector dominates the economic activities and attracts more capital resources.

Table 7 ARDL(1,0,0,1,2,1) Error Correction Model of *ipr* (Eq.6)

	1	*dipr*(-1)	*dipu*	*dibg*	*dgdp*(-1)	*dcre*(-2)	*drir*(-1)	*d74*	*ect*(-1)
Coefficient	0.029	0.247	-0.347	0.138	1.187	-0.232	-1.029	0.743	-0.744
Std. Error	0.02	0.11	0.09	0.07	0.39	0.13	0.42	0.12	0.23
Prob.	0.26	0.04	0.0007	0.05	0.005	0.07	0.02	0.000	*0.003* [10]

Notes: Adjusted R^2 = 0.793 Standard Error of Regression=0.103 Log Likelihood=35.76
$F(\mathrm{SC}_1)$=0.667 [0.42] $F(\mathrm{WH})$=1.097 [0.41] $\chi^2_N(2) = 0.960$ [0.62] $F(\mathrm{FF}_2)$=0.723 [0.49]
$F(\mathrm{SC}_1)$, $F(\mathrm{WH})$ and $F(\mathrm{FF}_2)$ denote Fisher Statistics to test for no residual serial correlation, no residual heteroskedasticity and no functional form misspecification respectively, and $\chi^2_N(2)$ denotes Chi-Square Statistic for residual normality; all with p-values given in [.].

Figure 2 Plot of CUSUM & CUSUMSQ of Recursive Residuals from Eq.6



[10] The equilibrium correction coefficient is large and significant, but the t-ratio reported does not have the standard t-distribution (Pesaran et *al*. 2001, theorem 3.2). This problem is related to the nullity of π_{yy} and $\pi_{yx,x}$ in the VAR framework i.e. if these nullities are rejected, then it would be possible that the error correction term (ect) follows asymptotically the t-student distribution.

6. Conclusions

This paper founds some evidence that private investment, public investment, GDP, credits to private sector and real interest rate are bound together in the long-run. The finding shows that public enterprises investment crowds out private investment in short and long-run. This crowding out effect does not signify the unavailability of capital, because the Saudi financial sector does not suffer from shortage of funds. But there is some mismatching between fund needs of private enterprises and loanable funds of banks. The private enterprises could be in vicious loan-credit cycle indicating the absence of financial accelerator mechanism. The results show that long-run crowding-out exceeds short-run crowding-out, because the public sector dominates the economic activities and attracts more capital resources. The disequilibrium due to a shock is widely corrected and converges back with a high speed of adjustment to the equilibrium. The main policy recommendations are that the infrastructure government investment would be a useful channel to boost private sector in Saudi Arabia. The real interest rate, discouraging private investment efforts in short and long term, would be at lower level by reducing nominal interest and inflation rates. Also, given negative effects of internal or external shocks, the private sector should be assisted to sustain its contribution to the economic growth. The government measures should break down the vicious loan-credit cycle and expand the joint private local and foreign investment projects.

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