INVESTMENT and ECONOMIC GROWTH

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Abstract

We used unit root and cointegration techniques to determine the long run relationship between GDP and investment for 90 countries using data from World Bank for the period 1960-1992. In the first step of our analysis we found GDP and investment integrated of different orders for 33 countries. Second step of our analysis shows no cointegration between GDP and investment for 25 countries and cointegration for 25 countries with both variables of order I(1). The other 7 countries with both variables of order I(0) are in long run relation and do not need cointegration test. To determine the direction of causal effect between GDP and investment we used Granger causality test as the third step of our analysis. We found causality in the short run for 15 countries and in the long run for 23 countries. Bi-directional causality is found for 10, unidirectional causality from GDP to investment for 18 and from investment to GDP for 10 countries. The causality from GDP to investment is positive for 11 countries and from investment to GDP for 6 countries. Bi-directional causality is mostly positive between the two variables.

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1. Introduction

There is general agreement that, in all countries, the process of economic growth and investment/capital formation is closely interconnected. Both neo-classical and Marxist economists have placed main emphasis on capital accumulation as the engine of economic growth. An important use of capital is to increase the production of capital intensive goods. The consumption of such goods generally increases with the growth of income through which capital accumulation promotes growth of income (Sundrum, 1993). All growth models focus on capital as one of the two central parameters in determining the rate of economic growth. An increase in the capital stock certainly needed to promote growth of production. According to World Bank (1989), GDP growth is higher for those countries, which have relatively higher investment/GDP ratio.

Generally speaking investment refers to all economic activity which involves the use of resources to produce goods and services. Investment in infrastructure is particularly important for the development of less developed countries (LDCs), because infrastructure makes it possible for producers to use modern technology and by introducing modern technology to producers, infrastructure expansion directly stimulates productive activities. Investment in education and training produces skilled and more productive labor. Investment in agricultural research and extension services improves and facilitates the dissemination of the results of scientific researches that also increases production.

Investment in human capital raises the value of parent time and cost of raising children. An increase in the cost of raising children decreases fertility and increases desired saving per person, which in turn raises the per capita growth rate (Barro, 1991).

In the general literature on economic development, writers have emphasized the importance of investment/capital formation in the process of development. In view of the importance of the subject, many empirical studies have been conducted to assess the role of investment/capital formation in economic growth. In his paper Anderson (1990), tries to find the role of investment in economic growth and development by deriving an accounting relationship between the rate of economic growth and variables representing the rate, allocation and efficiency of investment. His analysis shows that investment plays greater role in a country's growth if it is used efficiently to increase the output. On the other hand if investment is made inefficiently it results in lower rate of growth of output.

Blomstorm et al. (1996) in their analysis of fixed investment and economic growth used Granger-Sims Causality framework for 101 countries. Their findings show that growth has more causal effect on subsequent capital formation rather than capital formation on subsequent growth and fixed investment does not have a key role in economic growth.

Chow (1993) studied the role of capital formation in China's economy as well as in the five major sectors; agriculture, industry, construction, transportation and commerce. He found rate of return to capital in 1980 as 0.16, 0.20, 0.17, 0.26, 0.04 and 0.02 for aggregate economy, agriculture, industry, construction, transportation and commerce respectively. His analysis shows that from 1952 to 1985 China's aggregate income grew by an average rate of 0.06 and capital growth rate increased by 0.076. During this period capital growth rate contributed in the growth of economy by an average rate of 0.045.

Khan and Reinhart (1990) used a simple growth model to test the effects of private and public investment separately on economic growth for 24 developing countries. Their findings show that private and public investment have different effects on the long-run rate of economic growth. Private and public investment plays larger and more important role in economic growth than public investment.

Potiowsky and Qayum (1992) studied the effects of domestic capital formation and foreign assistance on the rate of economic growth for 58 developing countries. Their results do not show any great effects of domestic capital formation and foreign assistance on per capita rate of growth during the years of 1970-1980.

Despite the differences in methodologies and sectors of investment emphasized, Anderson, Blomstrom et al., Chow, Khan and Reinhart, Long, Patnaik and Chandrasekher, and Romer seem generally agreed on the importance of investment in economic growth. These studies have made useful contribution to understand the role of investment in economic growth. However, to our knowledge none of the studies made use of the latest econometric techniques for time series data (like unit roots and cointegration) and examined the causality between investment/capital formation and economic growth. The aim of this study is to test for causality between investment and economic growth for 90 countries using data for the period 1960-1992.

2. Methodology

The Granger (1969) concept of causality is appropriate and used by most of the studies for testing the relationship between variables. According to the Granger causality approach a variable Y is caused by X, if Y can be predicted better from past values of Y and X than from past values of y alone.

For a simple bivariate model, the pattern of causality can be identified by estimating regression of Y and X on all the relevant variables including the current and past values of X and Y respectively and by testing the appropriate hypothesis. By using the following model the causality between two variables can be tested.

$$Y_t = b_0 + \Sigma^{m}_{j=0} a_j X_{t-j} + \Sigma^{m}_{i=1} b_i Y_{t-i} + u_t \quad (1)$$

$$X_t = c_0 + \Sigma^{m}_{i=1} c_i X_{t-i} + \Sigma^{m}_{j=0} d_j Y_{t-j} + v_t \quad (2)$$

Where u_t and v_t are mutually uncorrelated white noise series. Testing the null hypotheses that $a_j = d_j = 0$ for all j ($j = 0, 1 \ldots m$) against the alternative hypotheses that $a_j \neq 0$ and $d_j \neq 0$ for atleast some js will determine the direction of the relationship between X and Y.

Before conducting the causality test we need to ensure that variable series are stationary individually and cointegrated together. A series X_t is said to be integrated of order d denoted by X~I(d) if it becomes stationary after differencing d times and thus X_t contains d unit roots. A series which is I(0) is said to be stationary. To determine whether a series is stationary or non-stationary, unit root test developed by Fuller (1976) and

Dickey and Fuller (1981) is used. The Augmented Dickey Fuller test (ADF) is based on the estimation of the following regression.

$$\Delta X_t = \alpha_0 + \alpha_1 t + \alpha_2 X_{t-1} + \Sigma^{k}_{i=1} \alpha_i \Delta X_{t-i} + e_t \qquad (3)$$

where Δ is the first difference operator, t is a linear time trend and e_t is a normally distributed error term. In (3), the null hypothesis that H_0: $\alpha_2 = 0$ against the alternative hypothesis H_1: $\alpha_2 \neq 0$ is tested by comparing the calculated t-ratio of the estimated α_2 with Mackinnon critical values, which are essentially adjusted t values. If the absolute value of the calculated t-ratio is greater than the critical value, then the null hypothesis of a unit root (non-stationarity) is rejected. In this case the level of time series X_t is characterized as integrated of order zero, i.e. I(0). If it is found that the individual time series in eq. (3) are integrated of order one, I(1), and hence non-stationary, the next step is to examine the cointegration among the series.

A set of variables is said to be cointegrated if a linear combination of their individual integrated series I(d) is stationary. This procedure needs an estimation of the cointegration regression equation.

$$Y_t = \beta * X_t + e_t \qquad (4)$$

If the residuals, e_t, from the regression are I(0), then X_t and Y_t are cointegrated and hence interrelated with each other in the long run. The constant and trend values can also be included in equation (4).

If the series are found cointegrated, then we construct standard Granger causality tests by augmenting with an appropriate error correction term derived from the cointegration equation (4). If the series are I(1), the Granger causality tests are applied after taking their first differences and with that (1) and (2) take the form

$$DY_t = b_0 + \Sigma^m_{j=0} a_j DX_{t-j} + \Sigma^m_{i=1} b_i DY_{t-i} + \lambda_1 ECT_{t-1} + u_t \quad (5)$$

$$DX_t = c_0 + \Sigma^m_{i=1} c_i DX_{t-i} + \Sigma^m_{j=0} d_j DY_{t-j} + \lambda_2 ECT_{t-1} + v_t \quad (6)$$

where the ECT_{t-1} is the error correction term lagged one period and D denotes the first difference of the variables. The lag length m is 2 unless otherwise mentioned. While the choice of lag is arbitrary, it does represent the period long enough to show the effect of investment on GDP and vice versa. Some countries might take longer time to complete the investment projects than others (e.g. developing vs. developed) therefore, more than one lag length is used.

For the ADF, cointegration and causality tests, we used the Econometric Views (EViews) software package. ADF tests were tried with constant and trend terms, with a constant only, and without constant or trend terms. The results reported in all tables include a superscript c and t if the constant and trend terms are significant in the ADF test. For the cointegration tests, we tried five combinations of constants and trends available with the EViews package.

The data used for this study are taken from World Data available on CD-ROM from the World Bank (1994). Values for GDP and investment are in constant local market prices for the years 1960 to 1992. In a few cases the period covered is different from 1960-1992 and in such cases actual period is shown with or below the name of the country. The variables used are; LGDP = log of GDP per capita, and LINV = log of the ratio of investment to GDP.

3. Empirical results

3.1. Order of Integration

Using the ADF test, we found that for 33 countries, GDP and investment are integrated of different orders. Table 1 shows the results of the ADF test. The stars *, **, *** show statistical significance levels at 1, 5, and 10 percent respectively, and ‘c’ and ‘t’ shows constant and trend terms respectively if they are significant in the ADF test. For most of the countries the two variables are integrated of order zero or one, i.e., I (0) or I (1). There are only 3 countries namely Colombia, Hungary, and Malta for which GDP is integrated of order 2, I(2). There are 8 developed (DCs), 1 OPEC, 2 newly industrialized countries (NICs), and 22 less developed countries (LDCs) in this group. There is no further statistical test for these countries, because the results of those tests would produce inconsistent parameters. For the other 57 Countries GDP and investment are integrated of the same orders.

Table 1
Results of ADF, and Cointegration tests on LGDP and LINV integrated of different orders for 33 countries

Country	LGDP	LINV	Country	LGDP	LINV	Country	LGDP	LINV
Belgium	I(0)^{*,c}	I(1)^{**,c}	Hungary	I(2)*	I(1)^{*,c}	Papa New Guinea	I(1)^{**,c,t}	I(0)^{**,c}
Canada	I(0)^{***,c}	I(1)^{*,c}	India	I(1)^{*,c}	I(0)^{**,c}	Portugal	I(1)^{**,c}	I(0)^{***,c,t}
Colombia	I(2)*	I(1)^{*,c}	Indonesia	I(0)^{***,c,t}	I(1)^{*,c}	Sireleon (1960-88)	I(1)*	I(0)^{**,c,t}
Congo	I(1)**	I(0)^{***,c}	Japan	I(0)^{***,c}	I(1)^{***,c}	Singapore	I(1)^{**,c}	I(0)^{***,c,t}
Cost Rica	I(1)^{**,c}	I(0)^{***,c}	South Korea	I(0)^{***,c,t}	I(1)^{*,c,t}	South Africa	I(0)^{***,c}	I(1)^{**,c}
Dominican Republic	I(1)*	I(0)^{**,c}	Lesotho	I(1)^{*,c}	I(0)^{***,c,t}	Somalia (1960-89)	I(0)^{**,c}	I(1)^{***,c}
Ethiopia	I(1)*	I(0)*	Madagascar	I(1)^{*,c}	I(0)^{**,c}	Thailand	I(1)^{**,c}	I(0)***
Finland	I(1)^{*,c,t}	I(0)^{*,c,t}	Malta	I(2)*	I(1)^{***,c}	Togo	I(1)^{**,c}	I(0)^{***,c}
France	I(0)^{**,c}	I(1)^{*,c}	Myanmar	I(1)*	I(0)^{**,c}	U.K.	I(0)^{***,c,t}	I(1)^{*,c,t}
Greece	I(0)^{**,c}	I(1)^{*,c}	Netherlands	I(0)^{**,c}	I(1)^{**,c,t}	Uruguay	I(0)^{*,c,t}	I(1)^{***,c}
Honduras	I(1)*	I(0)^{**,c}	New Zealand	I(1)^{*,c}	I(0)^{**,c}	Zimbabwe	I(1)**	I(0)^{**,c}

*,**,*** denotes significance at 1,5,and 10 percent respectively
^{c} constant is significant
^{t} trend is significant
I(0) stationary in levels
I(1) stationary after first differencing
I(2) stationary after second differencing

3.2. Cointegration

In the next step of our analysis, we used Johansen Cointegration test for the countries for which GDP and investment are integrated of the same order to test the long run relationship between them. There are 25 Countries for which GDP and investment are integrated of the same order I(1) but they are not related to each other in the long run namely Algeria, Argentina, Bangladesh, Benin, Burundi, Chad, Chile, Ecuador, Egypt, Gabon, Gambia, Ghana, Iceland, Luxembourg, Malawi, Mali, Nigeria, Niger, Paraguay, Peru, Philippine, Rwanda, Spain, Venezuela, and Zambia. There are 2 DCs, 2 OPEC and 21 LDCs among them. From this group, 11 countries show short run causality and they are discussed later.

There are 32 countries for which GDP and investment are cointegrated. The results of cointegration tests for them are presented in Tables 3 and 4. Stars *, **, ***, c, and t represent the same as in Table 1. Values for constant and trend coefficients are reported, if these terms are used in the cointegration equation for some countries. Values in parentheses under LINV coefficient are standard errors. GDP and investment are I(1) for most of the countries except El Salvador, Hong Kong, Mauritania, Sudan, Swaziland, Tanzania, and USA for which they are I(0). Cointegration test is statistically significant at 1 percent level for 15 and at 5 percent for 10 countries. Cointegration results show relationship between GDP and investment positive and negative for 13 countries each[1]. For 7 countries GDP and investment are I(0) and therefore there is no cointegration test for them because variables stationary in levels are supposed to be in long run relation (4 countries are reported in Table 2 and the other 3 in Table 4).

3.3 Causality

Increase in income provide incentive for more savings and in turn more investment thus GDP causing investment. With increase in GDP, governments spend more on infrastructure, which increases the marginal productivity of capital and labor in private sec-

[1] In cointegration equation both the variables are on left hand side therefore positive coefficient on β means negative relationship and vice versa.

tor, encouraging more investment. On the other hand, more investment provides more production capacity, more opportunities for jobs and higher wages resulting in higher income so investment causing GDP.

Both GDP and investment are interdependent and could cause each other simultaneously or there could be no causality among them but they might move together under the influence of other factors.

3.3.1. Causality in the Short Run

As mentioned earlier, there are countries that do not show cointegration between the two variables and for some other countries GDP and investment are stationary in levels i.e. I(0). Equation (1) and (2) are used to determine the causality between GDP and investment for these countries. The existence of causality between the two variables is tested through the null hypotheses that $a_j = 0$ in eq. (1) and $d_j = 0$ in eq. (2) for all js which is done by using the Wald test. If $a_i = 0$ and $d_j = 0$ for all js, then there is no causality. If some $a_j \neq 0$, then Y is said to be caused by X, whereas if some $d_j \neq 0$, then X is caused by Y. Bi-directional causality is inferred if both $a_j \neq 0$ and $d_j \neq 0$ for some js. The sign of the causal effect is determined by adding the coefficients on lagged independent variables.[2]

The results for the 15 countries that show short run causality are displayed in Table 2. Unidirectional causality runs from GDP to investment for 5 countries, from investment to GDP for 5 countries and the remaining 5 countries show bi-directional causality. Bi-directional causal effect is positive for 3 countries and negative for 1 country in both directions. For Iceland causal effect is positive from GDP to investment and negative in reverse direction. The unidirectional causal effect from GDP to investment is positive for 3 and negative for 2 countries. The unidirectional causal effect from investment to GDP is positive for 4 and negative for 1 country.

Table 2
Results of ADF, and Causality tests on LGDP and LINV for 15 countries exhibiting short run causality

	Unit root test		Causality test based on p. values (Wald test)	
Country	LGDP	LINV	LGDP→LINV	LINV→LGDP
Argentina	$I(1)^{*,c}$	$I(1)^{**,c}$	Yes^{*} (+)	Yes^{*} (+)
Burundi	$I(1)^{**,c}$	$I(1)^{*,c}$	Yes^{***} (-)	Yes^{**} (-)
El Salvador	$I(0)^{***,c}$	$I(0)^{***,c}$	Yes^{*} (+)	Yes^{*} (+)
Chile	$I(1)^{**,c}$	$I(1)^{*,c}$	No	Yes^{***} (+)
Egypt	$I(1)^{**,c}$	$I(1)^{**,c}$	No	Yes^{**} (+)
Ghana	$I(1)^{*,c}$	$I(1)^{*,c}$	No	Yes^{**} (+)
Iceland	$I(1)^{**,c}$	$I(1)^{*,c}$	Yes^{**}(+)	Yes^{***} (-)
Luxembourg	$I(1)^{*,c,t}$	$I(1)^{***,c}$	Yes^{***} (+)	No
Malawi (3)	$I(1)^{*,c,t}$	$I(1)^{*,c,t}$	Yes^{***}(+)	No
Nigeria(3)	$I(1)^{**,c,t}$	$I(1)^{**,c,t}$	Yes^{**} (+)	No
Peru	$I(1)^{*,c,t}$	$I(1)^{***,c,t}$	No	Yes^{***} (-)
Spain	$I(1)^{*,c,t}$	$I(1)^{**,c,t}$	Yes^{*} (+)	Yes^{*} (+)
Sudan	$I(0)^{***,c}$	$I(0)^{**,c}$	Yes^{**}(-)	No
Tanzania	$I(0)^{**,c}$	$I(0)^{***,c,t}$	No	Yes^{**} (+)
USA	$I(0)^{***,c,t}$	$I(0)^{*,c}$	Yes^{***}(-)	No

*,**,*** denote significance at the 1,5,and 10 percent respectively. ^{C}, constant is significant. ^{t}, trend is significant. I(0) stationarity in levels, I(1) stationary after first differencing. The + and - signs show the sign of the summed coefficients on the lagged independent variables. The lag length used is 2 unless otherwise given in the parentheses after the country names.

[2] Dodaro (1993) and Ram (1987) used the same method to determine the sign of relationship.

3.3.2. Causality in the long Run

Granger causality test was used to determine the causation between GDP and investment for 25 countries for which both variables are I(1) and found cointegrated.

Causality analysis with cointegrated variables is more extensive and centers on the speed of adjustment coefficients. Causality tests are done on the null hypotheses that $a_j = \lambda_1 = 0$ in eq. (5) and $d_j = \lambda_2 = 0$ in eq.(6) for all js. If the null hypothesis is accepted, there is no causality. If the null is rejected, causality is inferred. The next step is the analysis of the direction of the λs to see if they infer a long run equilibrating relationship. The sign of causal effect was again determined by adding the coefficients on the lagged variables.

Results for long run causality tests for 23 countries are presented in Table 3. Causality between GDP and investment runs in both directions for 5 countries, for the other 18 countries there is unidirectional causality. Bi-directional causality is statistically significant at 1 percent level in both direction for all countries except Sweden from investment to GDP which is statistically significant at 5 percent level. Causality from GDP to investment is statistically significant at 1, 5 and 10 percent levels for 8, 3 and 3 countries respectively. Whereas causality from investment to GDP is statistically significant at 1 percent level for 2 countries and at 5 percent level for 3 countries. Causality between the two variables is positive for 4 countries in both directions. Unidirectional causality is positive from GDP to investment for 8 and from investment to GDP for 2 countries. There are 7 DCs, 1 NIC and 15 LDCs in this group.

Table 3
Results of ADF, Cointegration and Causality tests on LGDP and LINV for 23 countries, exhibiting long run causality

	Unit root test		Cointegration test				Causality test based on p. values (Wald test)	
			Max. Eigen test	Cointegration equation, normalized on LGDP				
Country	LGDP	LINV	L.R. Values	LINV	Constant	Trend	LGDP→ LINV	LINV→ LGDP
Australia	I(1)^{**,c,t}	I(1)^{**,c}	19.03*	2.06 (0.48)	-6.7		No	Yes** (-)
Austria	I(1)^{**,c,t}	I(1)^{*,c}	19.80*	-5.17 (1.96)	-18.93		Yes*** (+)	No
Bolivia	I(1)^{**,c}	I(1)^{**,c}	18.18*	9.73 (315.07)	15.33	0.48	Yes* (+)	No
Brazil	I(1)**	I(1)^{*,c}	17.36**	-5.13 (0.20)			Yes*(-)	No
Burkina Faso (1965-92)	I(1$^{)*,c}$	I(1)^{**,c}	21.73*	0.06 (0.02)	-10.78	-0.01	Yes*(-)	No
Central Africa	I(1)*	I(1)^{**,c}	19.37**	0.29 (0.08)	11.44	0.02	No	Yes**(-)
Denmark	I(1)^{*,c,t}	I(1)^{*,c}	25.03**	3.45 (1.61)			Yes* (+)	Yes* (+)
Germany	I(1)^{*,c}	I(1)^{*,c}	30.43**	-1.51 (3.60)	-14.05		Yes* (+)	Yes* (+)
Guatemala	I(1)***	I(1)^{*,c}	16.22**	-1.46 (0.53)	-9.08		Yes*(+)	No
Ireland	I(1)^{*,c}	I(1)^{*,c}	29.09*	-1.17 (0.93)	-8.78		No	Yes**(+)
Israel (3)	I(1)^{*,c}	I(1)^{*,c,t}	24.89**	0.13 (0.45)	-10.05		Yes**(-)	No
Italy	I(1)^{*,c,t}	I(1)^{*,c,t}	26.90**	1.22 (0.27)	-14.55		No	Yes*(-)
Jamaica (1960-91)	I(1)**	I(1)^{*,c}	19.72*	-0.75 (0.15)	-7.75	-0.02	Yes**(+)	No
Malaysia	I(1)^{**,c}	I(1)^{*,c,t}	30.23*	-2.71 (2.43)	-14.77		Yes**(+)	No
Mauritius	I(1)**	I(1)^{**,c}	15.20**	5.36 (0.46)			Yes*(-)	No
Mexico	I(1)^{**,c,t}	I(1)^{*,c,t}	26.55*	-1.94 (0.35)	-7.10		Yes* (+)	Yes* (+)
Pakistan (3)	I(1)^{**,c}	I(1)^{*,c,t}	24.65*	-0.46 (0.15)	-8.11	-0.03	Yes***(+)	No
Panama	I(1)**	I(1)^{*,c,t}	28.65*	-1.94 (1.46)	-10.33		Yes*(+)	No
Sri Lanka	I(1)^{***,c}	I(1)^{**,c}	16.78*	2.67 (0.68)			Yes*(+)	No
Sweden	I(1)^{**,c,t}	I(1)^{*,c,t}	33.13*	-0.24 (0.45)	-12.22		Yes* (+)	Yes**(-)

Switzerland	I(1)^{**,c}	I(1)^{**,c}	17.77*	-1.34 (0.48)	-12.20		Yes* (+)	Yes* (+)
Turkey	I(1)^{**,c}	I(1)^{*,c,t}	20.56**	1.63 (7.01)	-8.51		No	Yes* (+)
Zaire (1960-89)	I(1)^{*,c}	I(1)^{*,c,t}	14.40**	4.57 (0.18)			yes*** (-)	No

*,**,*** denote significance at the 1,5,and 10 percent respectively. ^{c} constant is significant. ^{t}, trend is significant. The + and - signs show the sign of the summed coefficients on the lagged independent variables. The lag length used is 2 unless otherwise given in the parentheses after the country names. The values in parentheses under the coefficients are standard errors.

There is no causality found between GDP and investment for 5 countries even though the two variables are related in the long run. The results for these countries are displayed in Table 4.

Table 4
Results of ADF and Cointegration tests on LGDP and LINV for 5 countries, exhibiting no causality

	Unit root test		Cointegration test			
			Max.Eigen test	Cointegration equation, normalized on LGDP		
Country	LGDP	LINV	L.R. Values	LINV	Constant	Trend
Hong Kong	I(0)^{**,c,t}	I(0)^{*,c}				
Mauritania	I(0)^{***,c}	I(0)^{*,c}				
Norway	I(1)^{***,c}	I(1)^{*,c,t}	16.55*	6.11 (0.89)		
Swaziland	I(0)^{***,c}	I(0)^{***,c}				
Tunisia	I(1)^{*,c}	I(1)^{***,c,t}	21.84**	0.76 (0.35)	-6.50	

*,**,*** denotes significance at 1,5,and 10 percent, respectively
^{c} , constant is significant
^{t} , trend is significant
I(0) stationary in levels
I(1) stationary after first differencing

Generally, one needs to compare the sign of a variable in the cointegration equation with the sign of λs to determine whether the response is consistent with an economic relation or whether the cointegration is just picking out some undefined long run correlation. If we rewrite our cointegration equation (4) as:

$$LGDP - \beta^{*}LINV = e_t = ECT_t \qquad (7)$$

The ECT_t is equivalent to the e_t and represents the disequilibrium residuals in the cointegration vector. It also contains the cointegration equation coefficients that need to be estimated.

The question of causality arises in evaluating whether the signs on the λs are consistent with long run relationship. If the coefficient β in cointegration equation (7) is positive and there is positive value of ECT_t then either LGDP or LINV fall to bring the system into equilibrium or any combination of the two variables returns the relation to equilibrium. Therefore, the signs on λs in equation (5) and (6) should be negative. By the same token, if LINV has a negative value in the cointegration equation then LGDP needs to decline to return to equilibrium and LINV to rise in subsequent periods to offset positive disequlibria.

We compared the sign of LINV in the cointegration equation with the sign of λs to determine the consistency with real economic relations. The comparison of these signs is given in Table 5.

Table 5
Speed of Adjustment (λ) and Cointegration Vector (β) Directions for Countries Exhibiting Cointegration

	β-		β+	
Variable	Countries with λ-	Countries with λ+	Countries with λ-	Countries with λ+
			Australia	
LINV			Bolivia	
	Austria	Brazil	Burkina Faso	
		Guatemala	Central Africa	
		Ireland	Israel	
		Jamaica	Italy	
		Malaysia	Mauritius	
		Pakistan	Sri Lanka	
		Panama	Turkey	
		Sweden	Zaire	
LGDP	Jamaica	Austria	Australia	Burkina Faso
	Pakistan	Brazil	Bolivia	Central Africa
		Guatemala	Israel	
		Ireland	Italy	Sri Lanka
		Malaysia	Mauritius	
		Panama	Turkey	
		Sweden	Zaire	

Note: The λs are coefficients on the ECT_{t-1} in equations (5) and (6), while the β is the direction of the coefficient on LINV in the cointegrating equation shown in Column 5 of Table 3.

The first two columns show countries with positive and negative λs if the β in the cointegration equation is negative. Negative β in equation (7) implies positive economic relation between LGDP and LINV. The appropriate sign on λs for a positive value of ECT_{t-1} for LGDP is negative and for LINV is positive. Therefore, the countries in the LINV block with a positive λ and in the LGDP block with negative λ show correct economic relation. With positive value of β, LGDP and LINV should decline to bring the system back into equilibrium. Therefore, countries with negative λ in both blocks of LINV and LGDP show correct economic relations.

When the relationship between GDP and investment is positive, while investment seems to move in the right direction for most of the countries GDP moves in the wrong direction except for Jamaica and Pakistan.

4. Concluding Remarks

We used unit root and cointegration techniques to determine the long run relationship between GDP and investment for 90 countries using data from World Bank for the period 1960-1992. In the first step of our analysis we found GDP and investment integrated of different orders for 33 countries. Second step of our analysis shows no cointegration between GDP and investment for 25 countries and cointegration for 25 countries with both variables of order I(1). The other 7 countries with both variables of order I(0) are in long run relation and do not need cointegration test. To determine the direction of causal effect between GDP and investment we used Granger causality test as the third step of our analysis. We found causality in the short run for 15 countries and in the long run for 23 countries. Bi-directional causality is found for 10, unidirectional causality from GDP to investment for 18 and from investment to GDP for 10 countries. The causality from GDP to investment is positive for 11 countries and from investment to GDP for 6 countries. Bi-directional causality is mostly positive between the two variables.

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