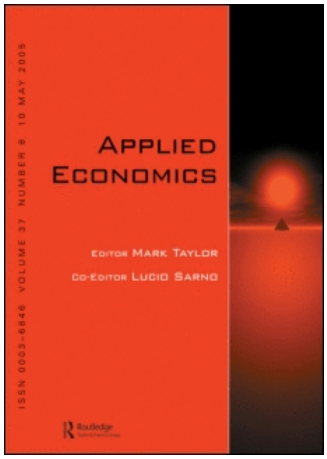

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Causality between financial development and economic growth: an application of vector error correction and variance decomposition methods to Saudi Arabia

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Causality between financial development and economic growth: an application of vector error correction and variance decomposition methods to Saudi Arabia

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This article makes an attempt to test the possible directions of causality between financial development and economic growth, which were labelled by Patrick (1966) as the supply-leading and demand-following hypothesis. Saudi Arabia is taken as a case study. The methods applied are the error correction and variance decompositions techniques including the most recently developed 'long-run structural modelling (LRSM)' (Pesaran and Shin, 2002), which by imposing exactly identifying and overidentifying restrictions on the cointegrating vector has taken care of a major limitation of the conventional cointegrating estimates in that they were *atheoretical* in nature. To the best of our knowledge, there has not been any study on this issue with the application of the techniques that incorporate 'LRSM'. The stability of the functions has also been tested by Cumulative Sum (CUSUM), Cumulative Sum of Squares (CUSUMSQ) and Chow Test (CHOW) tests. Our findings, based on the above mentioned rigorous techniques, tend to suggest that the direction of causation between financial development and economic growth is supply-leading (rather than demand–following), as expected at the early stage of development. These findings have clear policy implications in that a pro-active policy of growth and reform of the financial sector will help enhance economic growth in an open developing economy like Saudi Arabia.

I. Introduction: The Issue Motivating This Article

For many decades since the seminal contributions of Schumpeter (1911), and more recently of Goldsmith (1969), McKinnon (1973) and Shaw (1973), the correlation between financial development and economic growth has been more or less recognized. But the direction of causality between them is not yet resolved. Does financial development promote economic growth or does economic growth promote financial development? These possible directions of

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causality are termed by Patrick (1966) as the supply-leading and demand-following hypothesis. The *supply-leading hypothesis* conjectures a causal relationship from financial development to economic growth. It implies a pro-active creation of financial institutions and markets will advance real growth by increasing the supply of financial services (i.e. the financial sector will lead to economic growth). On the other hand, the *demand-following hypothesis* conjectures a causal relationship from economic growth to financial development. It implies an increase in economic growth will enhance the demand for financial services leading to an expansion in the financial sector (i.e. the financial sector will respond to economic growth). Shan (2005) gives a good survey of the cross-sectional and time-series empirical studies on the lead-lag controversy between financial development and economic growth. However, the issue on the critical question of the direction of causality still remains unresolved.

Section II reviews the empirical studies for and against those two competing hypotheses leading to the major objective of the study in Section III. It is followed by the theoretical underpinnings and the very recent methodology used in Sections IV and V, respectively. Data, empirical results and discussions are dealt within Section VI. Finally, this article ends with the major conclusions and the policy implications of the study in Section VII.

II. Literature Review

There are many empirical studies that tried to resolve the causality issue between the supply-leading and demand-following hypotheses. Papers, such as McKinnon (1973), King and Levine (1993a, b), Neusser and Kugler (1998), Darrat (1999), Levine Loayza and Beck (2000), Fase and Abma (2003), Christtopoulos and Tsionas (2004), Chang and Caudill (2005), Rousseau and Vuthipadadorn (2005), among others, support the supply-leading hypothesis. However, papers such as, Gurley and Shaw (1967), Jung (1986), Lucas (1988), Chandavarkar (1992), Liang and Teng (2006), among others, support the demand-following hypothesis. These conflicting findings tend to indicate that the issue between the supply-leading and demand-following hypotheses remains unresolved.

Since the above mentioned causality issue relating to a particular country could not be resolved from the findings of the cross-sectional studies, single-country time-series studies were conducted to resolve the issue. However, most of these single-country time-series studies find either unidirectional causality from financial development to economic growth (Bell and Rousseau, 2001; Fase and Abma, 2003; Christtopoulos and Tsionas, 2004) or unidirectional causality from economic growth to financial development (Liang and Teng, 2006) or bidirectional causality (Demetriades and Hussein, 1996; Luintel and Khan, 1999; Calderon and Liu, 2003).

Hence even the time-series country studies could not resolve the issue. One of the major reasons for the differences of statistical results in the existing studies, apart from the institutional and structural differences among countries, was the limitation of the methodology used in those studies. We would make an attempt to improve on the existing time-series methodology employed so far in resolving this causality issue.

III. The Objective of the Study

Given the crucial importance of the direction of causality between financial development and economic growth in formulating development plans, we want to address this issue through the application of the recently developed time-series techniques of vector error correction and variance decompositions including the most recent 'long-run structural modelling (LRSM)' (Pesaran and Shin, 2002). Saudi Arabia is taken as a case study. This study will depart from earlier works and also advance the field in the following ways: (i) as far as our knowledge goes, this study will be the first attempt to investigate the issue of causal direction between financial development and economic growth in the context of this region, in particular Saudi Arabia; (ii) we believe that the application of the recently developed time-series techniques, such as, the vector error correction and generalized variance decompositions (including the 'LRSM', which is an improvement on and an extension to the standard cointegrating techniques) on this issue will also be the first attempt in this region and (iii) the findings of the study on the direction of causality will have distinct policy implications for Saudi Arabia for her development plans.

IV. Theoretical Underpinnings

Although the focus of this article is on the lead-lag relationship between financial development and economic growth, these two variables interact through some other 'control' variables. The theoretical literature is not very clear about the transmission channel between 'finance' and 'growth' but it is generally postulated that 'finance' affects 'growth'

through two channels: investment and/or productivity. We try to proxy the investment channel by the real per capita fixed capital formation and the productivity channel by the real interest rate whose positive coefficient might capture indirectly the productivity effects on growth (Luintel and Khan, 1999; Kliesen and Schmid, 2006; Liang and Teng, 2006) and finally, for an open economy highly dependent on exports, foreign trade is likely to be an important channel through which the financial development affects economic growth. So we bring in another conditioning variable represented by the proportion of exports in the GDP.

As regards the variables used, there are many definitions of financial development such as the ratio of M2 or M3 to nominal GDP, the ratio of broad money to base money, bank deposits to nominal GDP and private sector credit to nominal GDP. The use of money stock over GDP as a proxy for the financial development has been questioned because they proxy more the extent of monetization rather than that of financial intermediation, especially for the developing countries and also, they cannot capture the actual volume of funds given to the productive sector (Demetriades and Hussein, 1996 and Luintel and Khan, 1999, among others). In order to ensure that the size of the financial intermediaries is linked with the provision and quality of financial services, the financial development is proxied by bank deposits/GDP and/or bank credit to the private sector/GDP. Finally, economic growth is usually represented by the real GDP per capita.

Based on the above mentioned theoretical underpinnings, the lead-lag relationship between economic growth and financial development has been tested on the following variables: an economic growth variable (such as, real GDP per capita), a financial development variable (such as, bank deposit/nominal GDP or bank credit to the private sector/nominal GDP) and some 'control' variables (such as, exports/real GDP for an open economy), real deposit interest rate (standing as a proxy for investment and/or productivity channels). The economic growth variable and the financial variables are expected to be positively related. The causality will be tested mainly through the error correction model. Since there are four variables GDPPCAP, DEPGDP, EXPGDP and REALINT, there will be four equations with each variable in turn being a dependent variable. The first equation e.g. will be:

$$\Delta y_t = \alpha_1 + \alpha_y \hat{e}_{t-1} + \sum_{i=1} \alpha_{11}(i)\Delta y_{t-i} + \sum_{i=1} \alpha_{12}(i)\Delta z_{t-i} + \upsilon_{yt} \quad (1)$$

where in Equation 1 $\Delta z_{t-\mathrm{i}}$ represents the remaining three variables if Δy_t happens to be ΔGDPPCAP.

V. The Methodology Used

Either cross-sectional or time-series approaches have been adopted to test the hypothesis whether financial development leads (or lags) economic growth. The cross-sectional approach has a major shortcoming in testing lead-lag relationships because they are not appropriate in capturing the dynamics of the variables involved. Moreover, the implicit assumption of the cross-sectional studies is that the parameters across units/countries remain constant. This assumption is not realistic in the context of developing countries with different institutions, structures and stages of development. The time-series studies of individual countries are more appropriate for testing the temporal or lead-lag relationship between variables. The recent time-series studies based on cointegration have applied either vector error correction and/or variance decomposition methods for testing Granger causality or lead-lag relationship. Although these time-series techniques are an improvement on cross-sectional studies in testing Granger causality, one of the major limitations of error correction/variance decompositions methods is that they are based on the estimates of the cointegrating vectors, which are atheoretical in nature. The most recently developed ''LRSM' technique takes care of that major limitation of the conventional cointegrating estimates.

LRSM endeavours to estimate theoretically meaningful long-run (or cointegrating) relations by imposing on those long-run relations (and then testing) both identifying and overidentifying restrictions based on theories and *a priori* information of the economies. For testing each restriction, the results are presented in tables and one should check the LR statistic in each case whether the null of restriction/s should be rejected or accepted.

Hence, to test the lead-lag relationship we would apply the following procedures:

After examining the unit-root tests and the order of the VAR, the Johansen cointegration tests will be applied. The cointegrating estimated vectors will then be subjected to exactly identifying and overidentifying restrictions based on theoretical and *a priori* information of the economy. The test of cointegration is designed to examine the long-run theoretical or equilibrium relationship and to rule out spurious relationship among the variables. But the evidence of cointegration cannot tell us which variable is leading

and which variable is lagging. That can be done by the test of vector error correction model (VECM) that can indicate the direction of Granger causality both in the short and long run. The VECM, however, cannot tell us which variable is relatively more exogenous or endogenous. The variance decomposition technique is designed to indicate the relative exogeneity/endogeneity of a variable by decomposing (or partitioning) the variance of the forecast error of a variable into proportions attributable to shocks (or innovations) in each variable in the system including its own. The proportion of the variance explained by its own past shocks can determine the relative exogeneity/endogeneity of a variable. The variable that is explained mostly by its own shocks (and not by others) is deemed to be the most exogenous of all. The impulse response function (IRF) will then be applied. It is designed to map out the dynamic response path of a variable due to a one-period SD shock to another variable. The IRF is a graphical way of exposing the relative exogeneity or endogeneity of a variable. Finally, the persistence profiles will be applied. They are designed to estimate the speed with which the variables get back to equilibrium when there is a system-wide shock (unlike the IRF which traces out the effects of a variable-specific shock on the long-run relationship).

VI. Data, Empirical Results and Discussions

As discussed earlier, we use the following variables for our lead-lag analysis. The variables taken were real GDP per capita (GDPPCAP), bank deposits/nominal GDP (DEPGDP), exports/GDP (EXPGDP) and bank deposit rate/CPI as the real interest rate (REALINT). All the variables (except the interest rates) are transformed into logarithms to achieve stationarity in variance. All the 'level' forms of the variables were transformed into the logarithm scale but that was not necessary for the interest rate variable, which was originally in percentage form. The source of all these variables is the Saudi Arabian Monetary Agency (SAMA). Consistent data for all the variables were not available for more than 20 years. The readers should bear in mind the limitations of the relatively small size of the sample while interpreting the results.

We tested the unit roots of all the variables and found that they could be taken as I(1) on the basis of ADF and PP tests. We also found that the optimal order of the VAR could be taken as two on the basis of AIC and SBC criteria. We applied the standard Johansen cointegration test (Table 1) and found them to have one cointegrating vector at 90% significance level on the basis of maximal Eigen value and trace statistics. An evidence of cointegration implies that the relationship among the variables is not spurious, i.e. there is a theoretical relationship among the variables and that they are in equilibrium in the long run. However, in order to make the coefficients of the cointegrating vector consistent with the theoretical and *a priori* information of the economy, we applied 'LRSM' procedure. Since the main focus of this article was to identify the direction of causality between the real GDP per capita (GDPPCAP) and the financial development variable (DEPGDP), we first imposed a normalizing restriction of unity on the GDP variable at the 'exactly identifying' stage (Panel A of Table 2) and then experimented with a

Table 1. Johansen ML results for multiple cointegrating vectors – real GDP per capita, bank Deposits/nominal GDP, exports/real GDP and real deposit interest rate, (1985–2004)

H_0	H_1	Statistic	95% Crit.	90% Crit.
Maximum eigen value statistics				
$r=0$	$r\geq 1$	30.73	31.79	29.13
$r\leq 1$	$r\geq 2$	21.41	25.42	23.10
Trace Statistic				
$r=0$	$r\geq 1$	66.33	63.00	59.16
$r\leq 1$	$r\geq 2$	35.60	42.34	39.34

Notes: The statistics refer to Johansen's log-likelihood maximal eigen value and trace test statistics based on cointegration with unrestricted intercepts and restricted trends in the VAR. From the above results, we select one cointegrating vector based on the eigen value and trace statistics at 90% level. The underlying VAR model is of order 2 and is computed using 20 annual observations.

Table 2. Exact and over identifying restrictions on the cointegrating vector

	Panel A		Panel B	
GDPPCAP	1.00	(*None*)	1.000	(*None*)
DEPGDP	0.256*	(0.066)	1.000	(*None*)
EXPGDP	0.315*	(0.048)	0.648*	(0.189)
REALINT	0.054*	(0.014)	−0.017	(0.075)
Trend	0.000	(0.000)	−0.006	(0.002)
Log-Likelihood	170.367		165.713	
Chi-Square	None		9.307	[0.002]

Notes: The output above shows the maximum likelihood estimates subject to exactly identifying (Panel A) and over-identifying (Panel B) restrictions. The 'Panel A' estimates show that all the variables are significant (SE are in parenthesis). All the coefficients have the correct signs. However, the overidentifying restriction on real GDP = 1 is rejected (with a *p*-value of only 0.002 error while rejecting the null) and as a result we proceed with 'Panel A' for the remainder of the article.
*Indicates significance at 1% level.

restriction of unity on the financial development variable at the 'overidentifying' stage (Panel B of Table 2). When we imposed a normalizing restriction of unity on the coefficient of GDP (Table 2, Panel A) we found all the coefficients of the cointegrating vector as highly significant. However, when we imposed an overidentifying restriction of unity on the coefficient of bank deposit, it was rejected by the Chi-squared statistic (Table 2, Panel B). As a result, we proceeded with Panel A (rather than Panel B).

Cointegration, however, cannot tell us the direction of Granger causality as to which variable is leading and which variable is lagging (i.e. which variable is exogenous and which variable is endogenous). For discerning the endogeneity/exogeneity of the variables, we applied the vector error correction modelling technique (Table 3).

Looking at the significance or otherwise of the error correction coefficients, we find that the GDP variable is endogenous but the bank deposit variable is exogenous. That tends to indicate that the GDP variable responds to the bank deposit variable. The error correction term in the GDP equation is significant. It implies that the deviation of the variables (represented by the error correction term) has a significant feedback effect on the GDP variable that bears the burden of short-run adjustment to bring about the long-term equilibrium. The error correction model also helps us distinguish between the short-term and long-term Granger causality. The error correction term stands for the long-term relations among the variables. The impact of each variable in the short term is given by the 'F'-test of the joint significance or insignificance of the lags of each of the 'differenced' variables.

The diagnostics of all the equations of the error correction model (testing for the presence of autocorrelation, functional form, normality and heteroskedasticity) tend to indicate that the equations are well-specified. We also checked the stability of the coefficients by the CUSUM and CUSUM SQUARE tests (Fig. 1), which indicate that they are stable. In addition, we conducted the CHOW test of stability of the regression coefficients. The 'p' value of the observed 'F' is 0.374. This further confirms that the null hypothesis of stability of coefficients cannot be rejected.

Although the error correction model tends to indicate the endogeneity/exogeneity of a variable, we had to apply the generalized variance decomposition technique (Table 4) to discern the relative degree of endogeneity or exogeneity of the variables. The relative exogeneity or endogeneity of a variable can be determined by the proportion of the variance explained by its own past. The variable that is explained mostly by its own shocks (and not by others) is deemed to be the most exogenous of all. In our table, at the end of the forecast horizon number five, the contributions of own shocks towards explaining the forecast error variance of each variable are as follows: real GDP variable (41%), bank deposit variable (66%) and export variable (41%) and real interest rate (53%).

The variable that is explained mostly by its own shocks and depends relatively less on other variables is the leading variable. These results tend to indicate that the bank deposit variable is the most exogenous of all and also, it explains 35% of the variance of GDP variable, whereas the GDP variable explains only 11% of the variance of the bank deposit variable. These out-of-sample variance forecast results given by the generalized variance decompositions further strengthen our earlier within-sample results given by the error correction model that the

Table 3. Error correction models – real GDP per capita, bank deposits/nominal GDP, exports/real GDP and real deposit interest rate

Dependent Variables	DGDPPCAP	DDEPGDP	DEXPGDP	DREALINT
DGDPPCAP(−1)	0.362 (0.280)	−2.263 (1.192)	1.094 (1.709)	1.710 (2.713)
DDEPGDP(−1)	−0.177 (0.091)	−0.273 (0.388)	0.796 (0.557)	−0.380 (0.884)
DEXPGDP(−1)	0.073 (0.069)	−0.333 (0.297)	0.652 (0.426)	−0.222 (0.676)
DREALINT(−1)	−0.085 (0.030)	0.0133 (0.127)	0.086 (0.182)	0.078 (0.289)
ECM(−1)	−1.149* (0.366)	2.756 (1.559)	−3.331* (−1.490)	−4.854 (3.549)
Chi-square SC(1)	0.184 [0.66]	0.661 [0.41]	0.232 [0.63]	0.496 [0.48]
Chi-square FF(1)	1.903 [0.16]	0.290 [0.59]	0.135 [0.71]	0.507 [0.47]
Chi-square N (2)	0.429 [0.80]	17.491 [0.00]	0.409 [0.81]	1.498 [0.47]
Chi-square Het(1)	0.072 [0.78]	0.037 [0.84]	0.660 [0.41]	0.104 [0.74]

Notes: SEs are given in parenthesis. The diagnostics are chi-squared statistics for: serial correlation (SC), functional form (FF), normality (N) and heteroskedasticity (Het). The equations, therefore, are well specified.
*Indicates significance at the 1% level.

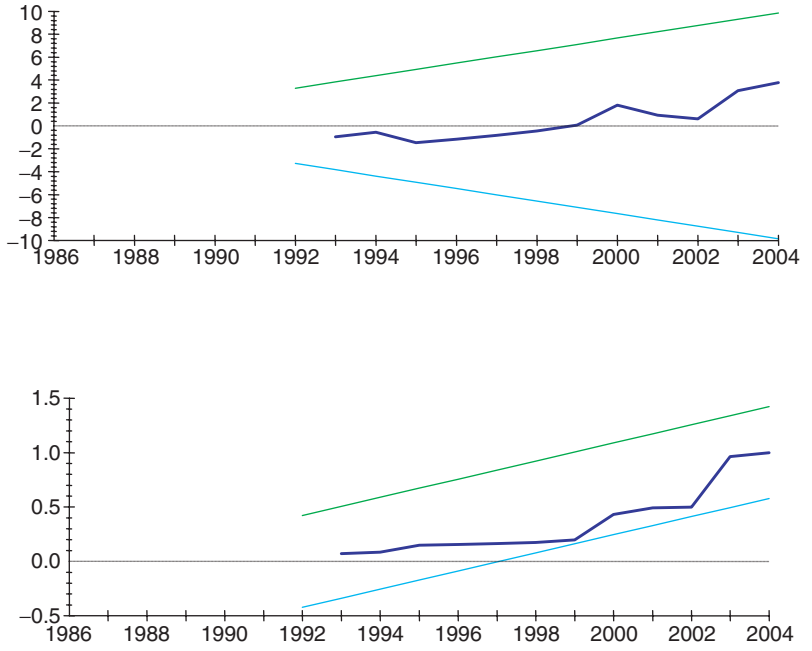

Fig. 1. GDPPCAP. (a) Plot of cumulative sum of recursive Residuals and (b) plot of cumulation sum of squares of recursive residuals

Note: The staright lines represent cirtical bounds at 5% significance level.

Table 4. Percentage of forecast variance explained by innovations in: Generalized variance decompositions

Years	ΔGDPPCAP	ΔDEPGDP	ΔEXPGDP	ΔREALINT
Relative variance in ΔGDPPCAP				
1	35.63	34.51	14.52	15.34
3	42.07	34.53	10.50	12.89
5	**41.89**	34.93	10.02	13.15
Relative variance in ΔDEPGDP				
1	7.01	57.16	27.10	8.73
3	9.13	63.86	20.98	6.03
5	11.39	**65.39**	18.28	4.95
Relative variance in ΔEXPGDP				
1	2.55	22.72	45.67	29.07
3	13.04	20.00	41.42	25.54
5	17.31	17.82	**41.16**	23.70
Relative variance in ΔREALINT				
1	2.29	8.51	36.70	52.49
3	1.09	7.99	39.22	51.70
5	0.75	6.67	39.90	**52.69**

'financial development' leads (rather than lags) 'economic growth'.

We then applied the generalized IRFs (Figs 2 and 3) and found that, consistent with the earlier results, the GDP variable is more sensitive to a 1% SD shock to the bank deposit variable (compared to the reverse).

Finally, an application of the persistence profile analysis (Fig. 4) indicates that if the whole cointegrating relationship is shocked, it will take about 3 years for the equilibrium to be restored.

VII. Conclusions and Policy Implications

The focus of this article was an attempt to test the possible directions of causality between financial

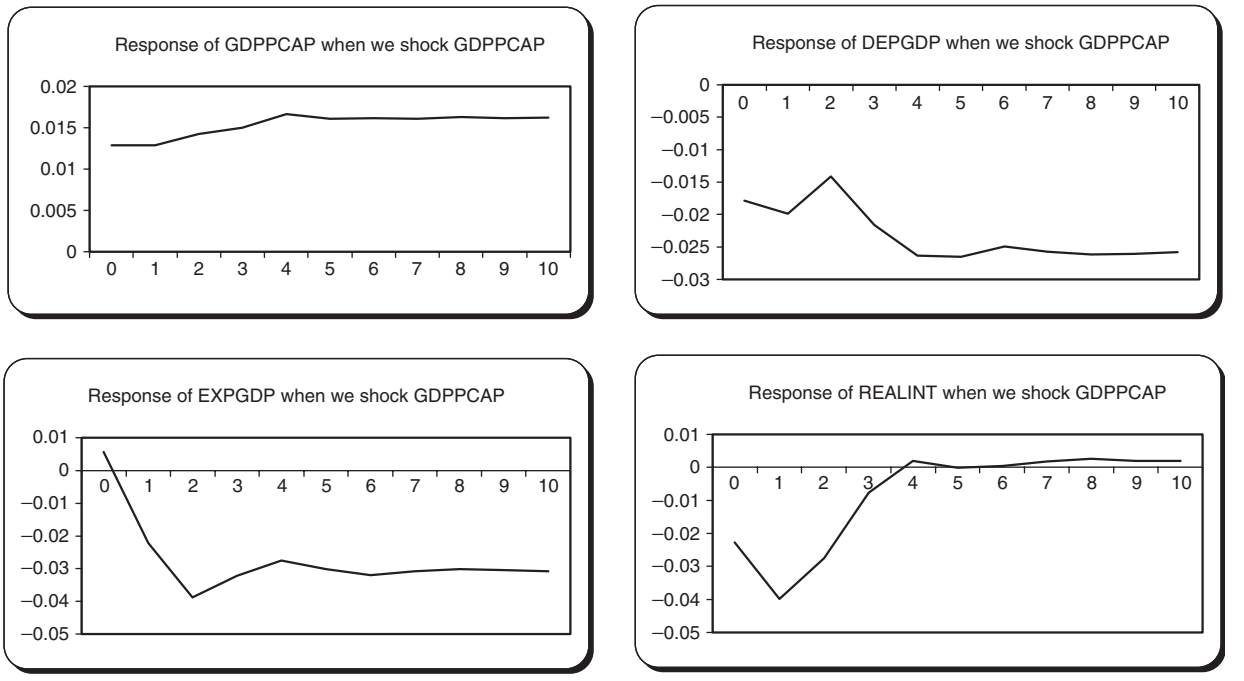

Fig. 2. Generalized impulse responses to one SE shock in the equation for GDPPCAP

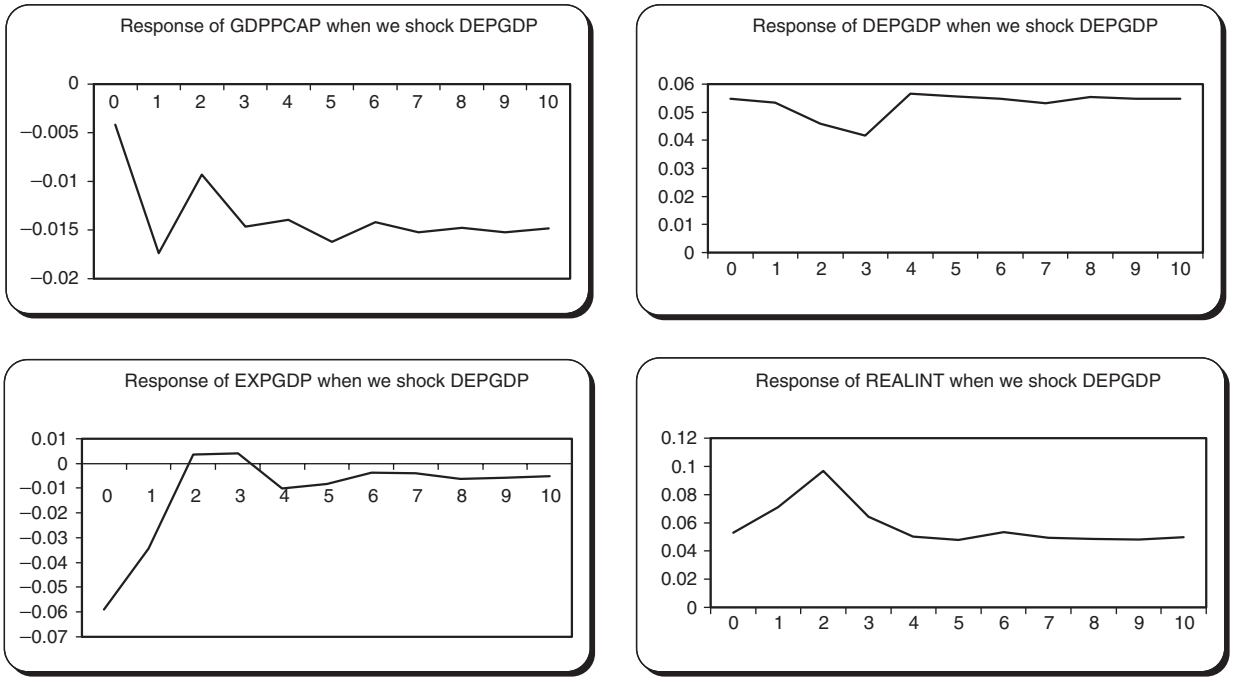

Fig. 3. Generalized impulse responses to one SE shock in the equation for DEPGDP

development and economic growth that were labelled by Patrick (1966) as the supply-leading and demand-following hypothesis. Since the financial sector affects the real GDP through either the investment channel and/or productivity channel, in order to test the above mentioned hypothesis we had to bring in some 'control' variables such as, gross-fixed capital per capita, real interest rate to test the transmission between them and finally, we included exports/GDP for an export-dependent economy. We applied the

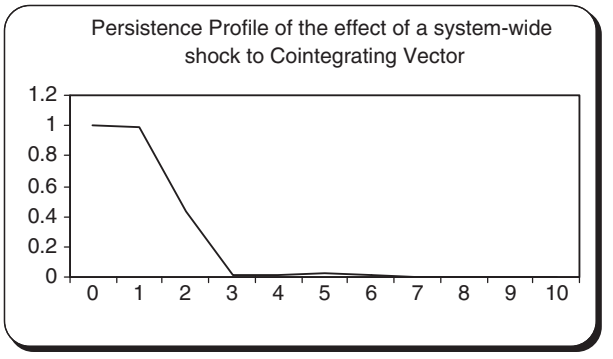

Fig. 4. Persistence profile of the effect of a system-wide shock

Notes: The above graph shows the persistence profile from a system wide shock. We see some sideways persistence during the first two years but then the system comes back to equilibrium after just over 3 years

recently developed time-series techniques, such as the VECM, generalized variance decompositions (including the 'LRSM', Pesaran and Shin, 2002), which is an improvement on and an extension to the standard cointegrating techniques. Both the error correction model and the generalized variance decompositions based on 'LRSM' unequivocally tend to suggest that it is 'financial development' that leads (rather than lags) 'economic growth'. In other words, the evidence tends to suggest that the direction of causation between financial development and economic growth is supply-leading (rather than demand-following), as expected at the early stage of development.

Our findings are in line with the pioneering work of Patrick (1966) who concluded that a supply-leading condition is likely to prevail at the early stage of economic development, while a demand-following condition is likely to prevail at the later stage of economic development. The major policy implication of the findings, based on our rigorous econometric analysis, is that a pro-active policy of growth and reform of the financial sector will help enhance economic growth in an open developing economy like Saudi Arabia. Recently, Saudi Arabia enacted a new foreign investment law and relaxed the restrictions imposed on foreigners with a view to attracting foreign investment and promoting privatization to enhance growth. The simultaneous development of the financial institutions, however, is essential to cope with the enormous growth of foreign investment particularly in the energy sector. Our statistical results tend to indicate that the potential rate of growth of output can be significantly enhanced by pursuing an active policy of sound financial sector development in developing countries like Saudi Arabia.

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