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How Does Public Investment Affect Economic Growth in HIPC? An Empirical Assessment

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Abstract – A better assessment of the impact of public investment on economic performance is crucial in order to design and implement effective fiscal policies for adjustment with growth in highly indebted poor countries. In this paper we investigate empirically the relationship between public investment, private investment and output, providing a dynamic econometric procedure on a selected group of Highly Indebted Poor Countries (HIPCs). Our results provide empirical support for both the crowding-in hypothesis and a positive effect of public investment on output.

Keywords - Fiscal adjustment, public investment, crowding-in, Highly Indebted Poor Countries (HIPCs).

JEL Classification: O23, E62

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1. Introduction

Throughout the last twenty-five years, several developing countries have experienced serious problems of unsustainable foreign indebtedness that compelled them to adopt severe macroeconomic and fiscal adjustments. The ratio for such policies is straightforward. A country suffering from high debt service and weak new capital inflows needs to accomplish a considerable net financial transfer abroad. As pointed out by Reisen and Van Trotsenburg (1988), this means facing two crucial problems: mobilising the domestic financial resources to be transferred abroad (*budgetary problem*) and converting these financial resources in foreign currency (*transfer problem*). Furthermore, if the public sector holds (or guarantees) a significant part of the foreign obligations, a *fiscal problem* arises since the financial burden of the transfer may significantly affect total public expenditures. If a growing debt service cannot be financed by new foreign (or internal) debt, the government has to perform a *fiscal adjustment* by means of increases in revenues and/or reductions in expenditures.

As the past experience of many developing countries testifies, adopting severe adjustments to face macroeconomic and fiscal disequilibria may compromise economic growth. Such evidence has given rise to an extensive theoretical literature analysing the relation between adjustment and growth with the aim to suggest effective policy receipts.

In this paper we focus on the fiscal dimension of adjustment in highly indebted countries. As it clearly emerges from the theoretical literature, the relation between fiscal adjustment and economic performance in highly indebted countries crucially depends on the underlying hypotheses about the effects of public investment on private investment and output. This point will be made clear in the following discussion.

Consider the model presented by Khan, Montiel and Haque (1990), which merges the IMF and the World Bank approaches. In this model the public sector is not engaged in any investment by hypothesis[1]. This means that public expenditure cannot contribute to capital accumulation. In such a framework, any reduction in public spending decreases the borrowing to the public sector. This measure, coupled with a smaller increase in the supply of credit to the private sector, allows reaching jointly adjustment and growth. Indeed, on the one side, the reduction of the overall domestic credit improves the balance of payments, while, on the other, the increase in domestic investment promotes economic growth. A rise in tax revenues may be

[1] For details see Khan, Montiel and Haque (1990: 157).

an alternative instrument to achieve the same aim. However, this latter measure is considered less effective than the former: the consequent increase in public saving is accompanied by a smaller reduction in private saving, so that total investment is enhanced, but less than proportionally.

It is worth noting that *any* reduction in public expenditure is able to pursue adjustment with growth even if public investment is included in the government budget constraint but the *crowding-out* hypothesis is brought into being. This hypothesis states that higher public investment leads to a reduction in private investment. The arguments supporting crowding-out are as follow. First, government expenditure, financed either by taxes or debt, competes with the private sector in the use of scarce physical and financial resources. Second, the increase in government demand for goods and services can raise the interest rate; this makes capital more expensive so to disincentive private investment. If the crowding-out hypothesis holds, it follows that cutting back public investment can stimulate private investing decisions. This policy results to be growth-enhancing in two cases: either if public investment crowds-out private investment more than proportionally or if the crowding-out occurs less than on a one-to-one basis but public investment is significantly less productive than private investment.

The described approach on *fiscal adjustment with growth* is quite controversial. In particular what seems to be restrictive is to neglect a possibly complementary relationship between public and private investment. Under this respect, the 'three-gap models' on adjustment with growth assume that the *crowding-in* hypothesis may hold (see Bacha, 1990; Taylor, 1994). But also some recent contributions referable to the so called 'orthodox approach' deem the possibility that public investment crowds-in private investment (see for instance Agenor, 2000).

Public and private investment may be linked by a complementarity relationship if public capital provides positive externalities on the private sector. Many channels may be involved: first, the availability of economic and social infrastructures may create favorable conditions for private decisions to invest, by offering essential services to the production system both in the short and in the long run (transportation, communication, education, and so on); second, higher public capital may lead, on the one side, to increments in total factor productivity and, on the other, to reductions in production costs (through availability of streets, highways, electrical and gas facilities, mass transit, and so on); finally, public investment, by increasing total demand, may give rise to profit and sales expectations, so to spur private decisions to invest more. Such a

view is especially sustained when economic resources are underemployed as it often occurs in developing countries.

If the crowding-in hypothesis holds, a rise in public investment increases domestic investment more than on a one-for-one basis. In this case, the shortage of public investment may become a crucial factor that compromises economic growth in highly indebted countries. Thus, as suggested by Khan and Reinhart (1990), even if private investment is found directly more productive than public investment, any conclusion on adjustment strategies should be qualified with the consideration of the relationship between public and private investment. Indeed, if the crowding-in hypothesis holds, a fiscal adjustment which reduces public investment implies a contraction in the fixed capital formation and a slowdown in economic performance.

As recently pointed out by IMF and World Bank (2001a), a better understanding of the relationship between adjustment and growth in highly indebted low-income countries is also crucial in order to reassess the concept of foreign debt sustainability. Indeed, although reducing the ratios of indebtedness (with respect to GDP, exports and/or fiscal revenues) to the 'thresholds of solvency' could guarantee foreign debt sustainability in the short run, further debt problems may emerge in the medium-long term. This occurs if the macroeconomic and fiscal adjustments are not accompanied by adequate growth rates of income, fiscal revenues and exports. Hence investigating the relationship between adjustment and growth is important not only because the macroeconomic and fiscal adjustments (if not properly designed) may compromise domestic economic performance, but also because a compromised economic performance may affect the long run effectiveness of the adjustment itself.

To shed light on this issue, this paper further explores empirically the role of public investment in affecting private investment (crowding-in versus crowding-out) and output. In particular we develop a time-series analysis on a selected sample of Heavily Indebted Poor Countries (HIPCs).[2] Such investigation is especially important for these countries: since early '80s they have faced unsustainable levels of foreign indebtedness and adopted macroeconomic and fiscal adjustments with bad results in terms of economic performance and levels of poverty. At present HIPCs are involved in a policy of reduction of foreign debt to sustainable levels by means of both adjustments and debt relieves from donor countries. We believe that an inquiry

[2] The denomination 'HIPCs' refers to the group of developing countries considered as potentially eligible for the debt relief initiative promoted in 1996 by G8 countries (see IMF and World Bank, 2001b).

on the role of public investment in promoting economic performance in HIPCs can be useful to understand the impact of both adjustment policies and debt relieves.

The outline of the paper is as follows. In section 2, after a brief summary of the previous empirical works on crowding-in versus crowding-out, we outline our econometric procedure. The method is based on a time-series cointegration strategy, estimation of a Vector Autoregressive Error Correction Model and impulse response analysis. In section 3 we describe and discuss the empirical results obtained. Finally, in section 4, we draw some concluding remarks.

2. Testing the crowding-in versus the crowding-out hypothesis

The issue of the crowding-in versus the crowding-out hypothesis has been extensively investigated in the empirical literature using different econometric techniques and somewhat different samples (for either developing or developed countries)[3]. In Table 1 we offer a summary of a selected group of studies that focus on developing countries. We report comparative information on the sample countries, the used econometric method and the main findings.

As one can notice, the provided results are mixed. Several studies make use of pooled samples that mix regions with different macroeconomic problems and distinct situations. This makes it difficult to find sufficient basis for generalization. But, even when the focus is on a single country (e.g. the case of India; compare Mallik, 2001, Serven, 1996, and Sundarajuan and Thakur, 1980), conclusions may result contradictory. Then a further empirical investigation is called for.

In this paper we implement a time series study on a sample of HIPCs. In particular we have included in the sample all the countries belonging to the HIPC group[4] for which at least twenty years time series were available in the official statistics[5]. Relying on this method, we have selected seven countries with similar macroeconomic characteristics (low or even negative growth rates, high external debt, and widespread poverty) and precisely: Cameroon, Congo Democratic Republic, Ghana, Kenya, Malawi, Myanmar, and Nicaragua. The overall

[3] Gramlich (1994) provides an interesting review essay about the debate on public infrastructure.
[4] The list of the HIPCs is available in IMF and World Bank (2001b).
[5] A more detailed data source description is in Appendix A.

Table 1. Crowding-in versus crowding-out in developing countries

Reference	Sample countries	Econometric technique	Conclusions
Ahmed and Miller (2000)	39 developing + OECD countries	Panel regression estimation with fixed and random effects	*IG* crowds-out *IP* in general but transportation and communication expenditure crowds-in *IP* in developing countries.
Blejer and Khan (1984)	24 developing countries (Latin America and Asia)	Private investment model estimation	*IG* in infrastructure crowds-in *IP* Non-infrastructural *IG* crowds-out *IP*
Easterly and Rebelo (1993)	Over 100 developing + OECD countries	Cross-section regression estimation	Crowding-out with total *IG*, but different mixed conclusions with disaggregated *IG* by sector and level of government.
Everhart and Sumlinski (2000)	63 developing countries (South, East and Central Asia, Eastern Europe, Middle East and North Africa)	Panel regression estimation with random effects and pooled squares estimation	In the pooled estimation crowding-out (stronger when corruption is included into the model) Crowding-out also for regional estimations with the only exception of Africa
Ghura and Goodwin (2000)	31 developing countries (Asia, Sub-Saharan Africa and Latin America)	Panel regression estimation with fixed and random effects	Crowding-in with the pooled data *IG* stimulates *IP* in Sub-Saharan Africa, but crowds-out in Asia and Latina America
Greene and Villanueva (1991)	23 developing countries (Asia, Sub-Saharan Africa and Latin America)	Pooled time-series, cross-section approach	Crowding-in
Hadjimichael and Ghura (1995)	41 Sub-Saharan African countries	Panel regression estimation (GLS)	Crowding-in Important role of macroeconomic and other public policies in encouraging *IP* and growth
Mallik (2001)	India	Macroeconomic simulation model	Crowding-in
Odedokun (1997)	48 developing countries (Sub-Saharan Africa, Asia, Europe and North Africa)	Panel regression estimation with fixed effects	Infrastructural *IG* crowds-in *IP* Non-infrastructural *IG* crowds-out *IP*
Ramirez (1996, 1998, 2000)	Chile and Mexico (Ramirez, 1996); Mexico (1998); Latin America (2000)	Growth model estimation	Crowding-in
Serven (1996)	India	Vector-autoregressive error correction model estimation	In the short run *IG* crowds-out *IP* In the long run *IG* in infrastructure crowds-in *IP*
Sundarajuan and Thakur (1980)	India and Korea	Dynamic model estimation	Crowding-out

IP = Domestic private investment; *IG* = Domestic public investment

period considered covers the years 1970-1999 (but it changes somewhat depending on the availability of data).

The econometric strategy applied pays particular attention on both the dynamic behaviors of the series and the presence of feedbacks in their mutual relations[6]. The procedure includes cointegration analysis, *VECM* (Vector Autoregressive Error Correction Model) estimation and impulse response study. The empirical investigation is applied on public investment (*IG*), private investment (*IP*) and gross domestic product (*GDP*). All the variables are considered in logarithmic form.

The reasons for the choice of this econometric procedure are the following. As well known, an approach based on the estimation of static equations in levels, which are mostly used by the literature[7], may present some limitations. First, if a regression in levels is run without employing a time series analysis, the procedure does not tackle with the non-stationarity of the variables (see also Munnell, 1992). Hence, if the variables are non-stationary and cointegration does not occur, the regression is spurious and the estimation results are meaningless. Otherwise if the variables are non-stationary and further cointegrated, but the regression does not include the dynamic adjustments, the *OLS* estimates may suffer from the simultaneity bias and residuals may be correlated. In this case, even if *GLS* correction is implemented, conclusions on causality remain affected and are likely to be unreliable. Second, single regression estimation imposes strong restrictions on the model specification and the direction of causality among the variables. Hence the dynamic feedbacks are neglected in the analysis[8]. On the contrary, in our procedure the two cases (*IP* versus *IG* and *IG* versus *IP*) of Granger causality are allowed[9], and all the dynamic interrelationships among the variables are taken into account in a multivariate framework, examining the short run impacts as well as the adjustment processes over a long term horizon (10 years).

[6] The procedure mainly follows the empirical method used by Pereira (2001a, 2001b), although focusing on different variables and a different countries sample.
[7] See, for instance, Aschauer (1989a, 1989b).
[8] If a regression is estimated with *IP* as endogenous and *IG* (together with others) as explanatory variable, it is a priori required that *IP* does not exert any effect on the variables on the right side, and feedbacks are excluded.
[9] In order to solve the identification problem, as it will be specified below, some restrictions on the instantaneous shocks on the variables are imposed at the beginning and relaxed later on. However they do not affect the Granger causality which, as well known, allows for the effects of one variable lagged at least once on the other.

The strategy is described more in detail as follows. As a preliminary step, we allow for the presence of non-stationary trends due to autoregressive unit root. Following the Engle-Granger methodology, we run a time series analysis for any variable under observation. Dickey-Fuller (*DF*), augmented Dickey-Fuller (*ADF*) and Phillips-Perron (*Z*) tests are implemented on our sample.

Then we test for cointegration among the three variables in order to find out, if any, the existence of economically significant relationships. On the one hand, we conduct the *ADF* test on the residuals yielded by the long run equilibrium regression among the variables. On the other hand, we run the likelihood-based Johansen procedure which employs cointegration techniques within a multivariate system of equations.

As stated by the Granger theorem, variables which are found $I(1)$ and cointegrated admit an error correction representation. In this case a vector autoregressive error correction model (*VECM*) is suggested. Indeed, in presence of non-stationarity and further cointegration, model techniques which do not consider the dynamic adjustment of the variables on the long run equilibrium relationships would lead to incorrect conclusions. On the contrary, the *VECM* estimation applied on non-stationary variables enables us to study the dynamic relations among the series through the adjustment mechanism. The well-specification of the *VECM* is proved by the diagnostic tests on the residuals.

Then, we implement impulse response analyses in order to single out the effects produced by shocks in one variable on all the others, and study the dynamic behaviors of the series on a ten years horizon. Finally, sensitivity analysis and variance decomposition are implemented.

3. Empirical results

3.1 Unit root and cointegration tests

As a preliminary step, we run unit root tests (*DF*, *ADF* and Phillips-Perron) on the three time series *IP*, *IG* and *GDP*. We found that the null hypothesis of unit root is not rejected for all the series in the sample (results are available upon request). We also test the presence of roots of higher order. The hypothesis of $I(2)$ is always strongly rejected. We conclude that the three variables under consideration present a unit root, i.e. they are non-stationary in levels but stationary in first differences.

Then standard Engle and Granger[10] cointegration tests are applied on the same group of variables: *IG*, *IP*, and *GDP*. Accordingly, the long run regression of each variable on the others is estimated and the *ADF* test is run on the residuals (the auxiliary regression does not include either intercept or trend). The choice of the lag-length follows what suggested by the Akaike and the Schwartz Information Criteria. The output is reported in Table 2.

Table 2. Cointegration test: *ADF* on the residuals

Country (obs.)	Eq. regression	Lag(s)	Statistic	Result[1]
Cameroon (25)	1	1	-3.59962	reject at 1%
[Lags in *VAR*=2]	2	1	-2.85709	reject at 1%
	3	1	-2.33952	reject at 5%
Congo D.R. (27)	1	1	-4.01030	reject at 1%
[Lags in *VAR* =3]	2	1	-3.25958	reject at 1%
	3	1	-3.72455	reject at 1%
Ghana (22)	1	1	-3.90032	reject at 1%
[Lags in *VAR* =2]	2	1	-3.74095	reject at 1%
	3	1	-3.14189	reject at 1%
Kenya (25)	1	2	-4.55107	reject at 1%
[Lags in *VAR* =2]	2	2	-4.25596	reject at 1%
	3	1	-3.33513	reject at 1%
Malawi (20)	1	1	-3.28131	reject at 1%
[Lags in *VAR* =2]	2	2	-3.54051	reject at 1%
	3	1	-2.60697	reject at 5%
Myanmar (26)	1	1	-2.95346	reject at 1%
[Lags in *VAR* =2]	2	1	-3.49098	reject at 1%
	3	1	-4.95272	reject at 1%
Nicaragua (26)	1	2	-2.42068	reject at 5%
[Lags in *VAR* =2]	2	1	-3.16540	reject at 1%
	3	1	-3.19124	reject at 1%

[1] Critical values in Dickey-Fuller tables reported by MacKinnon (1991)

As one can notice, the null hypothesis of no cointegration is very strongly rejected for the entire group of variables (always at the 1% level, but few cases at the 5%). The conclusion of cointegration is confirmed by the results of the Johansen procedure[11]. The test implemented is of the likelihood-based inference type; it circumvents some problems which arise for the *ADF* and has proved to be more powerful than alternative cointegration approaches[12]. The assumption of none, linear or quadratic time trend in the data, as well as the presence of intercept and/or trend in the cointegrating regression, are based on the Akaike and the Schwartz Information Criteria. As one can observe in Table 3, the hypothesis of at least one cointegrating vector is not rejected for the whole sample. The hypothesis of three cointegrating vectors is always rejected, what is

[10] See Engle and Granger (1987).
[11] See Johansen and Juselius (1990).
[12] For a comparative study on alternative cointegration approaches we refer to Gonzalo (1994).

expected since otherwise it would mean stationarity of all the series (which we exclude according to the unit root analysis above).

Table 3. Cointegration test: Johansen

Country (obs.)	Data trend	Det. comp.	Eigenvalue	LR	No. of CE(s)[2]
Cameroon (25)	none	none	0.50716	24.55374	none*
[Lags in *VAR* =2]			0.27151	8.98710	at most 1
			0.08764	2.01792	at most 2
Congo D.R. (27)	none	none	0.48168	25.25512	none*
[Lags in *VAR* =3]			0.34434	10.14060	at most 1
			0.01861	0.43207	at most 2
Ghana (22)	linear	c & t	0.90575	75.95438	none**
[Lags in *VAR* =2]			0.72538	31.08064	at most 1**
			0.29070	6.52590	at most 2
Kenya (25)	none	none	0.64084	34.12368	none**
[Lags in *VAR*=2]			0.37629	11.59589	at most 1
			0.05353	1.21038	at most 2
Malawi (20)	none	c	0.84424	43.92385	none**
[Lags in *VAR*=2]			0.37027	12.31342	at most 1
			0.23038	4.45159	at most 2
Myanmar (26)	linear	c & t	0.82146	71.18701	none**
[Lags in *VAR* =2]			0.60162	31.55879	at most 1**
			0.36350	10.39067	at most 2
Nicaragua (26)	linear	c & t	0.76394	47.27966	none*
[Lags in *VAR* =2]			0.32396	14.07564	at most 1
			0.19787	5.07121	at most 2

[2] Critical values in Johansen and Juselius (1990)

*: rejection of the null hypothesis at 5%; **: rejection null hypothesis at 1%

The previous results lead us to conclude in favor of the hypothesis of cointegration for all the variables under consideration and for the whole sample.

3.2 Vector Error Correction Model

In order to investigate the dynamic interrelations among the variables, we construct a non-structural *VECM* for the three variables under consideration, without imposing any zero constraint on the parameters[13]. The *VECM* specification may assume no deterministic trend, as well as linear or quadratic time trend in the data. In each case, intercept and/or trend may be included in the cointegrating equation. The choice of the lag-length as well as the inclusion of intercept and/or trend follows the Akaike and the Schwartz Information Criteria. Finally, the number of cointegrating vectors (i.e. the rank) is defined on the basis of the results of the Johansen procedure previously applied (details about the *VECM* specifications are available upon request).

Diagnostic tests verify the validity of the model specification. Therefore we implement tests for normality, first and second order autocorrelation and *ARCH* (conditional

[13] About a discussion on the over-parameterization of the unrestricted *VAR* see Sims (1980).

heterosckedasticity) effects[14] on the residuals. We obtain conclusions supporting the null hypothesis of white noise at least at one percent significance level (results are available upon request).

3.3 Impulse response and sensitivity analysis

In this section we identify the interrelated dynamics of *IG*, *IP* and *GDP* in response to shocks in *IG* over a ten years time horizon, paying attention to both the instantaneous effects (through the evaluation of the impact multipliers) and the subsequent paths of dynamic adjustment, which inform about the persistence of the initial innovation on the time series considered.

A preliminary remark is due. Residuals yielded by a non-structural *VECM* are never completely contemporaneously uncorrelated[15]. Therefore, we need to purge the effect under examination from the spurious influence due to residual correlation. Accordingly, additional restrictions are necessary in order to attribute all the effects of the common stochastic component to only one of the variables. In such a way, the circular transmission of the shocks is broken and the identification of the impulse responses is made possible. Technically, the matrix of contemporaneous correlations is orthogonalized by the Choleski decomposition, which enables to introduce asymmetry in the system. This defines an ordering of causality among the variables (i.e. imposing a priority) and preventing some impulses on one variable (e.g. x) from having an instantaneous impact on one other (e.g. y). As a consequence, the latter (y) is considered as a prior with respect to the former (x).

Consistently with the above technical discussion, the following impulse response analysis relies, at the beginning, on a crucial hypothesis which characterises what we will call hereafter our 'central case'[16]. Indeed, we impose that the complementarity relation between public investment and private investment works from the former variable to the latter and not the other way round[17]. The underlying reasoning is the following: while it is plausible that the public sector is able to affect private decisions even in the short run (within one year period), it is quite

[14] Respectively Jarque-Bera test and first and second order Q-statistics test on the raw residuals and the squared residuals.
[15] Also in our case this conclusion may be deduced by observing the variance-covariance matrix of the residuals obtained from the *VECM* estimation. The correlation is always positive (with the only exception of Malawi) and quite high. Details are available upon request.
[16] However this hypothesis will be successively relaxed in order to test the robustness of the results obtained.
[17] We underline that the hypothesis of priority of public on private investment is assumed also in other empirical works on the same topic, see for instance Pereira (2001b).

unlikely that public expenditures adjust to private behaviours instantaneously, due to information, organization and implementation problems. As a consequence *IG* is set as exogenous at time zero. This means that impulses on *IG* are prior with respect to shocks in *IP* and *GDP*. The former instantaneously affect the others, but the reverse is excluded by hypothesis. Nevertheless all the variables mutually respond to shocks in the others within the entire subsequent adjustment process (within ten years horizon). Finally, no restrictions are made on *GDP* so that, as intuitive, this variable receives, preserves and transmits all the impulses originated from the other series in the model[18].

In Appendix B we provide the impulse response functions that describe the dynamic effects on current and future values of the three endogenous variables after one standard deviation shock in all the others. However, since the crux of this section consists in studying empirically the effect of public investment on private sector investment and *GDP*, we focus the attention on the impulse responses generated by shocks in *IG*.

As one can notice, conclusions are quite homogenous for six out of seven countries of our sample. Indeed, with the only exception of Malawi, the obtained impulse functions lie almost always over the zero line, providing evidence of positive responses of *IP*, *GDP* and *IG* itself to the initial positive shock in *IG*. This result may be interpreted as showing that a rise in public investment leads, in six out of seven countries, to an increase in private investment and *GDP*. Few further observations are worth noting. Firstly, in the case of Congo Democratic Republic the complementary relation between public and private investment works with one period (six-month) lag. Secondly, *IG* and *IP* impulse response functions for Myanmar and Nicaragua are negative for a short period about, respectively, the forth and the third year of the time horizon. However, since these negative variations are modest, the main conclusion remains unchanged. Finally, as already said, the case of Malawi is quite different from the others. We observe that once a positive impulse in *IG* is run, the variable itself shows positive response for the first three years and decreases thereafter. *IP*'s and *GDP*'s responses are characterised by negative and significant variations since the beginning.

Some comments on the magnitude of the impacts may be useful. By observing the impulse response dynamics, we observe that the effect on *GDP* is in general smaller in absolute terms. However, this result is the consequence of the fact that the standard errors referred to the

[18] Our central scenario includes the two possible orders (*IG*, *IP*, *GDP*) and (*IG*, *GDP*, *IP*) which provide analogous result if only the impulses on *IG* are considered.

equation of *GDP* are always smaller than the others due to a better estimation of the equation regression[19]. We may conclude that only the absolute value of the impulse response figures are affected and not their statistical significance.

In order to study the long term total effects caused by an innovation in *IG* over the entire time horizon, in Table 4 we report the aggregated response values of the three variables for our central case. The previous conclusions are corroborated: with the only exception of Malawi, we observe evidence of a complementarity relation between public and private investment and a positive effect of public sector investment on output.

Table 4. Sensitivity analysis

Country	Response	Order I[3]	Order II	Order III	Order IV	Order V	Order VI
Cameroon	*IG*	3.27977	3.27977	2.56209	3.29375	2.34231	2.56209
	IP	0.51746	0.51746	0.11903	0.52549	-0.00830	0.11903
	GDP	0.31934	0.31934	-0.15422	0.32460	-0.16467	-0.15422
Congo DR	*IG*	1.99274	1.99274	0.74935	2.30604	1.05953	0.74935
	IP	1.13664	1.13664	0.32621	1.41951	0.42777	0.32621
	GDP	0.32788	0.32788	0.00643	0.38978	0.11140	0.00643
Ghana	*IG*	3.65034	3.65034	1.27107	1.23874	2.74394	1.27107
	IP	2.46978	2.46978	0.78042	0.77445	1.80039	0.78042
	GDP	0.55756	0.55756	0.19063	0.19115	0.40805	0.19063
Kenya	*IG*	1.24230	1.24230	0.61133	1.22212	0.60161	0.61133
	IP	0.31318	0.31318	0.22972	0.29026	0.20896	0.22972
	GDP	0.39959	0.39959	0.14073	0.39254	0.13792	0.14073
Malawi	*IG*	0.18902	0.18902	0.23190	0.23182	0.18920	0.23190
	IP	-2.27141	-2.27141	-0.70368	-0.71516	-2.24703	-0.70368
	GDP	-0.71860	-0.71860	-0.67102	-0.66967	-0.72136	-0.67102
Myanmar	*IG*	0.51264	0.51264	-0.37198	0.11501	-0.39250	-0.37198
	IP	0.60905	0.60905	-0.51455	0.12661	-0.56346	-0.51455
	GDP	0.28131	0.28131	-0.18053	0.08780	-0.20939	-0.18053
Nicaragua	*IG*	2.46307	2.46307	0.96809	0.23739	0.64681	0.96809
	IP	1.16639	1.16639	0.06242	-0.39359	1.02588	0.06242
	GDP	0.73314	0.73314	0.22611	0.65480	0.23611	0.22611

[3]Alternative Choleski decomposition orders of the variables are referred in the table as follows.
I: *IG IP GDP*; II: *IG GDP IP*; III: *IP GDP IG*; IV: *IP IG GDP*; V: *GDP IG IP*; VI: *GDP IP IG*

Then, following Pereira (2000, 2001a, 2001b), we construct the total elasticities which inform on the total accumulated percentage point changes in *IP* and *GDP* per each long term accumulated percentage point change in *IG*, including all the dynamic feedbacks among the three variables[20]. In Table 5 our central case is compared with all the other possible cases

[19] This result is plausible. Indeed it is possible that the equation of *GDP* as dependent on *IP* and *IG* better fits the data with respect to the other two equations, once we consider that investment decisions are highly influenced by unforeseeable elements. Standard errors are available upon request.
[20] The total elasticities, as defined by Pereira (2001b), are obtained dividing the aggregated response values of each variable by the aggregated response values of public investment.

obtained changing the order of the three variables in the Choleski decomposition. This exercise may be interpreted in terms of sensitivity analysis as the robustness of the previous conclusions from our central case is challenged. However, as Table 5 shows, the results are not significantly affected since the signs of the total elasticities remain consistent in the six possible scenarios (with the only exception of few cases for Cameroon and one for Nicaragua) and their amplitude does not change much.

Table 5. Total elasticities

Country	Response	Order I[4]	Order II	Order III	Order IV	Order V	Order VI
Cameroon	*IP*	0.15777	0.15777	0.04646	0.15954	-0.00354	0.04646
	GDP	0.09737	0.09737	-0.06019	0.09855	-0.07030	-0.06019
CongoDR	*IP*	0.57039	0.57039	0.43532	0.61556	0.40373	0.43532
	GDP	0.16454	0.16454	0.00858	0.16902	0.10514	0.00858
Ghana	*IP*	0.67659	0.67659	0.61398	0.62519	0.65613	0.61398
	GDP	0.15274	0.15274	0.14998	0.15431	0.14871	0.14998
Kenya	*IP*	0.25210	0.25210	0.37577	0.23751	0.34734	0.37577
	GDP	0.32166	0.32166	0.23020	0.32120	0.22925	0.23020
Malawi	*IP*	-12.01695	-12.01695	-3.03440	-3.08493	-11.87666	-3.03440
	GDP	-3.80179	-3.80179	-2.89355	-2.88870	-3.81274	-2.89355
Myanmar	*IP*	1.18807	1.18807	1.38328	1.10084	1.43554	1.383275
	GDP	0.54875	0.54875	0.48532	0.76345	0.53347	0.48532
Nicaragua	*IP*	0.47355	0.47355	0.06447	-1.65801	1.58607	0.06447
	GDP	0.29765	0.29765	0.23357	2.75837	0.36504	0.23357

[4]Alternative Choleski decomposition orders of the variables are referred in the table as follows.
I: *IG IP GDP*; II: *IG GDP IP*; III: *IP GDP IG*; IV: *IP IG GDP*; V: *GDP IG IP*; VI: *GDP IP IG*

As final result we implement the variance decomposition analysis (detailed results are available upon request). We obtain that public investment is in general highly economically exogenous as the variance is mostly explained by itself even after 10 periods, in five out of seven cases. These results offer support to the idea that public investment is mostly dependent on autonomous policy decisions that do not necessarily reflect the economic cycle.

4. Concluding remarks

Understanding how public investment affects private investment and output is crucial in order to design effective adjustment policies in highly indebted low-income countries.

This paper provides an econometric procedure that pays attention to the dynamic interrelationships among public investment, private investment and gross domestic product. The method, besides studying the integration and cointegration properties of the time series considered, evaluates the direct and indirect effects generated by shocks on public investment and examines all the feedbacks over a long period time horizon (ten years). This procedure has

been applied on a selected group of HIPCs. The results obtained provide empirical support, in six out of seven cases, for the existence of a complementarity relationship between public and private investment and a positive effect of public investment on output.

Several extensions of the presented work seem worth pursuing in the course of future research. In particular more theoretical and empirical analysis is required and country studies are necessary in order to achieve adequate policy receipts. Moreover, the samples should be extended to include other highly indebted countries and serious data problems should be solved to obtain more secure econometric investigation.

Nevertheless, our conclusions suggest that the analysis of adjustment with growth in highly indebted countries should consider carefully and country-by-country the possibility of crowding-in and output-enhancing effects of public investment. Indeed, where these effects prevail, policies of fiscal adjustment which lower government investment may shrink aggregate investment, affect negatively output and even compromise the adjustment in the long run. In such a case, fiscal stability could be reached only at the high cost of compromising economic performance.

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Appendix A: Data

All the data are annual and obtained from the World Bank Development Indicators 2001. All the variables are used in logarithmic form. The variables we used are defined as follows:

- *GDP* (output) = Gross Domestic Product in constant local currency (LCU)
- *IG* (public investment) = Capital expenditure in constant local currency (LCU)
- *IP* (private investment) = Private gross fixed capital formation in constant local currency (LCU)

These variables are obtained from the dataset in the following way:

- *GDP* = Gross Domestic Product in constant LCU
- *IG* = (capital expenditure in % of total expenditure)* total expenditure/100
- Total expenditure = (total expenditure in % of GDP)* GDP/100
- *IP* = Gross fixed capital formation – IG
- Gross fixed capital formation = (Gross fixed capital formation in % of GDP)*GDP/100.

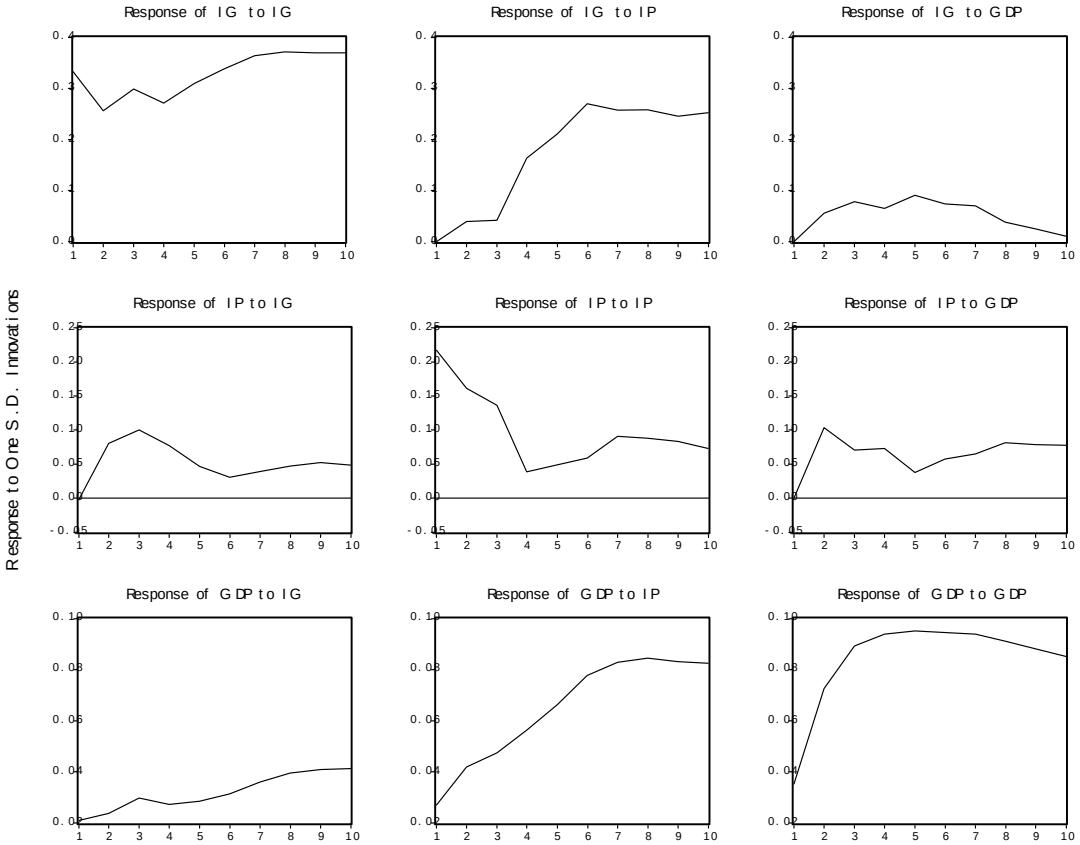
Countries and periods in the sample are as follows:

1. Cameroon: 1975-1999
2. Congo D.R.: 1971-1997
3. Ghana: 1972-1993
4. Kenya: 1972-1996
5. Malawi: 1972-1991
6. Myanmar: 1973-1998
7. Nicaragua: 1970-1995

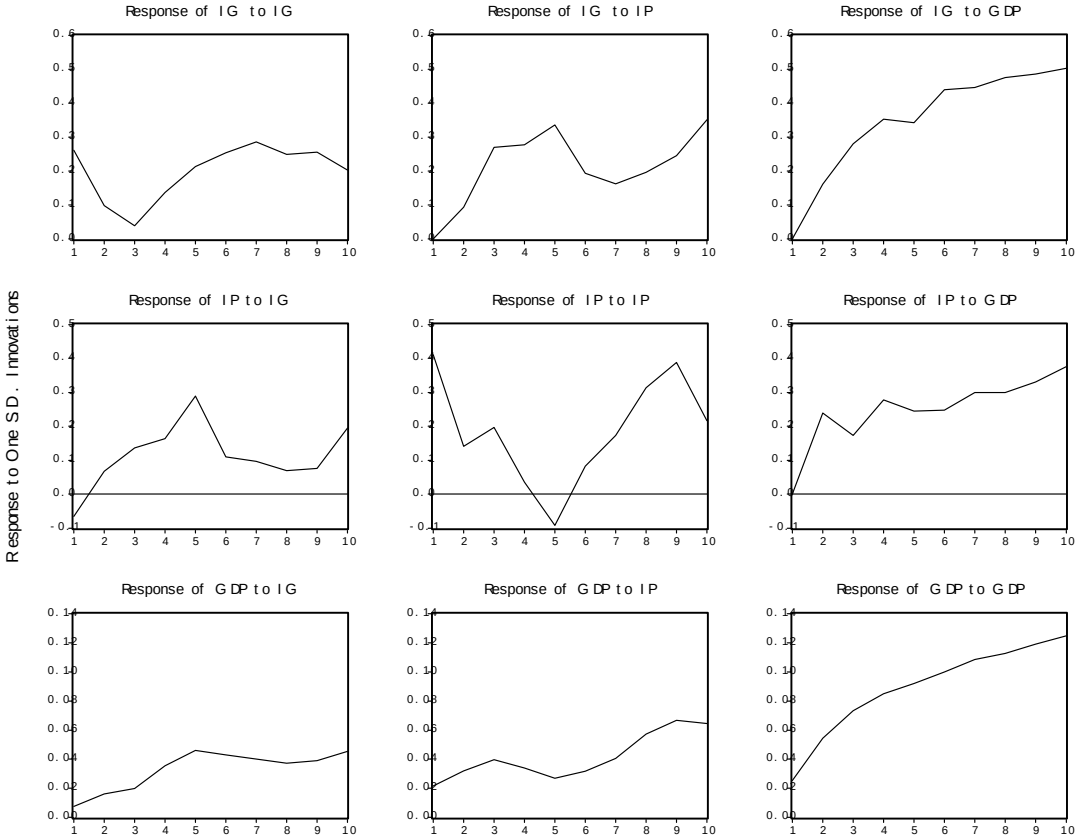
The econometric software package used is E-Views.

Appendix B: Impulse responses

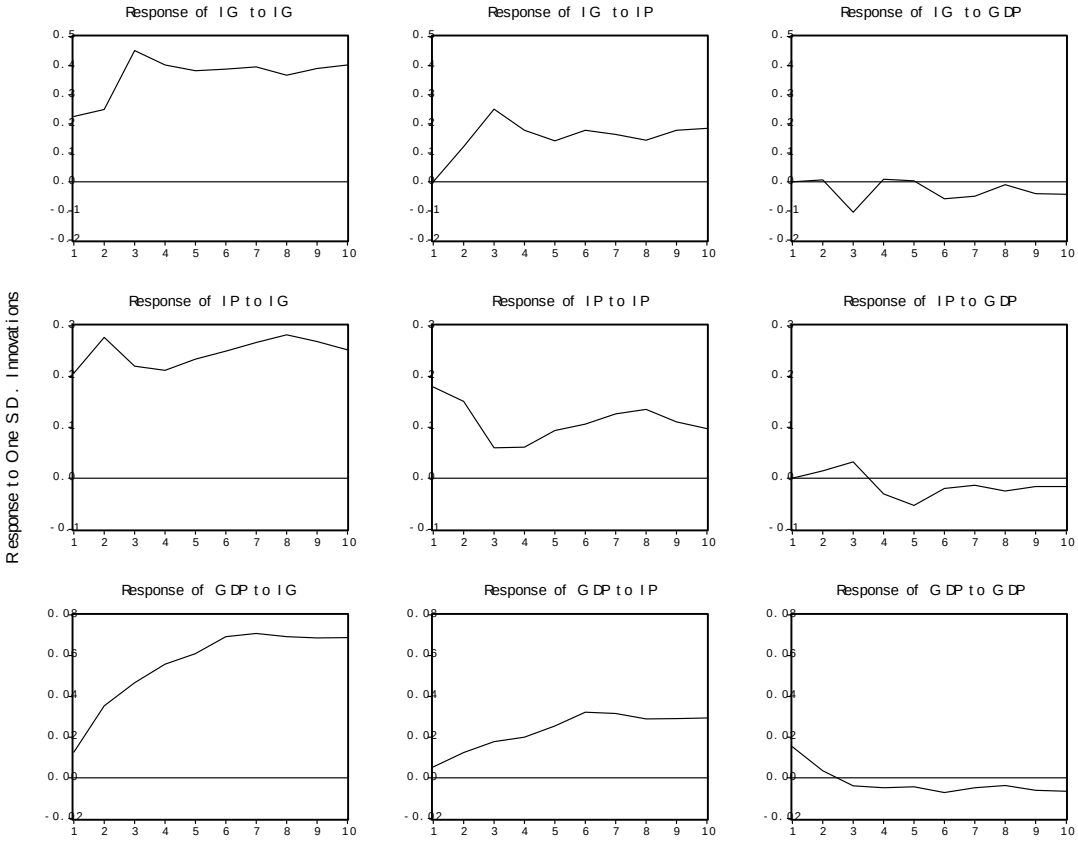
Cameroon



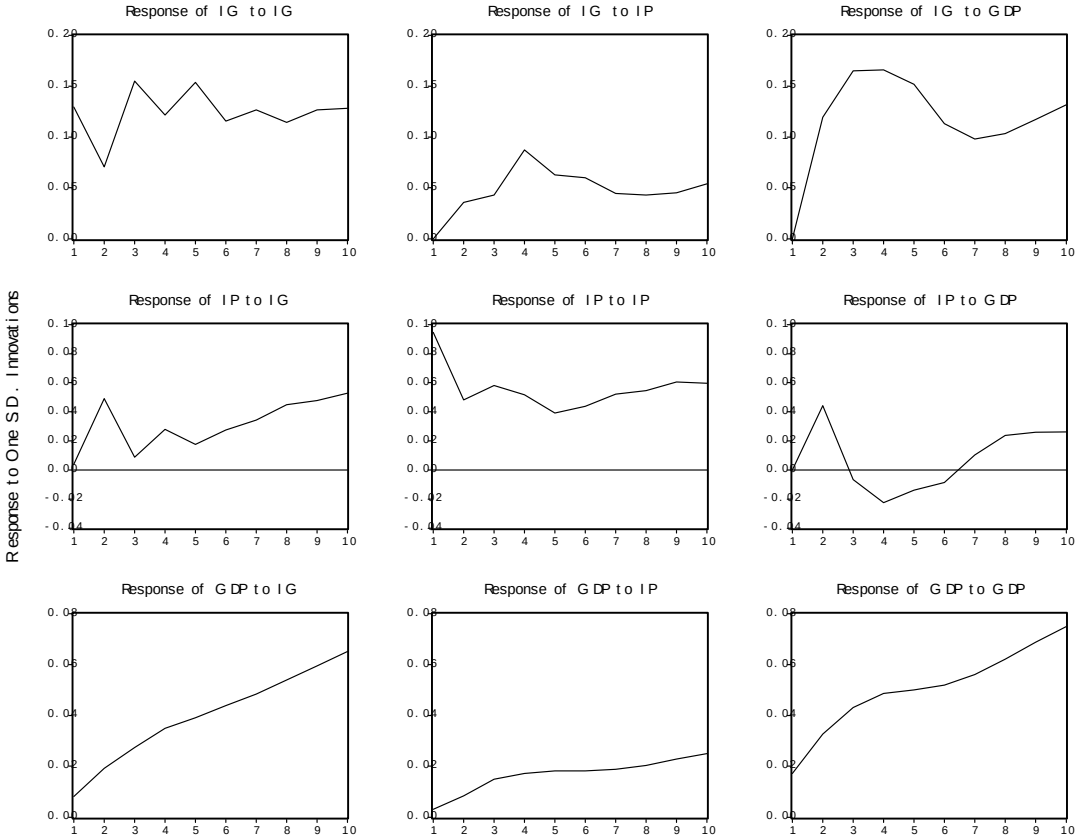
Congo D.R.



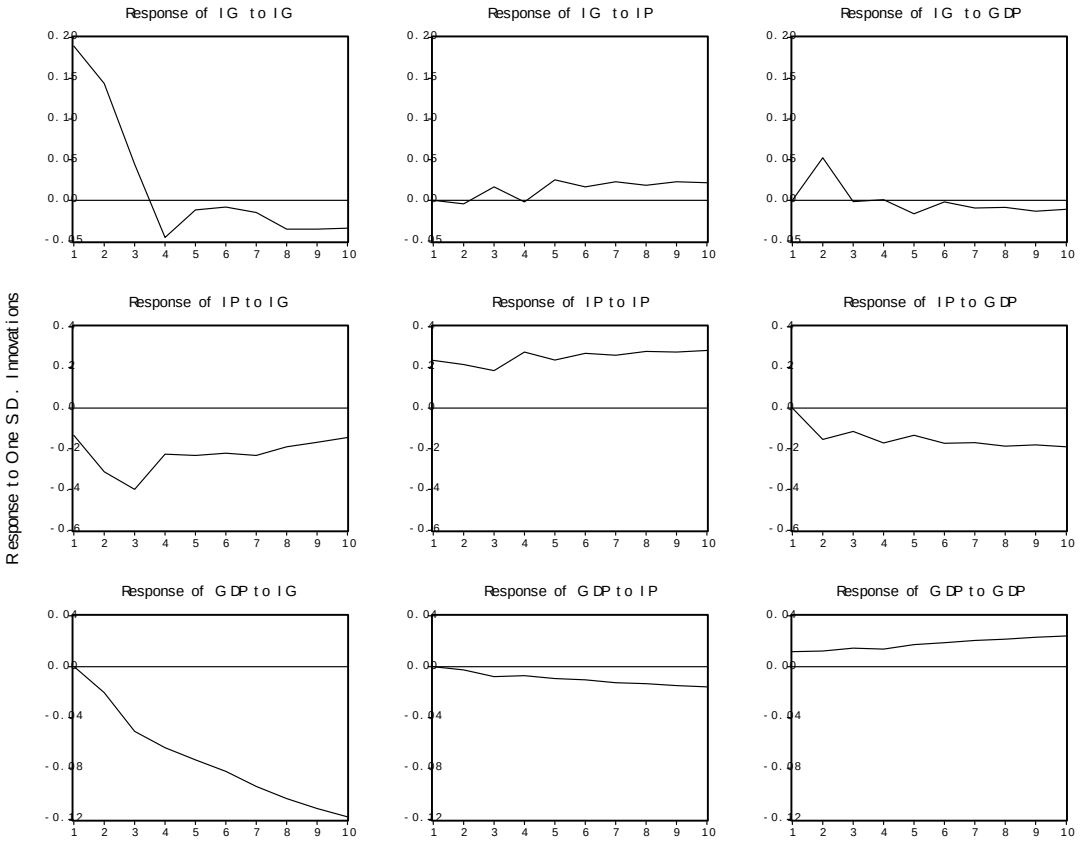
Ghana



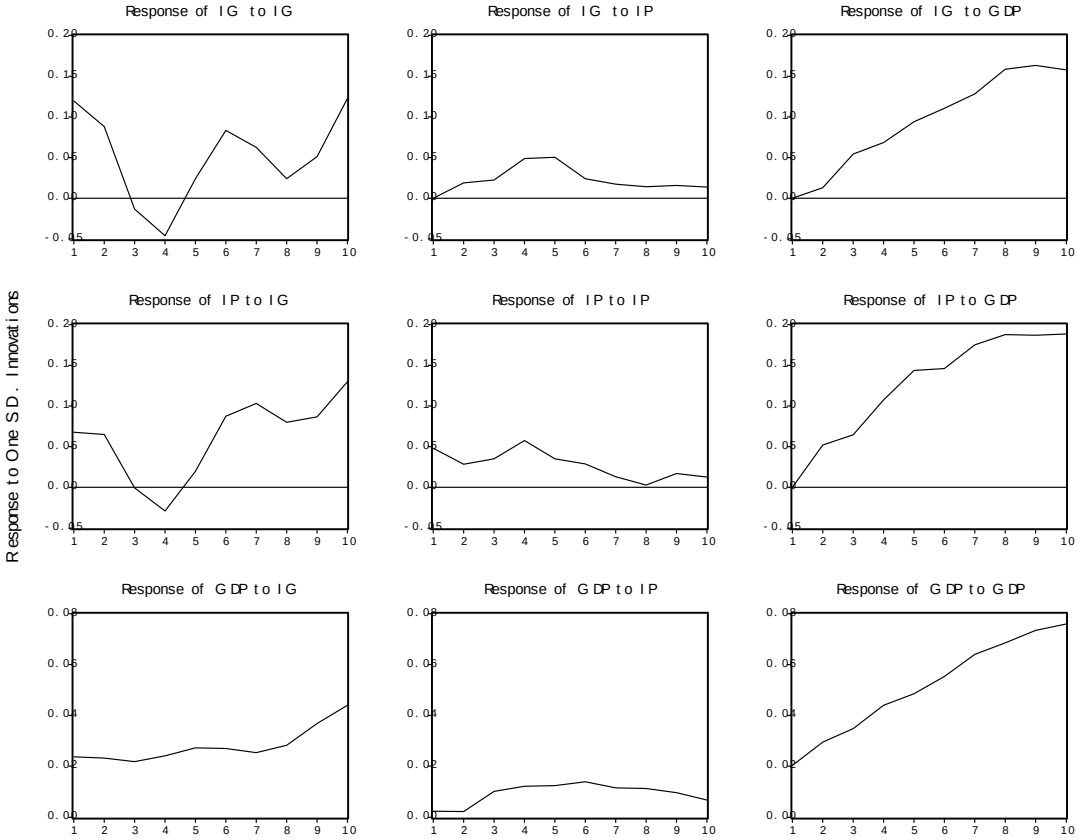
Kenya



Malawi



Myanmar



Nicaragua