INVESTMENT AND ECONOMIC GROWTH IN CHINA AND THE UNITED STATES: AN APPLICATION OF THE ARDL MODEL

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Abstract

This paper examines empirically the long-run relationship between real gross domestic product (GDP) and gross domestic investment (GDI) for the first two largest economies in the world - China (1961-2014) and the United States (1965-2015) using annual time series data. The analysis uses the autoregressive distributed lag (ARDL) approach to test for cointegration between investment and economic growth, followed by the Granger-causality to estimate the direction of causation in each country. The results reveal that a long-run relationship exists among variables in the case of China, in which GDP has a positive impact on GDI. Whereas no evidence of long run relationship to exist in the case of the United States. Besides in short term, the importance of investment on economic growth is confirmed as one percent increase in investment raise GDP by 0.34% in China. The findings further show a unidirectional Granger causality between GDP and GDI and runs from US economic growth to investment growth.

Keywords: Gross Domestic Investment, Economic Growth, Autoregressive Distributed Lag (ARDL) approach

1. Introduction

Investment position of a country is particularly related to its economic development and relative to the rest of the world. It is also an important factor in generating the economy growth rate (Balasubramanyam, et. al, 1996), which generates positive productivity effects for countries. Understanding the role of investment is crucial for policy makers to design an effective policy to promote economic growth and development. There is a widespread belief that investment spending makes direct contribution to economic activity and as the important part of overall financial planning. If we have some savings, we will try to invest to maximize return. A number of growth models advocate for a positive relationship between investment and economic growth (Waithiama, 2007). Besides, findings in this literature indicate that countries' GDP growth rates are highly correlated with their GDI rate (Akinlo, 2004; Nurudeen et al., 2010; Ahmad, 2012) which can be explained by the hypothesis that growth of investment can stimulate economic growth.

The role of investment in promoting economic growth has received considerable attention of economists around the world. For example, Borensztein, et al, (1998) examine the effect of foreign direct investment (FDI) and suggest that FDI is an important vehicle for the transfer of technology, contributing to economic growth. Ghazali (2010) studies the causal relationship between investment and economic growth (GDP) in Pakistan over the period 1981 to 2008 and finds a positive long run relationship between domestic investment and economic growth. More recently, Ahmad (2012) shows a significant relationship between investment and GDP growth in which one percent increases in investment will raise GDP by 0.32%. However, most studies in the literature look at this relationship by commonly testing for cointegration. This paper differs from other studies by examine the relationship among investment and growth by conducting unit root test and using the Autoregressive Distributed Lag (ARDL) approach which is more robust and performs better for the cointegration test. This paper arms to provide the policymakers in each country a planning tool that can help them in formulating their policies to promote economic growth by using annual data of China and the

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United States. The Chinese data is extracted from the World Bank, World Development Indicators online for the period 1961 to 2014 and the United States for the period 1965 to 2015.

The empirical results reveal that there is a long-run relationship, over the sample periods, between investment and GDP growth in the case of China while in the case of the United States such variables appear to have no long-run relationship between them. When examining the Granger causality between investment and real GDP, the test results support GDP has a positive and very significant impact on GDI. A 1% increase in GDP leads to approximately 1.184% increase in GDI in China. In the case of the United States, the results show there is a unidirectional Granger causality between GDP and GDI and that causality run from economic growth to investment growth.

The rest of the paper is organized as follows: the next section describes data and the model followed by the methodology. Section 3 discusses the empirical results. The final section concludes.

2. Econometric Methodology

The Autoregressive Distributed Lag (ARDL) approach is used to test for existence of a relationship between investment (GDI) and economic growth (GDP). The ARDL procedure is adopted for the following three reasons. The first one is that the ARDL does not need that all the variables under study must be integrated of the same order (Sultan, 2012). Secondly, even with small samples, more efficient co integration relationships can be determined (Ghatak and Siddiki, 2001). The third advantage is that the ARDL approach overcomes the problems resulting from non-stationary time series data (Laurenceson and Chai, 2003). The ARDL model used in this study is expressed as follows:

$$DP_t = \alpha_{0\mathrm{P}} + \gamma_{1\mathrm{P}} P_{t-1} + \gamma_{2\mathrm{P}} I_{t-1} + \sum_{i=1}^{t} \delta_{1P}\, DP_{t-i} + \sum_{i=1}^{t} \delta_{2P}\, DI_{t-i} + \varepsilon_t \quad (1)$$

$$DI_t = \alpha_{0\mathrm{I}} + \gamma_{1\mathrm{I}} P_{t-1} + \gamma_{2\mathrm{I}} I_{t-1} + \sum_{i=1}^{t} \delta_{1\mathrm{I}}\, DI_{t-i} + \sum_{i=1}^{t} \delta_{2\mathrm{I}}\, DP_{t-i} + \varepsilon_t \quad (2)$$

Where economic growth (P) is measured by the logarithm of GDP at purchaser's prices; investment (I) is measured by the logarithm of GDI at purchaser's prices, *D* is the first difference operator, and ε_t are the error terms.

The ARDL approach uses three steps to estimate the long run relationship. The first step in the ARDL approach is to estimate equations 1 and 2 by ordinary least squares. Then we conduct an F-test for the joint significance of the coefficients in order to test the existence of the long-run relationship among the variables in equations 1 and 2. That is, the null hypothesis of no co integration among variables in equation 1 is tested ($H_0 : \gamma_{1P} = \gamma_{2P} = 0$) against the alternative hypothesis ($H_1: \gamma_{1P} \neq \gamma_{2P} \neq 0$) using the F-test for the joint significance of the lagged levels coefficient in equation 1. In equation 2, when the gross domestic investment is the dependent variable, the null hypothesis of no co integration among variables is tested ($H_0 : \gamma_{1I} = \gamma_{2I} = 0$) against the alternative hypothesis ($H_1: \gamma_{1I} \neq \gamma_{2I} \neq 0$) using the F-test for the joint significance of the lagged levels coefficient in equation 2. If the estimated F-statistics is above the upper bound critical value, we conclude that the variables in question are co integrated. Conversely, if the estimated F-statistics falls below the lower critical value, the null hypothesis no co integration cannot be rejected.

Other ways, if the statistic falls between the lower and the upper bound critical values, the decision about cointegration among the variables involved is inconclusive. The approximate critical values for F-test were obtained from Pesaran et al. (2001). The optimal lag is determined using Akaike Information Criterion (AIC). In addition, because of the possibility of trend existence in both series, estimations, equations 1 and 2 are estimated taking into consideration case III: unrestricted intercept and no trend and case IV: unrestricted intercept and restricted trend as explained in Pesaran et al. (2001).

The second step is to estimate the coefficient of the long run relationships identified in the first step. Once cointegration is established, the conditional ARDL long-run model can be estimated as:

$$P_t = \alpha_{0\mathrm{P}} + \sum_{i=1}^{t} \delta_{1P}\ P_{t-i} + \sum_{i=1}^{t} \delta_{2P}\ I_{t-i} + \varepsilon_t \quad (3)$$

$$I_t = \alpha_{0\mathrm{I}} + \sum_{i=1}^{t} \delta_{1\mathrm{I}}\ I_{t-i} + \sum_{i=1}^{t} \delta_{2\mathrm{I}}\ P_{t-i} + \varepsilon_t \quad (4)$$

Where, all variables are as previously defined. The lag lengths are determined by Akaike Information Criterion (AIC).

In the third and final step, we obtain the short-run dynamic parameters by estimating a vector error correction model (VECM) associated with the long-run estimates as in equation 5 and 6. The long-run relationship between the variables indicates that there is Granger-causality in at least one direction which is determined by the F-statistic and the lagged error-correction term. The short-run causal effect and is represented by the F-statistic on the explanatory variables while the t-statistic on the coefficient of the lagged error correction term represents the long-run causal relationship (Odhiambo, 2009).

$$DP_t = \beta_{0\mathrm{P}} + \sum_{i=1}^{t} \theta_{1P}\ DP_{t-i} + \sum_{i=1}^{t} \theta_{2\mathrm{P}}\ DI_{t-i} + \rho_P EC_{t-1} + \varepsilon_t \quad (5)$$

$$DI_t = \beta_{0\mathrm{I}} + \sum_{i=1}^{t} \theta_{1\mathrm{I}}\ DI_{t-i} + \sum_{i=1}^{t} \theta_{2\mathrm{I}}\ DP_{t-i} + \rho_I EC_{t-1} + \varepsilon_t \quad (6)$$

Here θ_1 and θ_2 are the short run dynamic coefficients of the model's convergence to equilibrium and ρ is the speed of adjustment. EC_{t-1} is the lagged error correction term. EC_{t-1} in model 5 and model 6 is also known as the one period lag residual of model 3 and model 4, respectively. The sign before ρ or the sign of error correction term should be negative after estimation. The coefficient ρ tells us at what rate it corrects the previous period diseqiilibrium of the system. When ρ is significant and contains negative sign, it validates that there exists a long run equilibrium relationship among variables. However, if the variables are not cointegrated we use Vector Autoregressive model (VARM) in the first difference in the estimation given that both variable are I(1).

3. Empirical Results

3.1. Unit roots

The first procedure for any analysis involving time series data is to determine the stationarity of each variable by checking for the unit roots. Before done this test, we first plot variables together to examine time-series variables. The variable P and I that appears in Figures 1(a) and (b) are trending and characteristics of nonstationary variables. To recheck this result, the Augmented Dickey-Fuller (ADF) test has been used to conduct the unit root test. Table 1 shows the ADF test results for both P and I series as defined above. As the results show, both variables P and I have unit root at their level meaning nonstationary but they become stationary in their first difference in both countries. Both of variables are considered stationary because they tend to fluctuate around a constant mean without trending.

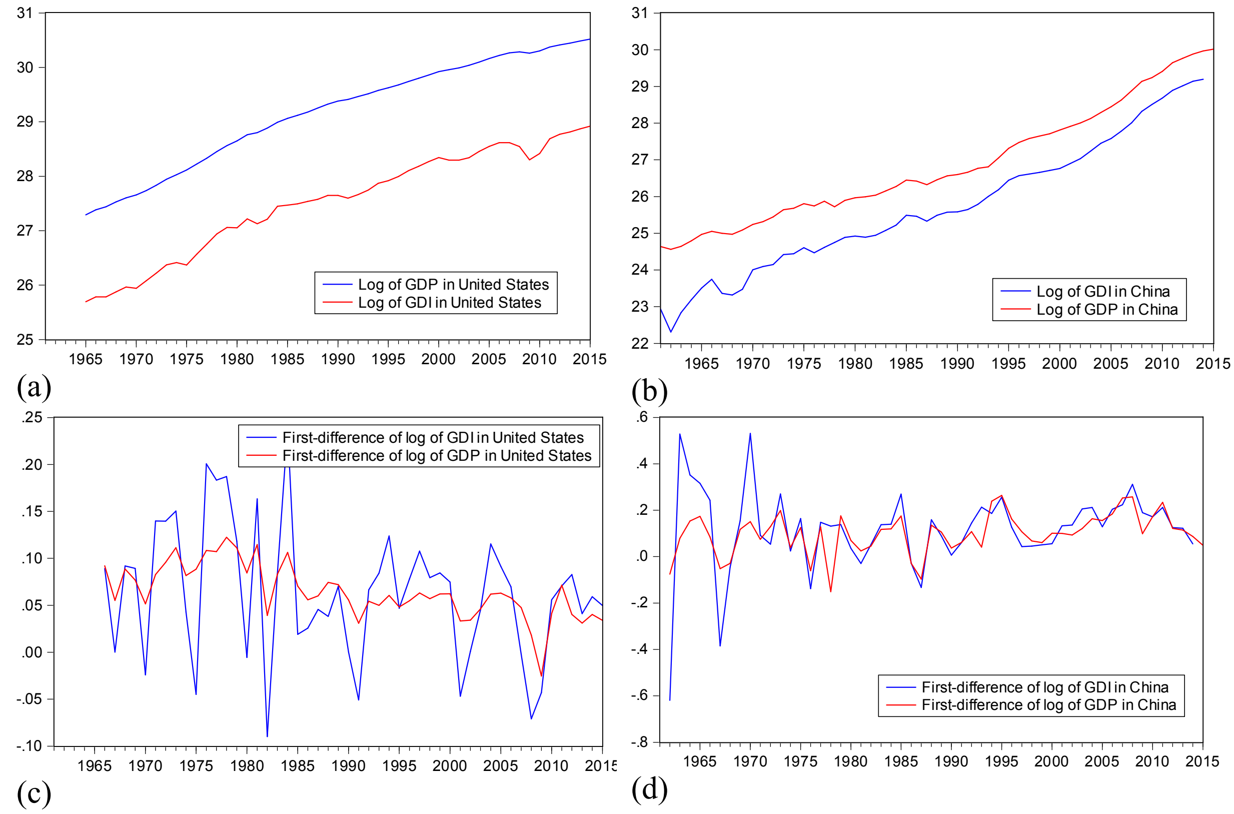

Figure 1: (a) Time series of GDP and GDI variables in the United States, (b) Time series of GDP and GDI variables in China, (c) The first difference of time series of GDP and GDI variables in the United States, (d) The first difference of time series of GDP and GDI variables in China

Table 1: Results of Augmented Dickey-Fuller Unit Root Test

Country	Variable	Only Intercept	Trend and Intercept	None
China (1961-2010)	P	2.673 (1.000)	-0.007 (0.995)	7.769 (1.000)
	DP	-5.814 (0.000)	-6.288 (0.000)	-1.869 (0.054)
	I	0.651 (0.989)	-2.492 (0.331)	4.447 (1.000)
	DI	-8.470 (0.000)	-8.305 (0.000)	-5.492 (0.000)
United States (1965-2010)	P	-2.982 (0.044)	1.031 (0.999)	2.637 (0.998)
	DP	-3.216 (0.026)	-4.708 (0.002)	-1.059 (0.257)
	I	-2.093 (0.248)	-0.567 (0.976)	4.559 (1.000)
	DI	-5.672 (0.000)	-6.069 (0.000)	-4.215 (0.000)

Notes: Variables P and I are the log of GDP and GDI at purchaser's prices, respectively. The operator D denotes the first difference for each of variable. *P-values* are in parentheses.

3.2. Co integration Test - The ARDL approach

The use of ARDL approach is guided by the short data span. We choose the optimal lag by using AIC for the conditional ARDL vector error correction model. As the lower the AIC value, better the model. The results reported in Table 2 indicate that the optimal lag order of 1 for the case of China and order of 2 for the case of United States.

Table 2: Akaike Information Criterion (AIC) Value

Country	**China**			**United States**		
Lag	1	2	3	1	2	3
AIC value	-3.66	-3.62	-3.55	-8.298	-8.617	-8.549

The existence of the long-run relationship among the variables has been investigated by calculating the F-statistics. The results are reported in Table 3 when each variable is considered as a dependent variable in the ARDL - OLS regressions. In case of China, when estimating equation 3, the computed F-statistics are 13.419 (with trend) and 8.795 (with no trend), which are higher than the upper bound critical values of 6.73 and 7.84, respectively at the 1% significance level that is provided by Pesaran et al. (2001). This implies that the null hypothesis of no cointegration is rejected when DI is the dependent variable. From this result, it is clear that there is a long run relationship between investment and economic growth in China.

However, when using the equation 2, when DP is the dependent variable, the null hypothesis of no cointegration can't be rejected because its F-statistics are 2.881 and 1.192 with no trend and trend, respectively, which is less than the lower bound critical values of 4.94 (with no trend) and 4.68 (with trend) at the 5% significance level.

Table 3: Bounds F-Test Results for Cointegration

Country	Dependent variable	F-Statistics (No trend)		F-Statistics (With trend)	
China	DP	2.653		1.280	
	DI	8.795		13.419	
United States	DP	4.864		0.443	
	DI	4.538		1.599	
		Case III		Case IV	
		I(0)	I(1)	I(0)	I(1)
Critical values at 1% for k =2		6.84	7.84	6.10	6.73
Critical values at 5% for k =2		4.94	5.73	4.68	5.15

Note: P is log of GDP and I is log of GDI at purchaser's prices. D is the first difference operator. Asymptotic critical value bounds are obtained from Table C1 - Case III: unrestricted intercept and no trend; Case IV: unrestricted intercept and restricted trend for k =2 in Appendix (Pesaran et al., 2001).

In the case of United States, when estimating equation 2, the computed F-statistics is 4.864 (with no trend) and 0.443 (with trend) which is less than the lower bound critical value of 4.94 (with no trend) and 4.68 (with trend) at 5% significant level. Therefore, the null hypothesis of no cointegration can't be rejected. When using equation 3, where I is the dependent variable, the result is the same with equation 2, the computed F-statistics is 4.538 (with no trend) and 1.599 (with trend) which is less than the lower bound critical value of 4.94 (with no trend) and 4.68 (with trend) at 5% significant level. This means that the null hypothesis of no cointegration can't be rejected when I or P is the dependent variable.

3.3. Granger short run and long run causality tests

When two variables are cointegrated then Granger causality exists in at least one direction. In the case of China, the cointegration test results of the ARDL model reveal that GDP and GDI are cointegrated when log of GDI is dependent variable so equation 7 was estimated using the following ARDL(1,0) specification. The results obtained by normalizing on GDI in the long run are reported in Column 1 Table 4. The estimated coefficients of the long-run relationship show that GDP has a positive and very significant impact on GDI. The coefficient of log GDP is 1.184 that means 1% increase in GDP leads to approximately 1.184% increase in GDI in China.

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the equation (7) are given in Column 2 Table 4. Beginning with the results for the long-run, the coefficient on the lagged error-correction term is significant at 1% level with the expected sign, which confirms the result of the bounds test for cointegration. Its value is estimated to -0.296 which implies that the speed of adjustment to equilibrium after a shock. Approximately 29.6% of disequilibrium from the previous year's shock converges back to the long-run equilibrium in the current year. In the long run, GDP Granger causes GDI. This result implies that causality runs interactively through the error-correction term from GDP to GDI. Moreover, short run coefficient value of GDP has been 1.319 and also significant at 1% level so GDP has an important impact on GDI in short term. Besides, when the dependent variable is GDP, the result indicates that no long run relationship exist between investment and GDP growth but short run coefficient value has been 0.343 and significant at 1% level so GDI has impact on GDP in short term. One percent increase in investment will raise GDP by 0.34% in short run so there is need to invest more.

Table 4: Estimated long run coefficients and Error correction representation using the ARDL approach in Case of China

Variables	(1) Long run	(2) Short-run dynamic parameters	
	I	DI	DP
P	1.184*** (0.020)		
DP		1.319*** (0.211)	
DI			0.343*** (0.057)
EC(1)		-0.296*** (0.102)	-0.091 (0.067)
C	-6.024*** (0.533)	-0.010 (0.028)	0.056*** (0.012)
Observations	54	53	53
R-Square	0.986	0.515	0.450
Note:		EC = I – 1.184*P + 6.024	EC = P – 0.833*I - 5.377

P is log of GDP and I is log of GDI at purchaser's prices. D is the first difference operator. The standard errors of estimated coefficients are displayed in parentheses. *, **, and *** represent the statistical significance at the 10%, 5%, and 1% levels respectively.

The regression for the underlying ARDL equation (7) fits very well at R-square equal 51.5% and the model is globally significant at 1% level. It also passes all the diagnostic tests against serial correlation (Durbin Watson test and Breusch-Godfrey Serial Correlation LM test) and the Ramsey RESET test also suggests that the model is well specified. It failed the white heteroskedasticity test at 5% level. However, according to Shrestha and Chowdhury (2005), since the time series constituting the ARDL equation are potentially of mixed order of integration. It is natural to detect heteroscedasticity. All the results of these tests are shown in Table 5.

Table 5: ADRL – VECM model diagnostic tests		
	F-statistic	Probability
Breusch-Godfrey Serial Correlation LM Test	0.604	0.441
White Heteroskedasticity test	9.173	0.000
Ramsey RESET Test (log likelihood ratio)	0.848	0.362

The stability of the long-run coefficient is tested by the short-run dynamics. Once the ECM model given by equation (7) has been estimated, the cumulative sum of recursive residuals (CUSUM) tests is applied to assess the parameter stability. Figure 2 plot the results for CUSUM and the results indicate the structural stability of the coefficients over the sample period because the plot of the CUSUM is inside the critical bands of the 5% confidence interval of parameter stability.

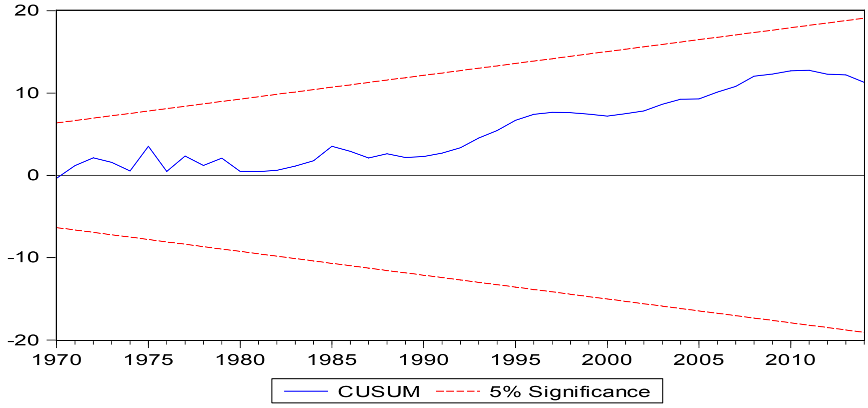

Figure 2: Plot of Cumulative Sum of Recursive Residuals

Since the bounds test results show no long run relationship between GDP and GDI of the United States, thus we can't use VER model to examine the Granger causality between the variables. Instead, we use estimate the VAR model. We want to find out if there is any causality between DI and DP in the United States. Because the Granger causality test depends critically on the number of lagged terms introduced in the model, so we present below the results of the F test using several lags. In each case, the null hypothesis is that GDI does not Granger cause GDP and vice versa. The results suggest that there is no statistically discernible relationship between the two variables. However, at three lags, there is a unidirectional granger causality between GDP and GDI and runs from economic growth to investment growth.

Table 6: Granger Causality Test VAR model in case of the United States				
Number of lags	1	2	3	4
Null Hypothesis	F-Statistic (P – value)			
DP does not Granger Cause DI	0.750 (0.392)	1.551 (0.225)	2.904 (0.048)	2.333 (0.077)
DI does not Granger Cause DP	3.409 (0.072)	1.245 (0.299)	1.768 (0.171)	1.457 (0.238)
Note: DP is the first difference operator of log (GDP) and DI is the first difference operator of log (GDI) at purchaser's prices. The P-value is displayed in parentheses.				

4. Conclusion

The paper examines the dynamic causal relationship among GDP and GDI of China for the period of 1961-2014 and and the United States for the period 1965 to 2015. It implements ARDL model to cointegration to investigate the existence of a long run relation among the above noted variables; and the Granger causality within VECM to test the direction of causality between the variables. The results show that there is cointegration among the variables specified in the model when GDI is the dependent variable. Economic growth promotes gross domestic investment in China in the long run. The results indicate that there is significant Granger causality from GDI to economic growth or from economic growth to GDI in the short run. This finding generates important implications and recommendations for policy makers in China. China government should spend most of its budget on productive tasks that lead to economic growth. Then its turn on again, economic growth will boost investment in both short and long run. However, in the case of the United States, the results reveal that no long run relationship exists between investment and GDP growth over the period examined. Furthermore, there is unidirectional granger causality between GDP and GDI and that causality runs from economic growth to investment growth. These results should be interpreted with cautious since they may be affected if we could have a large data set.

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