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Foreign Reserves and Economic Growth: Granger Causality Analysis with Panel Data

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Abstract

This paper will investigate the Granger causality between foreign reserves and economic growth in twenty largest reserves-holding countries ranging from 1980 to 2008. The method of first-differencing each variable is used to estimate the panel data VAR equations for Granger causality test. The results show the foreign reserves unilaterally Granger cause economic growth only in the emerging countries. In the advanced countries, there is no Granger causal relation between foreign reserves and economic growth.

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1. Introduction

The massive accumulation of foreign reserves over the past decade has been an interesting issue for discussion. Global reserves today exceed US$ 6.7 trillion which are more than tripled since 2000 (see Table 1). Roughly 63% of global reserves are now holding by the emerging and developing countries where almost half of reserves are concentrated in Asia. Moreover, in the end of 2008, the world's five largest reserves-holding countries – China, Japan, Russia, Taiwan and India - hold reserves more than U.S$ 3.6 trillion, roughly 54% of the global total. Most of these countries have experienced rapid economic growth in the recent years. This raises the question what is the role of foreign reserves? Does holding the foreign reserves really benefit the economy or the accumulation of foreign reserves is the by-product of the economic growth?

As suggested by Heller (1966), the benefit of holding foreign reserves is the ability to avoid the reduction in output resulting from a deficit in the balance of payments. Thus holding large size of foreign reserves is to provide a form of self-insurance against the risk of rapid withdrawal of cross-border investment which may lead to a deep recession. In addition, Frenkel (1983), Edwards (1983) analyze the role of the foreign reserves in the management of exchange rate regime. Dooley *et al*. (2005) take hoarding foreign reserves as tool for maintaining an under-valued real exchange rate which will stimulate export competitiveness. Many emerging Asian economies adapting exported-led policies need foreign reserves to intervene in foreign exchange market to maintain the exchange rate peg. Therefore, the accumulation of reserves is always consequent on extensive current account surpluses. Polterovich and Popov (2002) show countries with growing foreign reserves to GDP ratios exhibit higher capital productivity and higher rates of growth.

Conversely, there would be considerable opportunity cost arising from holding massive foreign reserves. Most foreign reserves are financed by the domestic borrowing or liabilities. The difference between the yield paid on the foreign reserves and the domestic cost of borrowing is the running cost of reserves holding. McCauley (2007) calls this as 'quasi-fiscal cost'. Aizenman and Lee (2007) find this cost is higher in developing countries because they always have lower level of capital and hence higher marginal product of capital. Gruz and Walters (2008) have discussed whether the accumulation of reserves is good for development. They indicate the stockpiling of reserves is not optimal for development.

Foreign accumulation may be the result of high current account surplus which is the important engine for economic growth. Besides, foreign reserves holding could be a tool for stabilizing or self insurance but it may raise deadweight loss for the economy. Therefore, a bivariate model (foreign reserves – economic growth) is used

to examine Granger causal relations for twenty largest reserves-holding countries. The method of first-differencing each variable is utilized to estimate the panel data VAR equations. This paper proceeds as follows. Section 2 illustrates the econometric model for testing causality with panel data. The data and the empirical results are presented in Section 3. The last section offers a conclusion.

Table 1 Total Reserves minus Gold

Millions of US$ (end of period)

	1980	1990	2000	2005	2008
World	409753	933069	2022088	4244406	6779600
1.Advanced	237272	589129	1274849	2096897	2514755
	(57.91)	(63.14)	(63.05)	(49.40)	(37.09)
2.Emerging and Developing	156075	195129	747239	2147509	4264844
Economies	(38.09)	(20.91)	(36.95)	(50.60)	(62.91)

*The shares of the global total (%) are given in parentheses.

Emerging and developing Economies

1. Africa	19075	16742	54572	160861	342718
	(12.22)	(8.58)	(7.30)	(7.49)	(8.04)
2. Developing Asia	37882	66229	322743	1160613	2356351
	(9.25)	(33.94)	(43.19)	(54.04)	(55.25)
3.Europe	6109	18711	116816	401129	778862
	(1.49)	(9.59)	(15.63)	(18.68)	(18.26)
4.Middle East	67200	46044	96715	169648	289886
	(16.40)	(23.60)	(12.94)	(7.90)	(6.80)
5. Western Hemisphere	38877	47489	158395	255260	497036
	(9.49)	(24.34)	(20.93)	(11.89)	(11.65)

***** The shares of the emerging and developing economies total (%) are given in parentheses.

Sources: computation of the data in *International Financial Statistics* (IMF).

2. Specification of the model

Assume that there are N cross-sectional units observed over T periods. The equation testing Granger causality that allows for individual effect is as follows:

$$y_{it} = \alpha + \sum_{j=1}^{p} \beta_j y_{it-j} + \sum_{j=1}^{p} \delta_j x_{it-j} + f_i + u_{it}, \qquad i = 1, \ldots N, \qquad t = 1, \ldots T. \tag{1}$$

where i index the cross-sectional observations and t the time periods. The term f_i is added as the ith unobserved individual effect and u_{it} is a white noise error term. To test whether x Granger causes y, the null hypothesis is defined as:

$$H_0 : \delta_1 = \delta_2 = \ldots = \delta_p = 0$$

The common technique to estimate equation (1) is the least squares dummy variable (LSDV) model. This method computes the deviation of each variable from its respective mean. However including the lagged dependent variables in the panel model involves the problem that the explanatory variables are correlated with the error terms. This procedure will yield inconsistent estimates. Anderson and Hsiao (1982) and Holtz-Eakin *et al*. (1988) suggest the method of first-differencing each variable to remove the individual effect. The transformed equation is written as:

$$y_{it} - y_{it-1} = \sum_{j=1}^{p} \beta_j (y_{it-j} - y_{it-j-1}) + \sum_{j=1}^{p} \delta_j (x_{it-j} - x_{it-j-1}) + (u_{it} - u_{it-1}) \qquad (2)$$

This specification sets up a dependence between the disturbance $(u_{it} - u_{it-1})$ and the regressor $(y_{it-1} - y_{it-2})$. The use of instrumental variable in this model will provide a consistent estimator. Since y_{it-2} or $(y_{it-2} - y_{it-3})$ are correlated with $(y_{it-1} - y_{it-2})$ but are uncorrelated with $(u_{it} - u_{it-1})$, the lagged terms of y_{it} are valid instruments. There are additional regressors x_{it} in equation (1), the lagged terms of x_{it} should be added as instruments too. So the set of valid instruments is $(y_{i1}, y_{i2}, ... y_{iT-2}, x_{i1}, x_{i2}, ..., x_{iT-2})$.

Consider the matrix $\mathbf{Z}_i$ defined as:

$$\mathbf{Z}_i = \begin{bmatrix} [y_{i1}, x_{i1}'] & & \cdots & 0 \\ & [y_{i1}, y_{i2}, x_{i1}', x_{i2}'] & & \\ & & \ddots & \\ 0 & & & [y_{i1}, y_{i2}, ..., y_{iT-2}, x_{i1}', x_{i2}', ..., x_{iT-2}'] \end{bmatrix} \qquad (3)$$

The orthogonality conditions are given by $E(\mathbf{Z}_i' \Delta \mathbf{U}_i) = \mathbf{0}$, where

$\Delta \mathbf{U}_i = [u_{i2} - u_{i1}, ..., u_{iT} - u_{iT-1}]$. The matrix of instruments is $\mathbf{Z} = [\mathbf{Z}_1', ..., \mathbf{Z}_N']$.

Performing GLS, we preliminary premultiply the differenced equation (2) in vector form by $\mathbf{Z}'$ and get

$$\mathbf{Z}' \Delta \mathbf{Y} = \mathbf{Z}' (\Delta \mathbf{Y}_{-1}) \boldsymbol{\beta} + \mathbf{Z}' (\Delta \mathbf{X}_{-1}) \boldsymbol{\delta} + \mathbf{Z}' \Delta \mathbf{U} \qquad (4)$$

where $\Delta \mathbf{Y}$ and $\Delta \mathbf{X}$ indicate the first difference vector of y_{it} and x_{it}. Then $\boldsymbol{\beta}$ and $\boldsymbol{\delta}$ indicate the corresponding coefficients matrices. Using two-stage least squares (2SLS) on the equation, the estimators of coefficients can be obtained from

the $\begin{pmatrix} \hat{\boldsymbol{\delta}} \\ \hat{\boldsymbol{\beta}} \end{pmatrix} = ([\Delta \mathbf{Y}_{-1}, \Delta \mathbf{X}_{-1}]' \mathbf{Z} \hat{\mathbf{V}}_N^{-1} \mathbf{Z}' [\Delta \mathbf{Y}_{-1}, \Delta \mathbf{X}_{-1}])^{-1} ([\Delta \mathbf{Y}_{-1}, \Delta \mathbf{X}_{-1}]' \mathbf{Z} \hat{\mathbf{V}}_N^{-1} \mathbf{Z}' \Delta \mathbf{Y} \qquad (5)$

where the estimated covariance matrix $\hat{\mathbf{V}}_N = \sum_{i=1}^{N} \mathbf{Z}_i' (\Delta \hat{\mathbf{U}}_i)(\Delta \hat{\mathbf{U}}_i)' \mathbf{Z}_i$ and $\Delta \hat{\mathbf{U}}_i$ is the

differenced residual on each equation separately.

I apply the procedure suggested by Holtz-Eakin *et al*. (1988) to test the hypothesis that x does not Granger cause y. The null hypothesis is $H_0 : \boldsymbol{\delta} = \mathbf{0}$. Let Q and Q_R be the unrestricted sum of squared residuals and the restricted sum of squared residuals respectively. Each Q and Q_R has a chi-squared distribution as N grows. Then the appropriate test statistics is

$$L = Q_R - Q \tag{6}$$

where L has a chi-squared distribution with degree of freedom equal to the degree of freedom of Q_R minus the degree of freedom of Q.

3. The data and the Estimated Results

3.1 The Data

Excluding those economies with missing data, the samples are the twenty largest reserves-holding countries in the end of 2008.[1] I classify the sample countries into two groups: 10 advanced countries and 10 emerging countries (including newly industrialized countries and developing countries). The sample countries listed in Table 2 are arranged according to the amounts of foreign reserves decreasingly in each group. The data set, obtained from the International Monetary Fund's *International Financial Statistics* (*IFS*), comprises annually observations ranging from 1980 to 2008 for each economy.

The variable GDP is the growth rate of real GDP. The expression FR is the growth rate of real foreign reserve (minus gold). The price index used to get the real term is GDP deflator (2005=100). Table 2 and Table 3 report the basic descriptive statistics of the two variables over the full sample. The growth rates of real GDP in most advanced countries except USA and Israel are normally distributed. The emerging countries experience higher growth in foreign reserves than the advanced countries. Moreover, in most emerging countries except Taiwan and Singapore, the distributions of growth rates of real GDP are left-skewed and slim. Almost half of these countries reject the normality assumption for the growth rate of real foreign reserves. Figure 1 and Figure 2 provide the time series for these two variables of each country. The movements of these two variables are in similar patterns for some countries, like Japan, Korea, Singapore and Thailand.

[1] I exclude Russia, Brazil, Hong Kong, Algeria, Libya, Turkey, Poland, Iraq, and Argentina. The data set in these countries is not complete.

Table 2 Basic descriptive statistics for *GDP*

	Mean (%)	Std. Dev. (%)	Skewness	Kurtosis	Jarque-Bera	Obs.
All countries	-0.26	20.70	-3.65	23.63	11176.94***	560
Advanced Countries	0.45	18.93	-4.26	35.09	12859.26***	280
Japan	5.28	11.96	0.38	2.40	1.08	28
USA	3.00.	1.71	-0.67	4.54	4.89*	28
Norway	1.77	12.65	0.14	2.39	0.53	28
Switzerland	3.52	13.25	0.21	1.85	1.75	28
UK	0.75	14.51	-0.24	2.68	0.40	28
Canada	2.58	8.44	-0.10	4.38	2.27	28
Germany	3.33	13.37	0.21	1.63	2.40	28
Israel	-18.20	44.37	-2.22	7.34	44.88***	28
Denmark	2.25	13.40	0.14	1.75	1.92	28
Italy	0.27	13.87	-0.07	1.77	1.79	28
Emerging countries	-0.97	22.34	-3.20	16.79	2695.52***	280
China	4.14	11.20	-1.31	3.79	8.71**	28
Taiwan	6.30	7.77	0.16	4.38	2.35	28
India	-0.82	11.07	-0.85	4.54	6.15**	28
Korea	4.01	17.10	-2.49	11.01	103.76***	28
Singapore	7.79	7.35	-0.68	3.20	2.23	28
Thailand	6.68	17.52	-1.90	8.94	57.99***	28
Mexico	-20.28	35.48	-1.67	5.02	17.83***	28
Malaysia	4.35	9.42	-2.92	13.22	161.76***	28
Nigeria	-16.41	38.61	-1.97	6.89	35.81***	28
Indonesia	-5.50	20.71	-1.86	5.89	25.93***	28

Notes: Statistical significance at the 1%, 5%, 10% levels is indicated by ***, **, *, respectively.

Table 3 Basic descriptive statistics for *FR*

	Mean (%)	Std. Dev. (%)	Skewness	Kurtosis	Jarque-Bera	Obs.
All countries	6.72	29.53	-0.46	9.86	1118.123***	560
Advanced countries	3.19	21.74	0.34	4.39	27.85***	280
Japan	10.33	19.41	0.64	3.33	2.03	28
USA	2.25	16.44	0.41	4.95	5.23**	28
Norway	4.68	18.27	0.45	2.49	1.24	28
Switzerland	0.84	14.32	-1.31	5.71	16.58***	28
UK	-0.20	22.74	1.40	6.54	23.84***	28
Canada	6.53	25.19	1.06	5.03	10.01***	28
Germany	-3.36	14.91	1.12	5.04	10.73***	28
Israel	6.14	19.29	0.15	3.99	1.25	28
Denmark	5.93	32.63	0.02	2.04	1.08	28
Italy	-1.25	26.85	-0.73	2.75	2.54	28
Emerging countries	10.24	35.35	-0.81	9.28	491.14***	280
China	20.78	31.17	-0.85	5.34	9.80***	28
Taiwan	13.38	27.65	2.05	8.90	60.18***	28
India	9.83	35.55	-0.67	4.61	5.15*	28
Korea	12.18	32.69	1.48	6.82	27.18***	28
Singapore	8.78	8.20	-0.26	2.99	0.32	28
Thailand	12.22	16.69	-0.89	4.49	6.28**	28
Mexico	9.46	62.18	-0.90	5.18	9.27***	28
Malaysia	7.90	18.60	0.14	2.34	0.59	28
Nigeria	2.94	60.88	-0.59	3.20	1.68	28
Indonesia	4.99	18.71	-0.98	4.31	6.45**	28

Notes: Statistical significance at the 1%, 5%, 10% levels is indicated by ***, **, *, respectively.

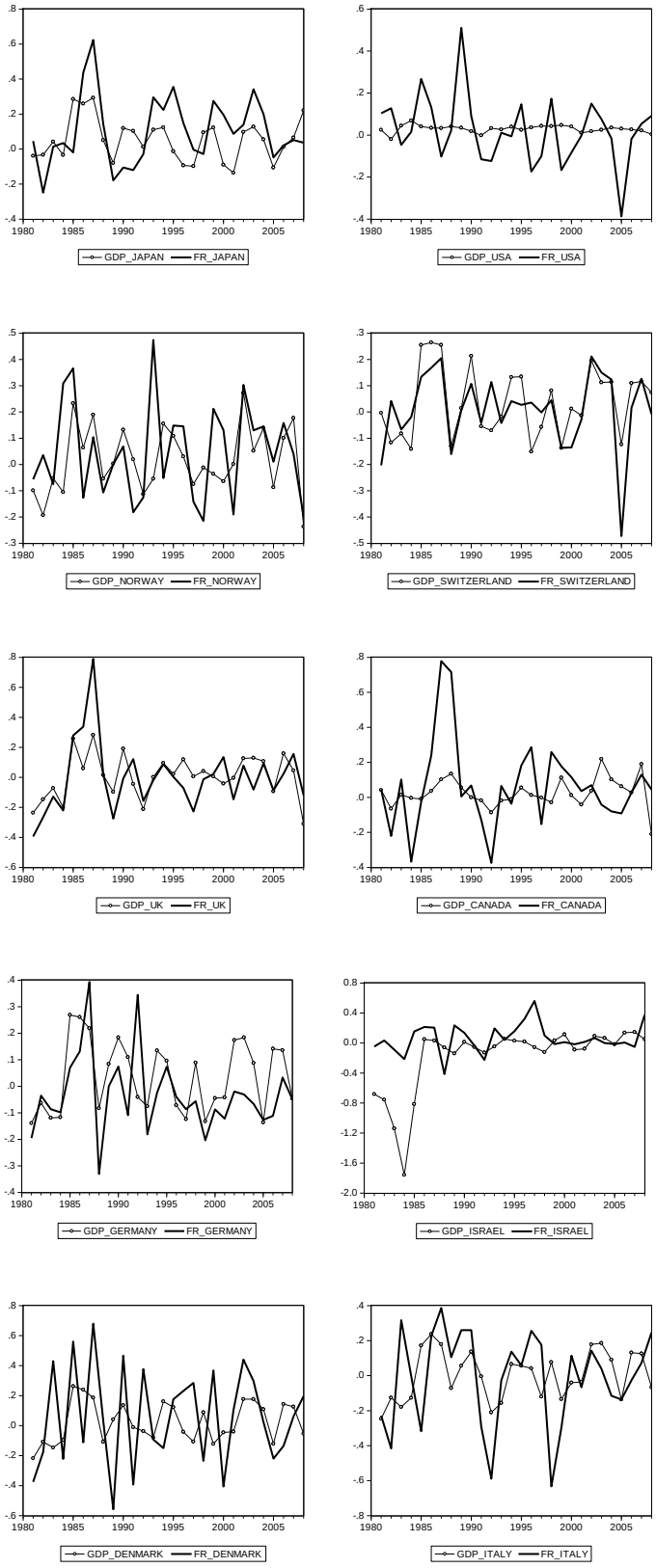

Figure 1 Plots for *GDP* and *FR* in advanced countries

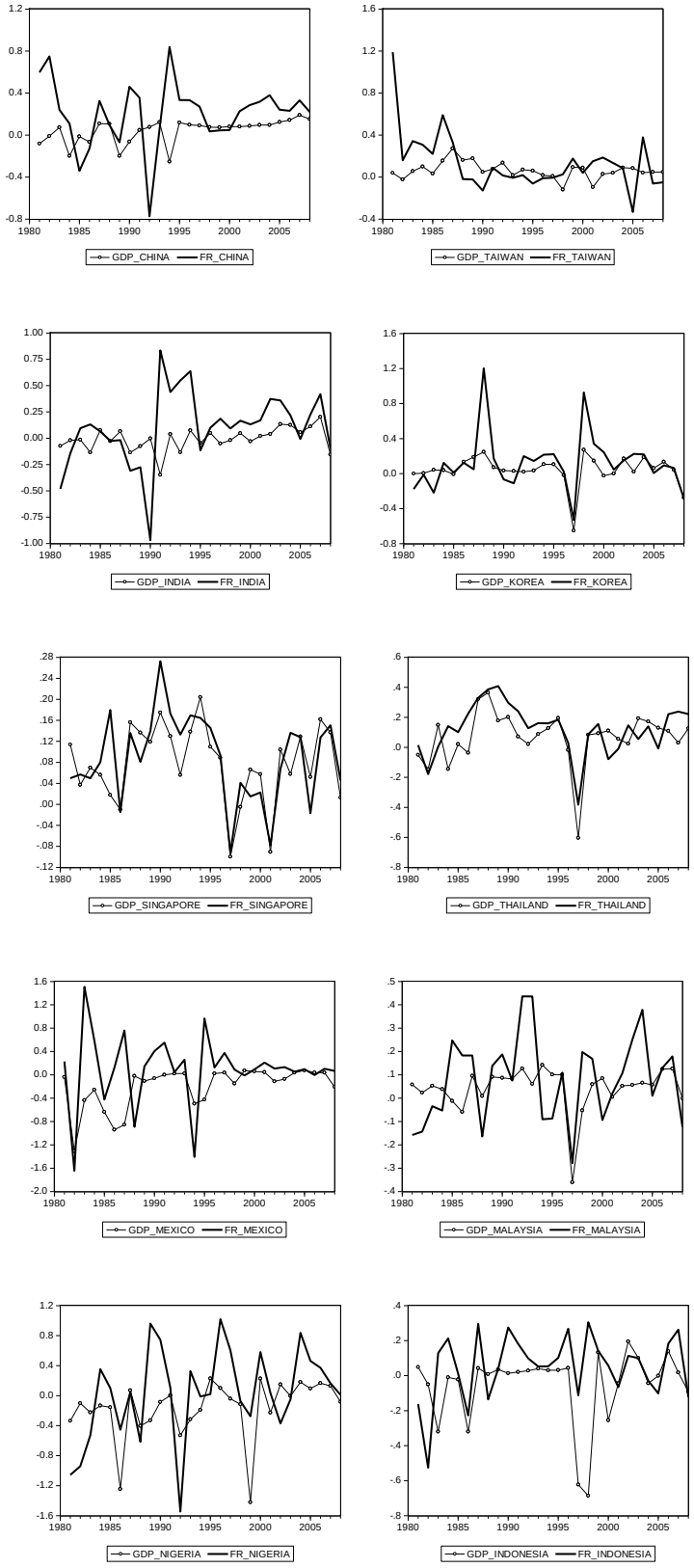

Figure 2 Plots for *GDP* and *FR* in advanced countries

3.2 Panel unit root test

Levin, Lin and Chu (2002) develop a panel unit root test under the assumption that the individual processes are cross-sectionally independent. The panel unit-root test proposed by Im, Pesaran and Shin (1997) allows heterogeneity on the lagged level term and bases on the average of the individual unit-root test statistics. I use EView6.0 to manipulate the panel unit root test and the results are shown in Table 4. All the variables reject the null hypothesis of a unit root and conclude that they follow stationary processes.

Table 4 Panel unit root test for *GDP* and *FR*

Levin, Lin and Chu test	**Null hypothesis: Unit root**		
	All countries	Advanced countries	Emerging countries
GDP	-10,9757***	-7.3912***	-8.1345***
FR	-13.5912***	-9.0896***	-10.1855***
Im, Pesaran and Shin test	**Null hypothesis: Unit root**		
	All countries	Advanced countries	Emerging countries
GDP	-10.9547***	-8.1753***	-7.3107***
FR	-15.4542***	-10.8712***	-10.9904***

Notes: Statistical significance at the 1%, 5%, 10% levels is indicated by ***, **, *, respectively.

3.3 Panel Granger causality test

We carry out the panel Granger causality test for two first- differenced models including one period lag $(p = 1)$ and two period lags $(p = 2)$. Table 5 shows the result for testing the Granger causality from growth of foreign reserves to growth of GDP. The only significant case is emerging countries. Observing the estimated coefficients on the lag terms of ΔFR_t, the growth of foreign reserves benefits the economic growth in emerging countries. Holding foreign reserves would be an important tool for stimulating economy in emerging countries. This could be the intention of manipulating the exchange rate or the self-insurance for currency crisis. However, this tool seems to be unimportant in the advanced countries.

The results of tests for hypothesis that economic growth Granger causes growth of foreign reserves are presented in Table 6. The insignificant tests statistics indicate that economic growth does not Granger cause growth of foreign reserves in both the advanced countries and the emerging countries. The explanation is that reserves accumulation mainly results from trade surplus. Nevertheless, international trade is not the only source of economic growth. Many factors, such as domestic consumption or investment, will influence the economic output. Therefore, economic growth does not cause the change in foreign reserves.

Table 5 Granger causality from growth of foreign reserve to growth of GDP

Dependent variable: ΔGDP_t

	All countries		Advanced countries		Emerging countries	
	$p=1$	$p=2$	$p=1$	$p=2$	$p=1$	$p=2$
ΔGDP_{t-1}	0.2068	-0.5938	1.1180	0.0413	-0.0825	-0.3584
	(0.1804)	(0.4684)	(0.5963)***	(0.3141)	(0.1068)	(0.2741)
ΔGDP_{t-2}		0.0465		-0.5154		0.0190
		(0.1236)		(0.2066)		(0.1141)
ΔFR_{t-1}	0.1488	0.1973	-0.1610	-0.0079	0.1388	0.1653
	(0.0902)*	(0.2286)	(0.1424)	(0.3368)	(0.0435)*	(0.2187)
ΔFR_{t-2}		0.1288		0.0532		0.1547
		(0.0636)**		(0.0765)		(0.0616)**
Q	30.4852	16.0970	17.0781	4.1743	15.9679	10.5338
L	2.4644	0.2646	2.5837	0.2722	4.0309**	8.5937***

Notes: Figures in parentheses are standard errors. Statistical significance at the 1%, 5%, 10% levels is indicated by ***, **, *, respectively.

Table 6 Granger causality from growth of GDP to growth of foreign reserve

Dependent variable: ΔFR_t

	All countries		Advanced countries		Emerging countries	
	$p=1$	$p=2$	$p=1$	$p=2$	$p=1$	$p=2$
ΔGDP_{t-1}	-0.3419	-0.6079	0.3493	0.5363	-0.6125	0.0307
	(0.1816)***	(1.0200)	(0.3884)	(0.6064)	(0.2574)**	(0.8989)
ΔGDP_{t-2}		0.1513		-0.1866		-0.1050
		(0.2806)		(0.2511)		(0.3064)
ΔFR_{t-1}	0.1540	-0.6792	0.0349	-0.4000	0.1688	-0.8796
	(0.1252)	(0.3676)***	(0.1212)	(0.6242)	(0.1750)	(0.2987)
ΔFR_{t-2}		0.1927		0.0879		0.1150
		(0.1805)		(0.1473)		(0.1914)
Q	73.1305	69.1395	23.9376	16.4427	48.1187	43.1883
L	2.6495	2.5961	0.1535	2.5381	1.8226	5.1945

Notes: Figures in parentheses are standard errors. Statistical significance at the 1%, 5%, 10% levels is indicated by ***, **, *, respectively.

4. Conclusions

This study investigates the Granger causality between foreign reserves and economic growth in twenty largest reserves-holding countries. The results show the foreign reserves unilaterally Granger cause economic growth only in the emerging countries.

In the advanced countries, there is no Granger causal relation between foreign reserves and economic growth. The change in foreign reserves could be a lead indicator for the economic condition in the emerging countries. The empirical results of this study will have policy implication for central bank's reserves management. The emerging countries should not reduce their foreign reserves because reserves accumulation really helps the economic growth. However, the conclusion is based on the empirical results of twenty largest reserves-holding countries. Enlarging the sample countries or changing the sample periods may help us to find more facts about the foreign reserves.

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