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Foreign Aid, Investment, and Economic Growth in Kenya: A Time Series Approach

by

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Abstract

Most of the literature on determinants of economic growth in developing countries is based on cross-country analysis and thus only yields some patterns that hold on average. The aim of this paper is to identify aspects of the determinants of growth in Kenya, in particular if aid played a role. The empirical specifications used in cross-country work do not translate easily into country studies: many of the variables are not available annually or tend to change very slowly over time, and it is not feasible to include all potential determinants. Thus, we focus on one element of growth and use a multivariate approach on time series data for Kenya over the period 1964 – 2002 to investigate the growth effects of foreign aid, investment and a measure of international trade. Our econometric results reveal two long run relations representing the reduced form growth equation and the behavioural function of private investment. We find that shares of private and public investment, and imports in GDP have strong beneficial effects on per capita income in Kenya. However, aid in the form of net external loans is found to have a significant negative impact on long run growth. Private investment relates to government investment and imports negatively, but positively to foreign aid. The implication for policy is that in order for Kenya to foster and sustain growth, closer attention should be given to factors that promote private investment.

Outline

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1. INTRODUCTION

Understanding the growth process is central to development economics; while theory is useful to provide guidance for identifying, analysing and interpreting the determinants of growth, how the process has worked or failed in countries is ultimately an empirical issue. Most of the empirical literature is based on cross-country growth regressions, which are at least useful in identifying those factors that most consistently appear to be important determinants (and theory should help us understand how and why). However, cross-country studies only highlight what appears to be important in general or on average; analytical country studies are needed to understand the process, and which factors were most important, in individual countries (e.g. Rodrik, 2003a). This paper is in the latter tradition.

The value of cross-country studies is that they allow one to try and identify which factors help to explain cross-country variations in growth performance. There have been so many such studies that numerous factors have been identified as potentially important; the proliferation of potential growth determinants has reached a level where the number can exceed the number of countries in a cross-country sample (Durlauf, 2000, 2002; Sala-i-Martin *et al,* 2003). The situation is compounded by the fact that some variables which have been found significant in some studies have turned out to be insignificant in others (Levine and Renelt, 1992; Sala-i-Martin *et al*, 2003). Such problems can be addressed, typically by focusing on the importance of a particular variable or set of variables (e.g. aid, FDI, trade) and availing of the high correlation between many determinants, although the possibility of omitted variable bias is always present. For our purpose, the limitation of the cross-country approach is that it is not usually informative for a particular country: the assumption of parametric invariance across countries renders it difficult to interpret results for a single country and therefore difficult to derive country-specific policy implications (Harrison, 1996; Durlauf, 2002; Hoeffler, 2002). This is an important limitation since policies or factors that are appropriate in a particular country might be inappropriate in another country (Kenny and Williams, 2001).

It is against this backdrop that this paper employs a multivariate time series estimation approach to investigate some of the determinants of economic growth in a single, small open developing country. Specifically, we aim to investigate the effects of foreign aid, investment and trade on growth in Kenya since the 1960s. While a country-specific approach allows one to address issues, for the country, that are not addressed adequately in

cross-country studies and avoids some of the problems in cross-country approaches, it raises many new problems. First, the empirical specification appropriate for cross-country studies is not readily applicable to time series country analysis. Many of the factors that explain cross-country variations in growth may not be helpful to explain variations over time within a country, either because annual data are unavailable or because the variables tend to change very slowly over time (e.g. institutions and governance). Second, the econometric concerns in time series analysis are different, specifically whether or not variables are non-stationary and cointegrated. Third, and related, the length of time for which data are available is typically very short for the techniques being used. One implication is that the power and size of tests tends to be low, and another is that it is desirable to restrict the number of variables included to as few as can be justified.

Notwithstanding these difficulties, we adopt the technique of vector autoregressive (VAR) modelling to assess if investment, aid and trade (imports) have had significant effects on growth in Kenya over the past four decades. Conceptually, our focus is on the effect of investment on growth. Private and public investment are both included, as the latter may influence the former (positively or negatively). Aid is included as it is an important source of financing for public investment, and imports are included as the trade variable to capture the need for imported investment goods. While this obviously omits factors that are important for growth, and even some that may be important for investment and growth (e.g. monetary policy), provided the variables included in the system are cointegrated they do form a long-run equilibrium relationship so we can draw some inferences.

The remainder of the paper is organised as follows. Section 2 provides a brief overview of some relevant literature on growth in developing countries, focussing on the variables of interest here. Section 3 outlines the empirical model and discusses the data. The results for the long-run (cointegrating) relationships are discussed in Section 4, while Section 5 provides a discussion of results for the short-run model. Some policy implications are considered in Section 6.

2 DETERMINANTS OF GROWTH: SOME CONSIDERATIONS

The conventional neoclassical model is often praised for its simplicity and flexibility in identifying the core determinants of long term growth (Rodrik, 2003b). On the other hand, advocates of endogenous growth models praise them for incorporating policy and institutional factors and for endogenising technological progress. However, there is growing

concern that endogenous models have only helped to strengthen the predictive power of the neoclassical model: 'One of the lasting contributions of endogenous growth theory is that it stimulated empirical work that demonstrated the explanatory power of the neoclassical model' (Barro, 1996: 2). In particular, investment (or the capital stock) is a core variable.

Endogenous growth theories assign an important role to investment both in the short and long term; Levine and Renelt (1992) and Sala-i-Martin (1997) identify investment as a key determinant. High investment ratios do not necessarily lead to rapid economic growth; the quality of investment, its productivity, existence of appropriate policy, political, and social infrastructure are all determinants of the effectiveness of investment (Hall and Jones, 1999; Fafchamps, 2000; Artadi and Sala-i-Martin, 2003). Private investment is often seen as the engine that drives a country's economy, while public investment provides the necessary infrastructure. The two are related, as public investment may crowd in (if it provides the infrastructure to support the private sector) or crowd out (by increasing costs of borrowing or 'cherry-picking' the best investment opportunities) private investment. Public investment itself affects growth either directly, via its productivity, or indirectly via its effect on private investment. Public investment in human capital (health and education), law and order, research and development, and social and economic infrastructure leads to creation of positive externalities which in turn improve the productivity of private investment. Thus, one would expect a positive relationship between public investment and economic growth (Barro, 1991, 1996, 2003; Artadi and Sala-i-Martin, 2003).

Another factor closely related to investment is foreign aid. In theory, foreign aid could relax any or all of three constraints on investment (Bacha, 1990). The savings constraint arises if, as is likely in low-income countries, domestic savings are insufficient to meet (public) investment requirements; aid (foreign savings) relaxes the constraint. The foreign exchange constraint arises because investment requires imported capital goods and the 'free' foreign exchange available from export earnings may be insufficient; as aid is in the form of foreign exchange, it permits a higher level of (capital) imports. The fiscal constraint captures the possibility that government behaviour affects private savings and public investment can affect private investment; aid, by financing public investment and reducing the need to raise seignorage revenue to finance a deficit, can relax this constraint. Chenery and Strout (1966) also posit a knowledge gap in developing countries and foreign aid in the form of technical assistance can relax this constraint (and increase productivity). If foreign aid is used to relax these constraints it is expected to be positively correlated with investment and growth (Hjertholm *et al*, 2000). Gomanee *et al* (2005) show that aid has a

beneficial impact on growth in Sub-Saharan African countries through financing public investment, although the impact on growth is small because productivity is low. Of course, aid may not have these beneficial effects, or may have other adverse effects. Elbadawi (1999) argues that in Sub-Saharan Africa foreign aid causes exchange rate appreciation thereby dampening growth of exports and thus economic growth.

Foreign trade is another variable that influences private investment and ultimately economic growth. According to neoclassical thinking, openness to trade has many advantages such as efficiency gains that come with specialisation and competition from international trade; embodied technological transfer through imported inputs; scale economies arising from expanded markets, and diffusion of ideas through global interaction (Piazolo, 1995; Zhang and Zou, 1995; Harrison, 1996; Frankel and Romer, 1999). On the other hand, competition arising from openness to trade may discourage innovation by making investment in research and development less profitable (Harrison, 1996); under-developed domestic industries are exposed to competition from imports while exports are often exposed to very volatile world markets. Although the literature on trade and growth tends to focus on exports, there are two justifications for concentrating on imports – they represent imported technology, capital, and intermediate goods and to some extent are used directly for investment.

Other important determinants of growth (positively or negatively) include human capital, technological advancement, government consumption expenditure, taxes, population growth, inflation, measures of rule of law, governance and democracy. In a single country study, the time series approach cannot incorporate all these factors; some are not measured annually, some change very slow over time (and would thus be poor at explaining annual growth which can vary significantly) and there is simply a limit to the number of variables that can feasibly be included. Hence the focus of this paper on only a sub-set of factors; within the large literature on growth determinants, we focus on foreign aid, investment, and imports.

3. MODEL AND DATA

We start with a vector autoregressive (VAR) model of the form:

$$x_t = \Phi_1 x_{t-1} + \Phi_2 x_{t-2} + ... + \Phi_k x_{t-k} + \mu + \varepsilon_t \quad (1)$$

where x_t is an *n x 1* vector of variables under study, Φ_i, *i = 1,2, … k* is an *n x n* matrix of parameters, μ a vector of deterministic components and $\varepsilon_t \sim i.i.d\ (0, \Sigma)$. According to Granger's representation theorem, when there is cointegration, the VAR model given in (1) can be reformulated into a vector error correction model (VECM) that incorporates short- and long- run dynamics, and takes the following form (Sims, 1980).

$$\Delta x_t = \mu + \Gamma_i \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + ... + \Gamma_{k-1} \Delta x_{t-k-1} + \Pi x_{t-k} + \varepsilon_t \qquad (2)$$

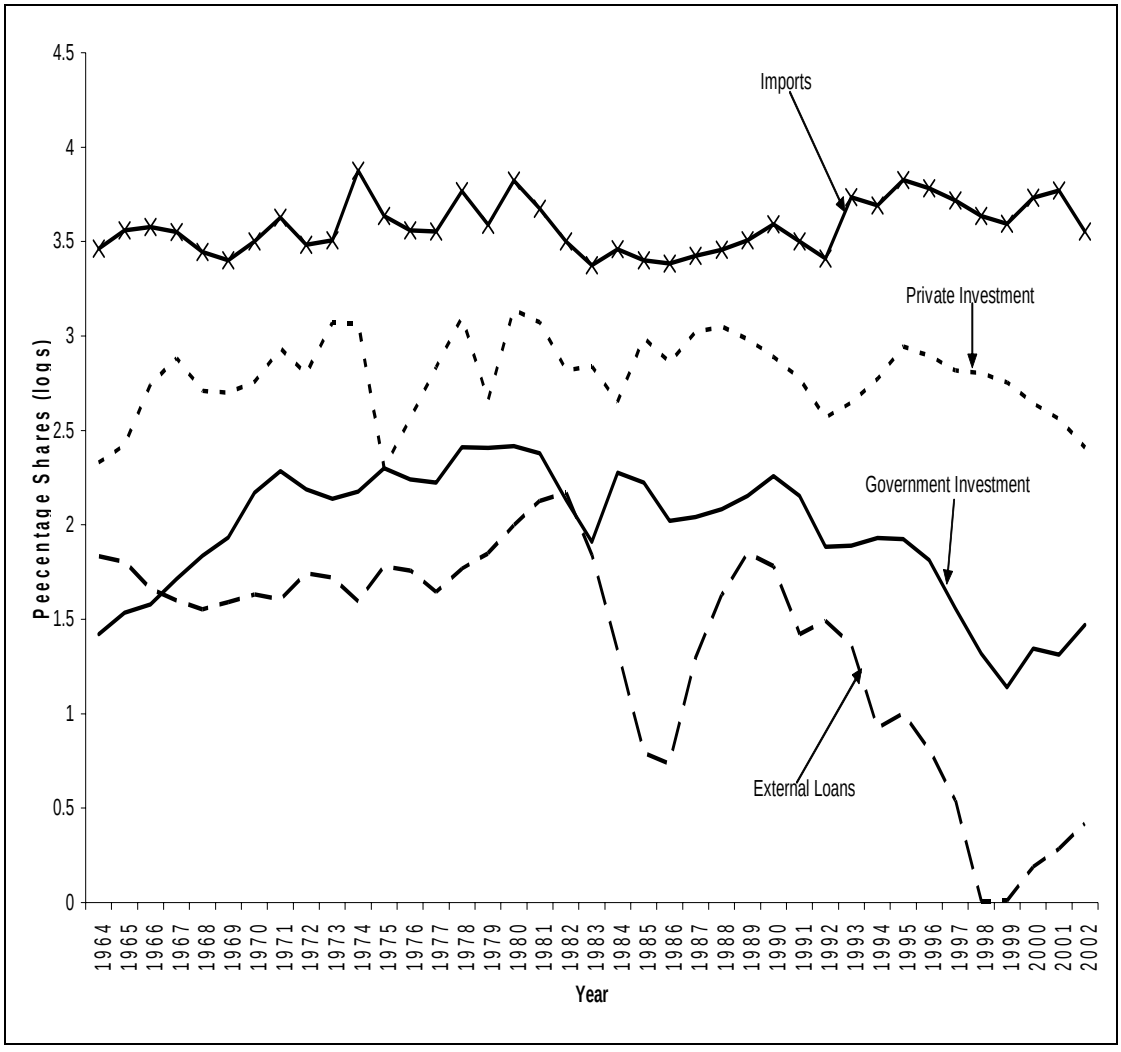
Where Δx_t is a vector of growth rates, $\Gamma_j = -\left[I - \sum_{i=1}^{j} \Phi_i \right]$ is an *n x n* matrix containing information on short run adjustments of changes in x_t, $\Pi = -\left[I - \sum_{i=1}^{k} \Phi_i \right]$ is an *n x n* impact matrix of parameters containing information on long run adjustments, μ is a vector of constants, ε_t is *n x 1* vector of white noise errors, and ***I*** is an identity matrix (Harris, 1995; Johansen and Juselius, 1992).

We use the above formulation to estimate a VAR model containing five variables (see Appendix A for definitions and sources): real per capita income (*Yp*), private investment (*PINV*), government investment (*GINV*), foreign aid (*LOAN*), and imports of goods and services (*IMPO*). In terms of estimating such a VAR, there is a possibility of two cointegrating vectors, an investment relationship and an output (growth) relationship. Gomanee *et al* (2005) argue that the effect of aid on growth is via its effect on investment, and that the two relationships should be separated in estimation.[1] Furthermore, data constraints prohibit including all potential variables in a single cointegrating vector (given the relatively short time series, a VAR including more than four variables is unlikely to yield robust estimates). This suggests two cointegrating vectors, so the Johansen-Juselius methodology is employed in identifying these vectors. In essence, one cointegrating vector captures the behavioral equation for investment, while the second represents the reduced form growth equation.

The variables mentioned above are expressed as shares in GDP before taking their logs. The source of data is *Economic Survey* (Republic of Kenya, various issues). To

account for the various external and internal shocks which have characterised Kenya's macroeconomy since 1970s, and if statistical evaluation allows, dummy variables will be employed. Imports are preferred as proxy for openness to trade because investment requires imported capital and Kenya's manufacturing sector depends heavily on imported machinery, equipment and other intermediate inputs. The crucial role of imports implies that any instability in their flows is likely to adversely affect (private) investment and growth. Trends of shares of imports, private and public investment are shown in **Figure 1** below.

Figure 1: Trends of ratios of Imports, private and public investment, 1964 – 2002



1 The models in Mosley *et al* (1987), Burnside and Dollar (200o) and Hansen and Tarp (2001) also support separating effects of aid on investment from effects of investment on growth, even if their estimation does

Figure 1 shows that imports and investment tend to be procyclical. However, *a priori* we cannot say which is causing which other than to note, for now, that there appears to be a co-movement between imports and private investment and less so with public investment. We conjecture that a dummy variable to correct an anomaly in one of them is likely to correct for the other. Also discernible from the above figure are pronounced swings in the trend of imports around 1973/4, 1983/84, and 1993/94. These periods coincide with the oil crisis and imposition of stringent controls of early 1970s, the advent of structural adjustment programmes in early 1980s, as well as trade and financial sector liberalisation of early and mid 1990s. When first differences of the series were plotted, only imports suggest a possible outlier problem (see Appendix Figure A1). Appropriate dummies will be used to account for potential bias in parameter estimates.

4 LONG-RUN RESULTS AND DISCUSSION

Tests indicate all the data series are non-stationary (see Table B1). In specifying a VAR model, there are two key considerations: choice of appropriate lag length and the number of variables to be included in the system (Favero, 2001). Usually, statistical tests determine the lag length while economic theory influences the number of variables to include in the model. In our case, statistical tests indicated that 2 lags were the optimal lag length for the VAR model (Appendix Table B2). From the estimated model, we note that the multivariate normality assumption was violated. It is important for this assumption to be satisfied if statistical inferences are to be valid (Favero, 2001), because the other statistical properties of the model depend on the assumption of normality of residuals. An inspection of diagnostic tests for individual variables revealed the source of the multivariate non-normality was in the imports series. To confirm this, residuals from the estimated model were used to simulate standardized residuals which were then used to check whether there were outlier problems in the series (Hendry and Juselius, 2001). As Appendix Table B3 shows, and on the basis of the criterion $\left|\hat{\varepsilon}_t\right| > 3.0$, there were some outlier problems in 1 the import series. According to this criterion, the 1984 and mid 1990s events do not seem to be large enough to warrant dummy variables. Although some studies have found the 1984 dummy to be significant (Matin and Wasow, 1992), it does not appear so by the above criterion. We therefore introduce a dummy in 1973/4 to capture the impact brought about by the onset and aftermath of the 1973 oil

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not make the distinction.

shock, and the concomitant policy pronouncements such as the tightening of financial and trade controls (Ryan, 2002). Such events as oil shocks and policy changes tend to have both short term and long term effects on the economy and therefore we will model this accordingly.

We follow Hendry and Juselius (2001) and introduce a dummy in such a way that it captures both the permanent mean shift and a permanent blip in the system. To do this, we introduce a mean-shift dummy ($Ds74_t$) taking the value zero between 1964 and 1973 and one from 1974 to 2002 (i.e. $Ds74_t = 1$ for t = 1974 – 2002, 0 otherwise) such that its first difference becomes an impulse dummy (i.e. … 0, 0, 1, 0, 0, …) which captures the permanent blip in the system. In other words, a shift in the level of imports becomes a blip in first difference. The shift dummy is restricted to lie in the cointegrating space while its first difference enters the model unrestrictedly and therefore does not appear in the cointegrating space. To find out whether this dummy was extraordinarily large, we enter its first difference with a lag in the short run model. If the dummy with a lag is found to be significant, we could conclude that the 1974 shock was large and indeed extraordinary. With these modifications, we can re-write the VECM above in the following form:

$$\Delta x_t = \mu + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \ldots + \Gamma_{k-1} \Delta x_{t-k-1} + \Pi x_{t-k} + \psi_s \Delta Ds74_t + \varepsilon_t \qquad (3)$$

where $\varepsilon_t \sim$ i.i.d $(0, \Sigma)$, Π is the error correction term that also includes the effect of the shift dummy ($Ds74_t$), while $\Delta Ds74_t$ is a $d_s \; x \; 1$ vector of first differences of the 1974 mean-shift dummy. As mentioned above, the mean shift dummy lies in the cointegrating space and enters the long run model as weakly exogenous whilst its first difference enters the model as an unrestricted impulse dummy, which appears only in the VECM.

Determination of the Π matrix

A number of criteria were used to determine the rank of the Π matrix. These included the Johansen's trace and max tests[2], plots of possible cointegrating vectors, and the significance

2 Conventional critical values are inappropriate in a situation where dummy variables are used and therefore the trace and max tests are only indicative. However, introduction of one dummy may not alter these critical values in a significant way.

or otherwise of the adjustment coefficients of the estimated model (Johansen, 1988; Hendry and Juselius, 2001). Appendix Table B4 shows the indicative trace and max test statistics of the estimated model. These tests give conflicting results, which is not unusual. For this reason, it is imperative to invoke economic theory and other criteria in trying to uncover the underlying structural relationships within a VAR model. To the extent that inclusion of dummy variables affects critical values of the cointegration tests, the trace and max test statistics are only indicative. We have theoretically suggested the possibility of two long run relationships, one capturing the reduced form growth equation and the other the behavioral equation for investment. The choice of two cointegrating vectors is also supported by an examination of the *t*-values of the speed of adjustment coefficients (αs) as shown in Appendix Table B5. The first two columns of the cointegrating vectors appear more significant than the others. An inspection of the plots of cointegrating relations (Appendix Figure B1) reveal two clearly stationary vectors, representing the output and private investment relations. Consequently, we selected rank two for subsequent analysis.

Appendix Table B6 gives results of the unidentified cointegrated VAR for the two cointegrating vectors. Results of the unidentified model are hard to interpret economically. The Johansen reduced rank procedure enables us to determine only the number of cointegrating vectors spanning the cointegration space, but does not necessarily lead to meaningful economic relationships (Johansen and Juselius, 1990; Hendry and Juselius, 2001). For economic interpretability, therefore, one needs to impose appropriate restrictions and normalisations on the long run betas. This is done by imposing either just-identifying and/or over-identifying restrictions on the estimated coefficients. The choice of which variable to normalise can be arbitrary although care must be taken to normalise on a variable that is representative of a given relation in order to be able to interpret the results. Hendry and Juselius (2001) also advise that imposition of restrictions and normalisations must make both economic and statistical sense.

In our case, we imposed two normalisations and two parameter restrictions to exactly identify the model, the result of which is given in Appendix Table B7. In the first cointegrating vector, which we took to represent the reduced form growth relation, we normalised on output and put zero restriction on the 1974 mean shift dummy. In the second vector, which describes the investment behaviour, normalisation was on private investment and a zero restriction on output (the main objective here was to investigate the relationship between aid, government investment and private investment). Relative to the other determinants, dummies are less likely to influence growth over the long run and thus the

choice of zero restriction on this dummy in the output vector. We also expect dummies to affect growth indirectly through other variables such as imports and investment.

Once the model was just-identified through appropriate restrictions, the next step was to impose and test further over-identifying restrictions. For a start, zero restrictions were imposed on government investment in the output vector and on imports in the investment vector. These restrictions were rejected by the likelihood ratio test (see Appendix Table B7). Second, we put zero restrictions on imports on the first relation and on government investment in the second. Although the likelihood ratio test did not out-rightly reject the restriction, the estimated coefficients did not make economic sense. Statistical criteria alone may not lead to a meaningful economic model and economic theory remains the cornerstone for model identification (Favero, 2001). This underlies the main problem of VAR modelling, which is that in pursuit of a statistically valid model one may end up with a model in which theoretically important factors play no role in the system. With this in mind, we adopted the just-identifying restrictions to unearth the underlying economic relationships spanning the cointegrating space. A scrutiny of individual variable and vector diagnostics do not reveal any model misspecification (Appendix Table B8), giving us confidence that our results are robust. Equations (4) and (5) below summarise the two identified long run relations.

Output Relation

$$Yp = 0.56PINV + 0.30GINV - 0.22LOAN + 0.44IMPO \quad (5)$$

(11.23) (3.78) (-4.65) (2.89)

Private Investment Relation

$$PINV = -0.35GINV + 0.27LOAN - 0.78IMPO + 0.09Ds74 \quad (6)$$

(-2.38) (2.84) (-2.75) (2.27)

Where figures in brackets are *t*-statistics. The high values of the *t*-statistics on the long run coefficients can be interpreted as a manifestation of the importance of selected variables in explaining the two identified relationships. The adjustment coefficients are -0.27 for the output relation and -0.43 for the private investment relation.

The Output Relationship

The results in our long run model depicting the output equation conform to theoretical predictions for all the variables except foreign aid. Both types of investment exhibit a strong positive relationship with real per capita output in Kenya. Private investment appears to have a stronger influence on growth than public investment; a 10% increase in private investment leads to about 0.57% increase in output while a similar increase in government investment leads to a 0.30% increase. The negative association between aid and growth may be due to our use of aid loans rather than grants. Aid grants have been relatively small for Kenya, about one per cent of GDP on average since the 1960s and not varying significantly, and were not found to be significant effect on growth in long-run equilibrium (M'Amanja *et al*, 2005). Aid loans tend to be two or more per cent of GDP when positive, although there are often periods of net repayment, especially in the 1990s, when loans are negative, and were found to have a negative effect on growth in a study of aid, fiscal relationships and growth (M'Amanja *et al*, 2005). Loans may have a negative association with growth (income) because the are incurred when there is an unanticipated deficit (therefore proxy for large budget deficits) and are repaid when there is a surplus, therefore reduce resources (public savings) available to the government.

Imports appear to play a positive role in the growth process, presumably by providing capital goods and the necessary intermediate inputs for the firms. Although the imports series is aggregate (i.e. consumption and inputs), it can be argued that the bulk of these imports, such as machinery and equipment, fertilizers, petroleum products etc, are for industrial and other production activities. We find a significant positive correlation between aggregate imports and per capita income in which a 10% rise in imports generates a 0.44% rise in real per capita output. The policy implication for the government is to continue ensuring the bulk of imports are those that enhance technological transfer and productivity of domestic investment.

The coefficient of the loading matrix for the output equation possesses the expected negative sign meaning that it is error correcting. In other words, any deviation from the long run equilibrium is corrected back to equilibrium though at a slow pace of about 27% in each subsequent period. The relatively low speed of adjustment can, perhaps, be attributed to structural rigidities common in developing countries, which slows down the adjustment process.

The Investment Equation

Government investment and imports are negatively related to private investment while aid loans and the 1974 shift dummy have a significant positive correlation with private investment. These results suggest that government investment crowds out private investment. Some possible reasons for this include the fact that it is likely that public investment competes for available resources with private sector, or could be producing output that substitutes for rather than complements private investment. In addition, there is a possibility that deficit financing, which has been a common feature of Kenya's fiscal management since the mid 1970s, leads to crowding out of private investment via its pressure on interest rates. This is consistent with the finding that aid loans have a negative association with income but a positive association with private investment (as the relax the deficit financing constraint).

Our finding on the relationship between public and private investment contrasts with that of Matin and Wasow (1992). Over the period 1968-1988 covered in their study, they found a strong positive association between private and public investment. However, we believe our results are plausible on two counts: first, we cover a longer period (1964 – 2002) and take into account all the dynamic and system-wide interactions among variables, and second it could be true that government investment was more productive before the 1990s than after. Perhaps our study is capturing the strong negative effect of unproductive public investment since the 1990s, a period when there was also net repayment of aid loans. Measurement problems could also account for the conflicting empirical results. In this study, for instance, government investment is proxied by total capital budget of the government which is likely to include some unproductive components.

The negative correlation between imports and private investment is somewhat surprising because one would expect the opposite effect. A possible explanation for this is that certain components of imports could be competing with domestic production. Excessive protection of domestic industries for nearly three decades of independence created uncompetitive industries and therefore when foreign trade was liberalised, most of the domestic firms were ill prepared for the ensuing external competition. It is also possible that imports of consumables are increasing which could be growth-inhibiting.[3]

3 See for example the 2005 Economic Survey, Republic of Kenya, which shows imports of consumables have increased tremendously in recent years.

Foreign aid loans are positively related to private investment. Because aid loans go to the government, it can be argued that these loans finance government expenditures that have a direct beneficial effect on private investment, such as transport and communication systems and other infrastructure, but do not require domestic financing (through domestic borrowing or taxes). The negative correlation between public and private investment suggests that it is the (domestic) financing of public investment that has a crowding-out effect. Foreign resources ease the government budget constraint and reduce the need for government to borrow from the domestic credit market, in turn releasing funds to the private sector. Similarly, reduction of government domestic borrowing due to availability of external aid alleviates pressure on domestic interest rates.

A surprising finding comes from the significant positive relationship between private investment and the long term effect of the shift dummy. A possible interpretation of the positive effect of the shift dummy is that the share of private investment in output was lower before the oil shock and higher after the shock. It can be argued that in 1973/4 prices of crude oil quadrupled thereby creating excess liquidity in oil exporting countries which in turn made it possible for government and private firms to borrow cheaply from these countries. From this viewpoint, it is possible that after the initial shock, private investment rose because cheap credit was available from the oil producing counties. Another conjecture is that given that Kenya supplies most of the East and Central African region with imported oil, which it refines and then re-exports to surrounding countries, the country benefited from higher oil prices on account of these re-exports.

5. SHORT-RUN (VECM) RESULTS AND DISCUSSION

A Vector Error Correction Model (VECM) was estimated starting with a general over-parameterised model depicted in equation (3). Then the VECM was subjected to a systematic reduction and testing process until a robust parsimonious model was obtained. In each round, all statistically insignificant regressors were dropped until further model reduction was rejected by the likelihood ratio test. Appendix Table B9 presents results of the over-parameterised VECM. Although the vector diagnostic tests appear satisfactory, there are many non-significant variables in each of the five equations. The resultant parsimonious model is reported in Table 1 below.

Table 1: Parsimonious Short-Run (VECM) Model

Variable	Equation 1 (DYp)	Equation 2 (DPINV)	Equation 3 (DGINV)	Equation 4 (DLOAN)	Equation 5 (DIMPO)
Constant	1.96	10.10	6.61	14.27	-5.86
	(5.95)	**(3.64)**	**(2.41)**	**(3.26)**	**(-3.56)**
DYp_t	---	---	-1.45	-2.04	---
	---	---	(-1.18)	(-1.19)	---
DYp_{t-1}	---	---	1.04	---	---
	---	---	(1.33)	---	---
$DPINV_t$	---	---	-0.25	-0.18	0.35
	---	---	**(-2.00)**	(-0.91)	**(3.76)**
$DPINV_{t-1}$	0.04	-0.16	0.13	---	0.10
	(2.44)	(-1.03)	(0.99)	---	(1.06)
$GPINV_t$	-0.03	-0.33	---	---	0.27
	(-1.10)	(-1.52)	---	---	**(2.19)**
$DGINV_{t-1}$	---	---	---	-0.22	---
	---	---	---	(-0.82)	---
$DLOAN_t$	-0.02	-0.17	---	---	0.19
	(-1.20)	(-1.18)	---	---	**(2.45)**
$DLOAN_{t-1}$	0.04	0.13	0.15	0.61	-0.13
	(2.82)	(1.04)	(1.59)	**(4.37)**	**(-1.83)**
$DIMPO_t$	0.03	0.99	0.49	0.81	---
	(0.80)	**(3.76)**	**(2.76)**	**(2.58)**	---
$DIMPO_{t-1}$	---	---	0.41	-0.39	---
	---	---	**(2.09)**	(-1.28)	---
DDs74	-0.03	-0.30	---	-0.51	0.38
	(-1.22)	**(-1.59)**	---	**(-2.30)**	**(4.15)**
$DDs74_{-1}$	-0.02	-0.53	---	---	0.10
	(-0.81)	**(-2.87)**	---	---	(0.79)
$ECT1_{t-1}$	-0.39	-1.94	-0.91	-3.53	1.36
	(-4.89)	**(-2.93)**	(-1.62)	**(-3.86)**	**(3.72)**
$ECT2_{t-1}$	-0.22	-1.16	-0.87	-1.42	0.61
	(-6.30)	**(-3.92)**	**(-2.78)**	**(-2.88)**	**(3.29)**

Multivariate vector diagnostics

Log-Likelihood 189.76 -T/2log|Omega| 452.27

Vector Portmanteau(5): 88.19

Vector Normality test: Chi^2(10) = 11.91 [0.2913]

Vector hetero test: Chi^2(240) = 248.13 [0.3455]

Notes: Standard t-statistics in parentheses; figures in bold mean the coefficient is significant. Further over-identifying restrictions on the model were rejected by the likelihood ratio test (LR test: $\chi^2(5) = 39.956$ [0.0000]**) meaning that the short run model presented in the above table is data congruent. All the relevant diagnostics are also satisfactory and therefore our model can be given economic interpretation.

In the output equation, the growth rate of real per capita output depends positively on changes in past private investment and foreign aid. It can be argued that the positive sign on

foreign aid means that in the short run, aid is a less distortionary way of financing a deficit. It is also possible to interpret the results in terms of Granger causality in which the significance of lagged coefficients of the two variables imply that both private investment and foreign aid Granger cause output in Kenya, with the direction of causality running from private investment/foreign aid to growth. The other variables do not seem to matter for growth in the short run. The constant term is positive and significant implying that there are important omitted variables such as technology. Both the output and private investment gaps represented by the error correction terms have a strong negative influence on the growth of current output.

Growth rate of private investment in the short run depends positively and robustly on current level of imports and negatively on the 1974 oil crisis impulse dummy. Perhaps what the positive import coefficient is showing is that in the short run they serve as capital goods or intermediate inputs but in the long run additional imports represent increased competition with domestic production. Furthermore, it could be the case that as the economy expands imports of consumables increase relative to imports of inputs which hurts private investment. As for the dummy variable, our results confirm what would be expected in the short run when there is a negative shock to the economy: an adverse effect on private investment and by implication on economic growth.

In the government investment equation, our results reveal that current level of public investment is influenced negatively by changes in current level of private investment, which further underlies the negative correlation between the two types of investments. This is a surprising finding because one would expect a booming private investment to go hand in hand with a vibrant public investment. Theoretically, one can argue that increased private investment generates tax revenue with which the government undertakes its investment programmes, thus giving rise to a positive relationship between private and public investment. Current imports have a strong positive relationship with government investment. None of the other variables except the error and the constant terms appear to be significant in determining public investment.

Turning to the aid equation, our results suggest that changes in current imports and past foreign aid have a strong positive influence on current growth of foreign aid. Granted, increased demand for imports requires additional foreign exchange. Foreign aid provides part of this foreign exchange, hence the positive correlation between imports and foreign aid. In the short run, the higher the ability of a country to absorb foreign resources, the higher the

likelihood that it would attract more foreign resources. This may be the reason why changes in past aid influence growth of current aid positively. Both types of investment – public and private – do not seem to be important factors influencing growth of foreign aid in the short run. The 1974 transitory dummy[4] has a significant negative effect on foreign loans according to our results. A likely explanation is that the long term impact of the oil shock was to encourage the government towards commercial and other forms of borrowing away from official bilateral and multilateral borrowing. The error correction terms are significant and bear the expected signs.

Growth of imports in the short run depend positively on changes in the current level of private and government investment, foreign aid as well as the 1974 transitory dummy. As previously argued, most imports are needed as capital goods or intermediate inputs for both private and public investment. Thus the positive relationship between these two variables and imports confirm the theoretical expectation. Similarly, foreign aid is required to meet foreign exchange requirements for imports which explain the positive relationship. If the 1974 dummy captures the effect of the oil crisis, we would expect a negative relationship with imports because the effect of the 1973-4 oil shock was to raise the prices of imported goods, especially crude oil which constitutes the highest share of Kenya's imports; it adversely affected terms of trade. One way to interpret the positive sign is to assume the dummy is capturing the increase in the value (cost) of imports. Matin and Wasow (1992) and Glenday and Ryan (2003) identify foreign exchange constraints as the main constraint on growth of imports in Kenya, especially the poor performance of imports over the 1983–93 period. It is possible that the negative constant term is capturing, amongst other factors, policy interventions that constrained imports.

6 CONCLUSIONS AND POLICY IMPLICATIONS

Although there are stylised facts that represent growth experiences of countries in general, growth remains a complex issue and growth regressions are as good as the data that goes into them. Growth is a summary of almost everything that goes on in a society and that being the case, it is never easy to pinpoint a couple of factors as key because these vary from country to country. The case for Kenya analysed in this paper was an attempt towards identifying some of these factors. Using a VAR approach, we found two long run

4 The first difference of a shift dummy becomes a transitory dummy (see Hendry and Juselius, 2001).

relationships representing the output and private investment equilibriums. Output depends positively on private and government investment and imports, but negatively on net external loans. Private investment on the other hand appears to be positively related to foreign loans, but negatively to both government investment and imports.

Private investment has been a consistently strong determinant of growth both in the short- and long- run. The implication here is that in order to stimulate and sustain economic growth in Kenya, policy makers need to pay closer attention to factors that determine private investment. Government investment has also exhibited strong positive effect on growth. Nonetheless, it can be made more effective by re-directing it towards economic infrastructure. Furthermore, the issue of efficiency needs to be considered to ensure public investment is made more productive. The policy recommendation therefore is for the government to improve the productivity of its investment so as to generate positive returns and enhance its complementary role to private sector. It should also institute measures that stimulate and support private investment such as mobilization of domestic savings and creation of a stable macroeconomic environment. Foreign aid in the form of loans can play a vital role in promoting growth directly or indirectly through private investment. It can be made even more productive if used to finance productive activities such as export promotion, infrastructure development, and domestic resource mobilization.

A topic for further research in this area is to replicate the methodology used in this study on disaggregated data. For instance, it would be interesting to subdivide government investment into such categories as investment in roads, telecommunications, and social infrastructure and assess their impact on private investment and growth. The same could be done for imports – distinguishing investment goods, machinery, equipment and other inputs, and consumption. In a similar fashion, foreign aid could be disaggregated into project loans, programme loans, and any other appropriate classification. The findings discussed in this paper provide a starting point to understanding factors influencing growth in Kenya.

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Appendix Tables

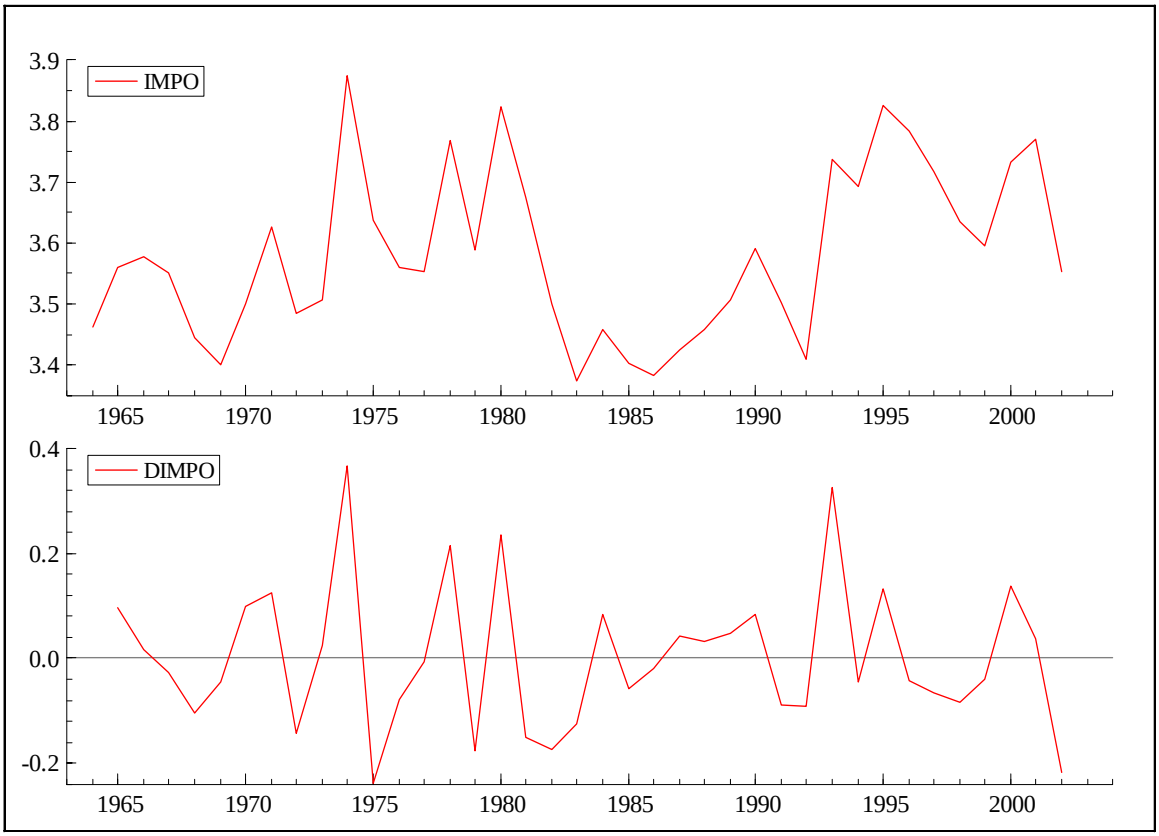
TABLE A1: Variable Definitions and Descriptions

Variable	DESCRIPTION
Yp	Real per capita GDP at factor cost expressed in constant 1982 prices. Series from 1964-1972 was in constant 1964 prices while the one from 1972-2002 was in constant 1982 prices. Ratios from an overlapping year (1972) were used to splice the series to express it in constant 1982 prices.
IMPO	Nominal imports of goods and services. No distinction is made between imports for consumption and imports for industrial use. Imports are used as a proxy for trade openness.
LOAN	Net external loans to the government (inflows minus outflows). Net loans have been negative for most of the 1990s. To be able to take logs, a constant figure was added to the series to get rid of negative values.
PINV	Private Investment – obtained by deducting government investment (GINV) from gross fixed capital investment (GFCF).
GINV	Government investment proxied by total capital or development expenditure of the central government.

Notes: All these variables were expressed as shares in GDP and then their logs taken.

Source: All data derived form *Kenya Economic Survey* (various years), checked against or supplemented by data in Ryan (2002).

FIGURE A1:
Level and First Difference of the Log Share of Imports in GDP, 1964 – 2002



Note: Considering the lower panel (represents series in first differences), we note some sharp instability between 1973 and 1975 which might necessitate use of a dummy variable to account for the big swings.

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Table B1: DF/ADF tests for unit roots and time trend (Levels and first differences)

ADF Model: $\Delta Yt = \alpha + \beta T + \gamma Y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i}$							
VARIABLES IN LEVELS						**FIRST DIFFERENCES**	
	Ho: $\gamma=0$	Ho:$\beta=\gamma=0$ (ϕ_3-test)	Ho:$\beta=\alpha=\gamma=0$ (ϕ_2-test)	Lag length	Inference	H_0: $\gamma=0$	Inference
Y_{Pt}	-2.08 (-3.53)	5.289 (6.73)	4.607 (5.13)	0	I(1)	-5.383**	I(0)
$GINV_t$	-2.27 (-3.53)	4.921 (6.73)	3.282 (5.13)	0	I(1)	-4.812**	I(0)
$LOAN_t$	-3.08 (-3.53)	4.776 (6.73)	3.302 (5.13)	1	I(1)	-3.757**	I(0)
$IMPO_t$	-2.83 (-3.53)	4.169 (6.73)	2.829 (5.13)	7	I(1)	-7.713**	I(0)
$PINV_t$	-0.903 (-3.53)	0.737 (6.73)	0.763 (5.13)	6	I(1)	7.512**	I(0)

Note: Unit roots test statistics are generated from PcGive version 10.1. Critical values for ADF-test are simulated from Mackinnon tables and their values at 5% significance level are given in parentheses. Simulation of the critical values are based on the formula $C(p) = \phi_\infty + \phi_1 T^{-1} + \phi_2 T^{-2}$ given in Harris (1995: 158). The simulated critical values for the ϕ_i tests at 1% and 10% significance levels are –4.22 and 3.20 respectively. In the above table, ** indicate significance at 5% significance level.

Table B2: F-statistic for sequential model reduction from lag 3 to lag 1

Model reduction	Degrees of Freedom		Test statistic [P-Value]
Model 1 $\rightarrow$ 2	F(36, 55)	=	0.9023[0.6236]
Model 1 $\rightarrow$ 3	F(72, 71)	=	1.1487[0.2799]
Model 2 $\rightarrow$ 3	F(36, 81)	=	1.4555[0.0832]

Note: Reduction from 3 to 2 lags was not rejected but not from 2 to 1. So we chose 2 lags for the estimated VAR.

Table B3: Simulated Standardised Residuals

YEAR	VYP	VPINV	VGINV	VLOAN	VIMPO	SYP	SPINV	SGINV	SLOAN	SIMPO
1964	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-
1966	0.03910	0.13046	-0.16588	0.02777	0.03370	2.32599	0.87614	-1.44543	0.17051	0.30189
1967	-0.03189	0.09279	-0.07353	0.03542	-0.03583	-1.89700	0.62320	-0.64072	0.21748	-0.32099
1968	-0.00635	-0.06143	0.05036	-0.00026	-0.04137	-0.37756	-0.41253	0.43881	-0.00162	-0.37060
1969	0.01054	-0.07006	0.01322	0.01860	-0.04372	0.62676	-0.47051	0.11519	0.11422	-0.39160
1970	0.00623	-0.11110	0.10522	0.00113	0.01463	0.37053	-0.74615	0.91686	0.00694	0.13103
1971	-0.00228	0.05029	0.00626	-0.07126	0.09055	-0.13568	0.33771	0.05453	-0.43750	0.81107
1972	-0.01963	-0.08781	-0.09629	0.04012	-0.09203	-1.16798	-0.58970	-0.83904	0.24629	-0.82438
1973	-0.01684	0.17763	-0.01266	-0.14893	-0.01064	-1.00190	1.19296	-0.11032	-0.91430	-0.09535
1974	**-0.02359**	**0.13709**	**0.03791**	**-0.15125**	**0.36158**	**-1.40335**	**0.92066**	**0.33034**	**-0.92856**	***3.23890***
1975	-0.01228	-0.24599	0.16810	0.16350	0.04127	-0.73044	-1.65203	1.46480	1.00376	0.36964
1976	0.00232	-0.13025	0.07303	-0.07141	-0.01652	0.13788	-0.87476	0.63641	-0.43843	-0.14797
1977	0.00397	-0.17832	-0.00251	-0.05969	-0.12097	0.23642	-1.19757	-0.02191	-0.36646	-1.08361
1978	0.02031	0.11499	0.18410	0.17621	0.14936	1.20844	0.77226	1.60419	1.08180	1.33792
1979	0.00533	-0.24868	0.02352	0.02431	-0.07714	0.31686	-1.67011	0.20497	0.14922	-0.69101
1980	-0.02995	0.30485	0.12899	0.19807	0.24022	-1.78173	2.04734	1.12403	1.21601	2.15178
1981	-0.00867	0.16668	0.06024	0.14708	-0.03105	-0.51583	1.11937	0.52492	0.90296	-0.27810
1982	0.00300	-0.08704	-0.09562	0.06529	-0.07875	0.17821	-0.58458	-0.83326	0.40086	-0.70538
1983	0.00979	0.04754	-0.18636	-0.11193	-0.15927	0.58258	0.31925	-1.62392	-0.68715	-1.42668
1984	**-0.02037**	**-0.18298**	**0.32922**	**-0.06547**	**-0.03079**	**-1.21158**	**-1.22885**	***2.86880***	**-0.40194**	**-0.27584**
1985	-0.00208	0.20877	-0.02944	-0.20796	-0.05351	-0.12349	1.40205	-0.25649	-1.27672	-0.47930
1986	-0.00805	-0.19562	-0.08929	-0.17804	-0.08295	-0.47913	-1.31375	-0.77806	-1.09305	-0.74307
1987	0.01664	0.15966	0.03043	0.17851	-0.03211	0.98960	1.07225	0.26513	1.09590	-0.28765
1988	0.00233	0.02476	-0.07712	-0.08196	-0.09760	0.13871	0.16629	-0.67201	-0.50318	-0.87427
1989	0.02153	0.05186	-0.02383	0.10831	-0.02677	1.28049	0.34827	-0.20769	0.66497	-0.23976
1990	0.02782	0.02339	0.02797	0.02493	0.03580	1.65475	0.15708	0.24369	0.15303	0.32064
1991	0.00080	-0.03782	-0.11130	-0.10073	-0.08827	0.04729	-0.25402	-0.96988	-0.61842	-0.79069
1992	-0.00420	-0.26891	-0.17441	0.35864	-0.13706	-0.25012	-1.80599	-1.51981	2.20182	-1.22777
1993	-0.01216	-0.15070	-0.05927	0.02953	0.15224	-0.72350	-1.01210	-0.51650	0.18127	1.36372
1994	-0.00012	0.15309	-0.04839	-0.13729	-0.02277	-0.00733	1.02814	-0.42166	-0.84285	-0.20400
1995	0.01851	0.11645	0.12315	0.30797	0.17406	1.10123	0.78207	1.07310	1.89072	1.55917
1996	0.01803	0.10584	-0.05095	-0.28595	0.04987	1.07275	0.71081	-0.44395	-1.75554	0.44672
1997	0.01792	0.08738	-0.10898	-0.22426	0.03823	1.06596	0.58683	-0.94961	-1.37682	0.34243
1998	0.01610	0.13275	-0.12142	-0.43360	-0.03085	0.95797	0.89152	-1.05801	-2.66200	-0.27636
1999	0.01132	0.09090	-0.07191	0.16440	-0.02193	0.67363	0.61050	-0.62664	1.00930	-0.19642
2000	-0.01645	-0.03577	0.17525	0.12116	0.08387	-0.97877	-0.24022	1.52714	0.74382	0.75127
2001	-0.02204	-0.06685	-0.08723	0.04326	0.06488	-1.31101	-0.44896	-0.76012	0.26557	0.58112
2002	-0.01462	-0.21782	0.14943	0.09580	-0.19832	-0.86964	-1.46288	1.30211	0.58812	-1.77650
Mean	**0.00000**	**0.00000**	**0.00000**	**0.00000**	**0.00000**					
Std dev	**0.01681**	**0.14890**	**0.11476**	**0.16288**	**0.11164**					

*Notes**:***
VYP = Residuals for output series from estimated model
VPINV = Residuals for private investment from estimated model
VGINV = Residuals for government investment from estimated model
VLOANS = Residuals for external loans from estimated model
VIMPO = Residuals for share of imports from estimated model
SYP = Simulated Standardised residuals for output series
SPINV = Simulated standardised residuals for private investment
SGINV = Simulated standardised residuals for government investment
SLOANS = Simulated standardised residuals for net external loans (AID)
SIMPO = Simulated standardised residuals for share of imports

It is only in 1974 that we have residuals (for imports series) exceeding 3 in absolute terms. Hence, we introduce a dummy variable in this year to capture shocks that hit the economy around this time.

Table B4: Test Statistics for Cointegrating rank (Trace and Max tests)

Rank	Null	Alt.	λ_{Trace} [Prob]	λ_{Trace} (T-nm)	Null	Alt.	λ_{Max} [Prob]	λ_{Max} (T-nm)
0	r=0	r≥1	101.38[0.000]**	73.98[0.021]*	r=0	r=1	37.40[0.015]*	27.29[0.256]
1	r≤1	r≥2	63.98[0.001]**	46.69[0.063]	r≤1	r=2	32.58[0.008]**	23.77[0.145]
2	r≤2	r≥3	31.40[0.032]*	22.92[0.258]	r≤2	r=3	20.79[0.054]	15.17[0.289]
3	r≤3	r≥4	10.61[0.240]	7.75[0.192]	r≤3	r=4	10.25[0.200]	7.48[0.443]
4	r≤4	r=5	0.37[0.543]	0.27[0.603]	r≤4	r=5	0.37[0.199]	0.27[0.603]

Note: The trace test (both adjusted for small sample size and the unadjusted) show at least two cointegration vectors. However, the critical values used by the econometric programme do not take into account inclusion of dummy variables which alters conventional critical values. It can be argued however that inclusion of one dummy may not alter significantly the critical values and therefore we may in fact assume two cointegrating vectors.

Table B5: *t*-Values of the Alphas (αs) of Cointegrating relations

DYP	6.1019182	2.0583265	-0.6965689	1.2347684	-0.8434758
DPINV	4.1203010	-2.6337757	1.0755495	-2.8157396	-0.4932666
DGINV	2.7578615	-4.9297864	2.2868269	1.3465290	0.4258350
DLOAN	0.7390766	3.5364619	3.6207060	0.5629878	0.3881792
DIMPO	0.6775341	-2.8501182	2.8442673	-0.4701428	-0.8995024

Note: Results generated from CATS software. The first two vectors (2nd and 3rd columns) appear more significant than the rest of the vectors – an indication that these two are cointegrated (Hendry and Juselius, 2001).

Figure B1: Plots of cointegrating vectors

Figure B1.1 Output Relationship

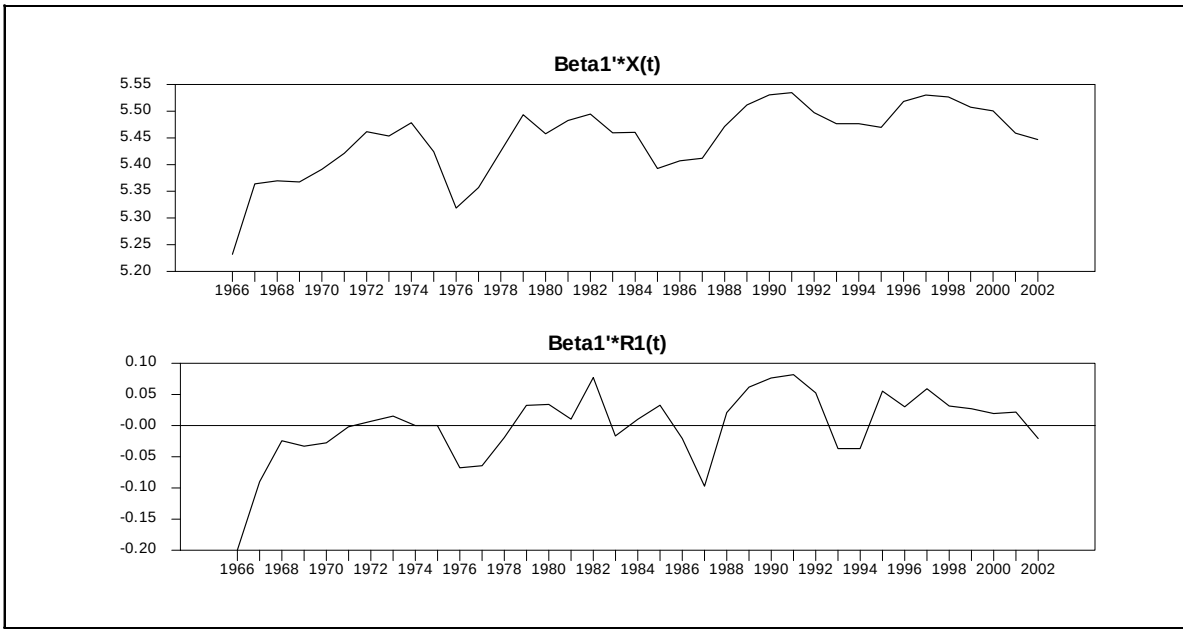


Figure B1.2 Private Investment Relationship

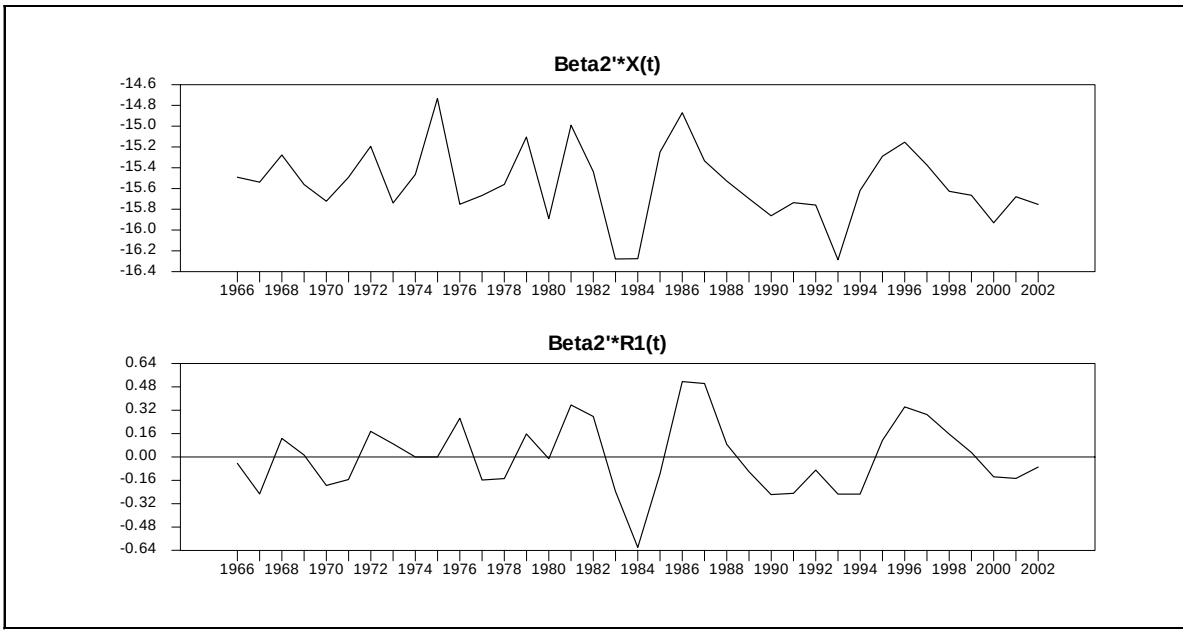


Figure B1.3 Public investment Relationship

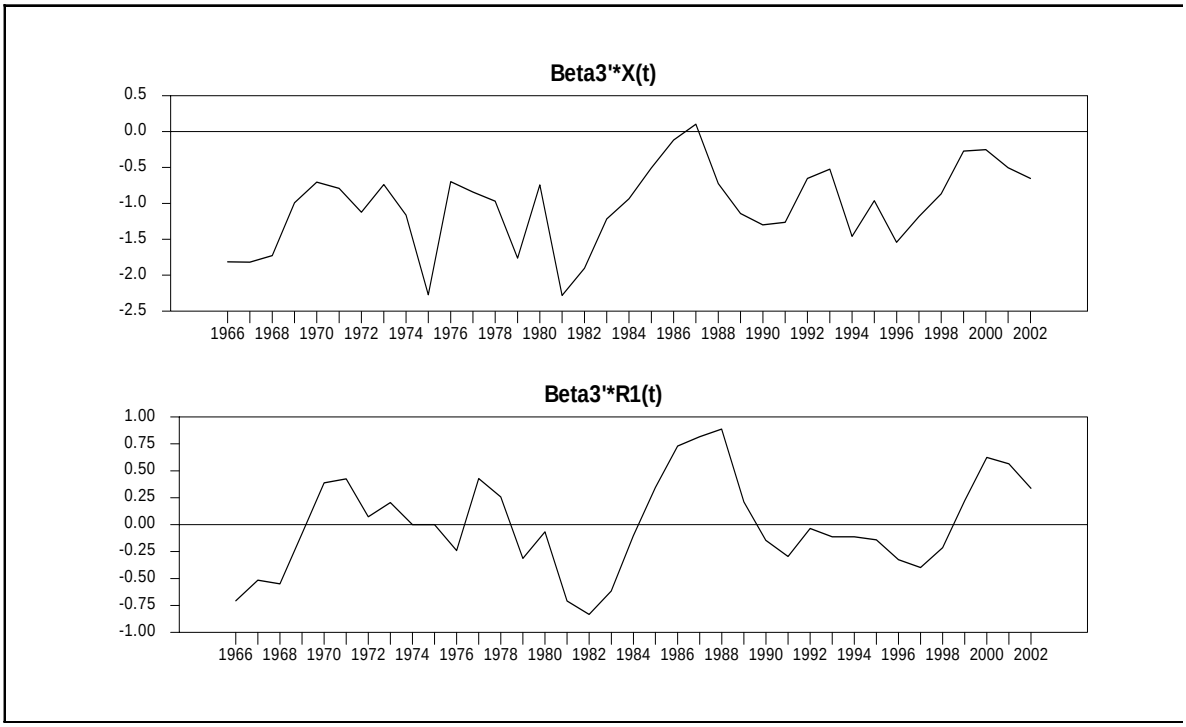


Figure B1.4 Foreign Aid Relationship

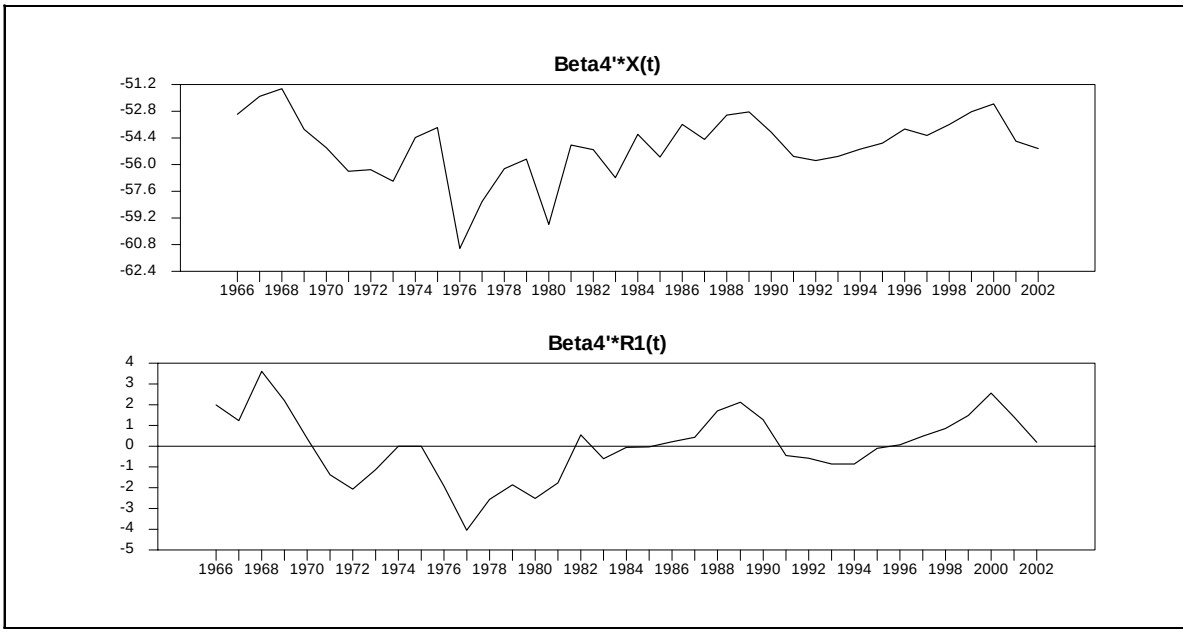
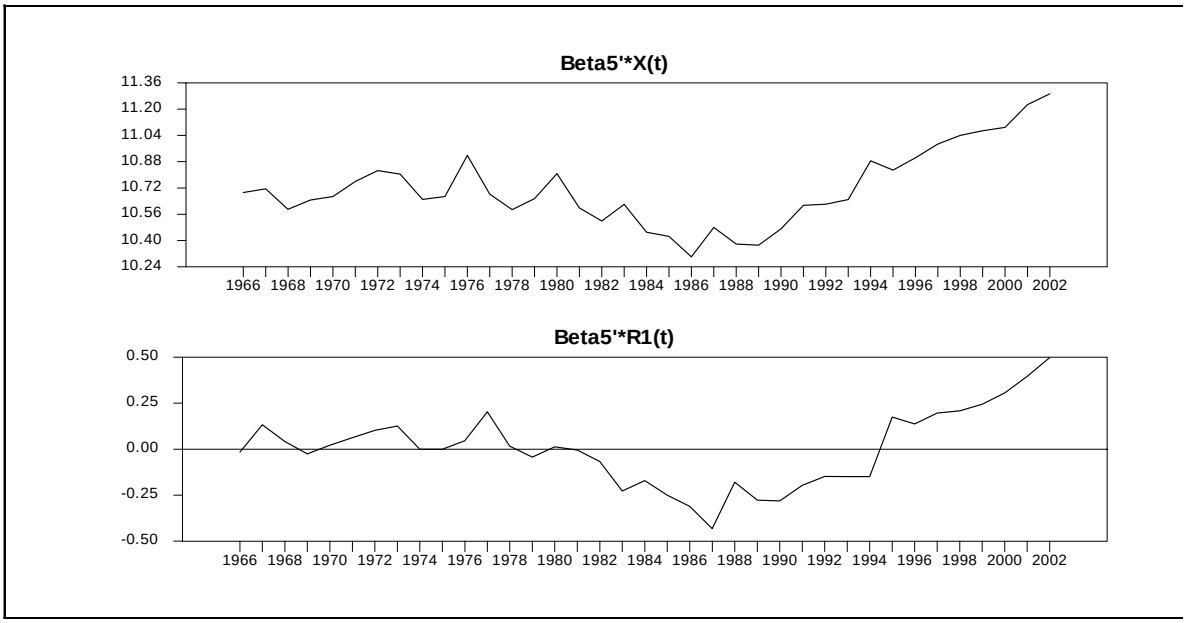


Figure B1.5 Imports Relationship



Note: The above graphs tend to indicate two clearly stationary vectors depicting the output and the private investment relations. Public investment is a borderline case while the others are clearly non-stationary. So we take two long run relationships as spanning the cointegration space.

Table B6: Cointegrating vectors (based on PcGive output)

Estimated betas and alphas based on rank two (r = 2)

	β_1	β_2	α_1	α_2
Yp	1.0000	-4.6912	**-0.1878**	0.0165
PINV	0.1985	1.0000	-1.1061	**-0.2502**
GINV	-0.0297	0.8153	-0.8543	-0.1679
LOAN	0.0271	-0.6226	-0.1392	0.5077
IMPO	0.1543	0.7796	-0.3033	-0.2186
Ds74	-0.0727	0.1563	---	---

Note: The alphas correspond with the betas and the appropriate error correction terms in each model are given in bold numbers, and are all error-correcting.

Table B7: Just – and Over-identifying Restrictions on the Long Run Model

Table B7.1: Just-identifying restrictions

	β_1	β_2	α_1	α_2
Yp	1.0000	0.0000	**-0.2651**	**-0.1695**
PINV	**-0.5611**	1.0000	0.0676	-0.4318
GINV	**-0.2956**	**0.3500**	-0.0669	-0.3750
LOAN	**0.2220**	**-0.2567**	**-2.5211**	**-0.9345**
IMPO	**-0.4370**	**0.7783**	0.7222	0.1264
Ds74	0.0000	**-0.0958**	---	---

Log-likelihood for just-identified model = 463.52

Table B7.2: Over-identifying restrictions 1

	β_1	β_2	α_1	α_2
Yp	1.0000	0.0000	**-0.3676**	**-0.2064**
PINV	**0.9748**	1.0000	-0.5819	-0.6923
GINV	0.0000	**0.1255**	0.6853	0.0020
LOAN	-0.0888	**-0.1808**	**-2.0695**	**-0.7983**
IMPO	-0.0621	0.0000	0.7440	0.2477
Ds74	0.0000	**-0.0414**	---	---

Likelihood Ratio (LR) test of restrictions: $\chi^2(2) = 6.2486[0.0440]$*

Table B7.3: Over-identifying restrictions 2

	β_1	β_2	α_1	α_2
Yp	1.0000	0.0000	**-0.1924**	-0.0093
PINV	**0.1678**	1.0000	0.1226	**-0.7296**
GINV	**-0.1838**	0.0000	0.3287	**0.4448**
LOAN	0.1132	-0.0643	**-2.3749**	**0.8162**
IMPO	0.0000	**0.4955**	0.7494	**-0.4667**
Ds74	0.0000	0.0514	---	---

Likelihood Ratio (LR) test of restrictions: $\chi^2(2) = 3.9012[0.1422]$

Note: Figures in bold indicate significance of the coefficient. In the upper panel, all coefficients in the cointegrating space are significant, while this is not the case for the middle and lower panels. In addition, private investment possesses the 'wrong' sign in lower two panels.

Table B8: Diagnostics Test for the Long Run Model

```
Yp          : Portmanteau( 5): 2.45169
PINV        : Portmanteau( 5): 4.11912
GINV        : Portmanteau( 5): 1.92043
LOAN        : Portmanteau( 5): 4.84917
IMPO        : Portmanteau( 5): 2.37209
Yp          : AR 1-2 test:      F(2,22)  =   1.0137 [0.3792]
PINV        : AR 1-2 test:      F(2,22)  =  0.85551 [0.4387]
GINV        : AR 1-2 test:      F(2,22)  =  0.45547 [0.6400]
LOAN        : AR 1-2 test:      F(2,22)  = 0.013938 [0.9862]
IMPO        : AR 1-2 test:      F(2,22)  =   2.9774 [0.0717]
Yp          : Normality test:   Chi^2(2) = 0.043389 [0.9785]
PINV        : Normality test:   Chi^2(2) =   1.5187 [0.4680]
GINV        : Normality test:   Chi^2(2) =   2.6249 [0.2692]
LOAN        : Normality test:   Chi^2(2) =   2.3694 [0.3058]
IMPO        : Normality test:   Chi^2(2) =   1.8127 [0.4040]
Yp          : ARCH 1-1 test:    F(1,22)  =   1.4461 [0.2419]
PINV        : ARCH 1-1 test:    F(1,22)  =   1.2982 [0.2668]
GINV        : ARCH 1-1 test:    F(1,22)  =  0.14883 [0.7034]
LOAN        : ARCH 1-1 test:    F(1,22)  =  0.78623 [0.3848]
IMPO        : ARCH 1-1 test:    F(1,22)  = 0.043203 [0.8373]
Yp          : hetero test:      F(21,2)  =  0.19726 [0.9840]
PINV        : hetero test:      F(21,2)  =  0.26516 [0.9601]
GINV        : hetero test:      F(21,2)  =  0.60539 [0.7843]
LOAN        : hetero test:      F(21,2)  =  0.26920 [0.9584]
IMPO        : hetero test:      F(21,2)  =  0.13408 [0.9964]
```

Multivariate Vector Diagnostics

Vector Portmanteau(5): 86.5241
Vector AR 1-2 test: F(50,48) = 1.1025 [0.3678]
Vector Normality test: Chi^2(10) = 11.4330 [0.3248]

Log-likelihood 479.217
R2 (LR) = 0.9997
R2 (LM) = 0.6383

Note: These diagnostic tests do not reveal any specification problems and suggest our model is a plausible representation of the data generation process.

Table B9: Over-parameterised short run VECM

Variable	Equation1 (DYp)	Equation2 (DPINV)	Equation3 (DGINV)	Equation4 (DLOAN)	Equation5 (DIMPO)
Constant	1.79	9.58	4.85	14.51	-6.89
	(3.58)	**(1.96)**	(1.21)	**(2.51)**	**(-2.51)**
DYp_t	---	0.25	-1.50	-1.43	0.56
	---	(0.14)	(-1.21)	(-0.66)	(0.54)
DYp_{t-1}	-0.01	0.50	0.61	0.37	-0.06
	(-0.08)	(0.43)	(0.68)	(0.29)	(-0.93)
$DPINV_t$	0.004	---	-0.23	-0.21	0.34
	(0.14)	---	(-1.45)	(-0.81)	**(3.45)**
$DPINV_{t-1}$	0.05	-0.22	0.23	-0.22	0.10
	(1.80)	(-1.03)	(1.32)	(-0.78)	(0.75)
$GPINV_t$	-0.03	-0.37	---	0.15	0.30
	(-1.12)	(-1.45)	---	(0.45)	**(2.09)**
$DGINV_{t-1}$	0.01	-0.02	0.17	-0.35	0.02
	(0.45)	(-0.09)	(0.81)	(-1.07)	(0.10)
$DLOAN_t$	-0.01	-0.13	0.06	---	0.18
	(0.66)	(-0.81)	(0.45)	---	**(1.95)**
$DLOAN_{t-1}$	0.04	0.09	0.11	0.57	-0.14
	(2.07)	(0.55)	(0.95)	**(3.45)**	(-1.49)
$DIMPO_t$	0.02	0.99	0.53	0.79	---
	(0.54)	**(3.45)**	**(2.09)**	**(1.95)**	---
$DIMPO_{t-1}$	0.02	0.22	0.25	-0.21	-0.13
	(0.35)	(0.62)	(0.87)	(-0.46)	(-0.59)
DDs74	-0.02	-0.26	-0.12	-0.48	0.37
	(-0.95)	(-1.24)	(-0.70)	**(-1.89)**	**(3.65)**
$DDs74_{-1}$	-0.02	-0.58	0.11	-0.18	0.15
	(-0.54)	**(-2.43)**	(0.53)	(-0.53)	(0.93)
$ECT1_{t-1}$	-0.34	-1.79	-0.52	-3.70	1.53
	(-3.00)	**(-1.67)**	(-0.60)	**(-3.16)**	**(2.61)**
$ECT2_{t-1}$	-0.21	-1.12	-0.67	-1.41	0.73
	(-3.80)	**(-2.09)**	(-1.55)	**(-2.14)**	**(2.39)**

Multivariate Vector Diagnostics

Log-Likelihood	190.40	-T/2log|Omega|	452.90
Vector Portmanteau(5):	83.21		
Vector Normality test:	Chi^2(10) =	12.81 [0.2344]	
Vector hetero test:	Chi^2(270) =	240.69 [0.4754]	

Note: The t-statistics are in parentheses, figures in bold indicate significant coefficients.