

# Testing the Validity of Feldstein-Horioka Puzzle in BRICS Countries

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**Abstract**—The increase of capital mobility across emerging economies has become an interesting topic for many economic policy makers. The current study tests the validity of Feldstein-Horioka puzzle for 5 BRICS countries. The sample period of the study runs from 2001 to 2014. The study uses the following parameter estimates well known as the Fully Modified OLS (FMOLS), and Dynamic OLS (DOLS). The results of the study show that investment and savings are cointegrated in the long run. The parameters estimated using FMOLS and DOLS are 0.85 and 0.74, respectively. These results imply that policy makers within BRICS countries have to consider flexible monetary and fiscal policy instruments to influence the mobility of capital with the bloc.

**Keywords**—Feldstein and Horioka puzzle, saving and investment, panel models, BRICS countries.

## I. INTRODUCTION

To determine the level of financial integration in modern days it has been the policy cornerstone for each economy. Several institutional and more international relations have been signed in order to accelerate the level of financial integration amongst countries. To investigate the level of capital mobility in any economy or the region, the theorem of Feldstein-Horioka puzzle (FHP) is used. Reference [6] proclaimed that high correlation between investment and domestic savings is well known as the FHP. The theory plainly believed that in a closed economy, domestic returns on additional saving is the domestic marginal product of capital. The puzzle of whether the national government should pursue policies to stimulate saving rate is therefore equivalent to deciding whether this domestic marginal product of capital offers a high enough reward to justify postponing consumption [6]. The puzzle itself claims that an estimated savings parameter would be high if there is no capital mobility. This situation ascends because national investment is financed by national savings. Therefore, if capital mobility exists, the coefficient would be zero as national investment is bankrolled by foreign savings. On the other hand, if saving coefficient is not statistically different from zero, then it implies perfect capital mobility.

This paper is structured as follows: Section II provides the overview of the study. Section III presents the literature

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review. Section IV provides the model specification of the study. Section V presents the econometric method of the study. Section VI discusses the empirical results of the study.

## II. OVERVIEW OF BRICS ECONOMIES

The grouping of emerging economies such as Brazil, Russia, India and China were originally suggested as BRICs in 2001 [17]. In 2006, these countries officially became a diplomatic-political entity called BRIC. Therefore, later in 2011, South Africa officially joined the group and the acronym was renamed to BRICS. BRICS cooperation is aiming to complement and strengthen the existing bilateral and multilateral between members' states. The statistics indicate that collectively BRICS countries contribution to world GDP has increased from 11% in 1990 to 25% in 2011 [17]. Therefore, this section also provides the style fact on BRICS countries based on investment and saving. Fig. 1 presents the trends on investment measured by gross capital formation as % of GDP for all the BRICS countries. The figure indicates that for 2001-2014 China was the most leading country in terms of gross capital formation as a % of GDP. It was followed by India with the second highest investment. However, for 2007 and 2011, India's investment peaked at 38%. South Africa and Brazil were the least countries performed in terms of capital formation as a % of GDP throughout the period. From this descriptive analysis, it is clear that South Africa and Brazil need to put more effort to sustain investment.

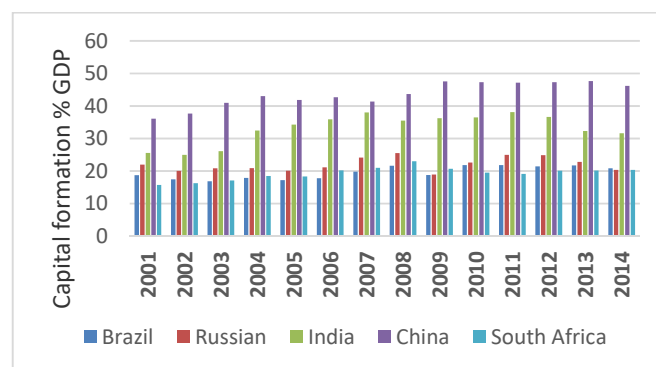


Fig. 1 Presentation on gross capital formation as a % GDP  
Source: Own compilation using data from World Development Indicators (WDI)

The trend on gross domestic saving in BRICS countries is presented by Fig. 2. Fig. 2 shows that China gross domestic saving is higher than those of counterparts among BRICS

countries. The second better performing country is India which reached the highest saving in 2007 by 41.3%. The rest of the countries within the bloc, South Africa, Russia and Brazil, performed moderately equal throughout the period of 2001-2014.

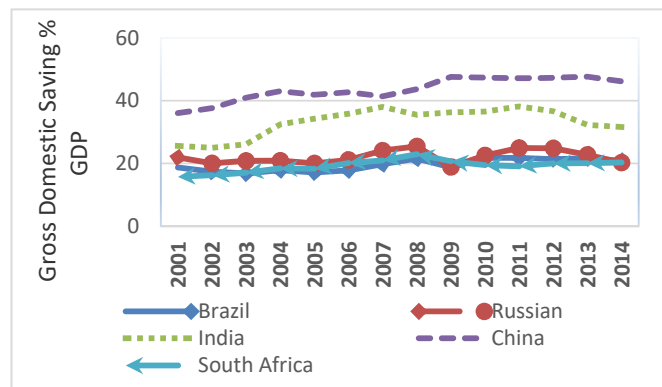


Fig. 2 Presentation on gross domestic saving as a % GDP  
 Source: Own compilation using data from WDI

### III. LITERATURE REVIEW

The literature purely shows that there are two types of empirical literature about investigating the validity of FHP. The first group of studies was based on group country studies and second group of studies was more into country specific studies. Among the existing literature, [10] studied the relationship between saving and investment in BRICS countries. The study was motivated by fast and high economic growth experienced by BRICS economies in the first decade of the new millennium. The study applied the recent technique of ARDL bounds cointegration to determine the existence of long run equilibrium between saving and investment in BRICS countries. The results of the study suggest that capital is not perfectly mobile in BRICS countries especially for India, China and Brazil, but it is more mobile in South Africa and Russia.

Reference [3] examined saving-investment nexus and the extent of capital mobility in BRICS countries over the period of 1970-2013. Empirical result indicates that Brazil and Russia exhibit intermediate degree of capital mobility, whereas China and South Africa demonstrate satisfactory degree of capital mobility. Lastly, India displays low capital mobility.

Reference [9] investigated the degree of capital mobility in Russia by testing the validity of FHP. To determine the degree of saving-investment relationship, the study employed basic OLS and FMOLS procedures. In a case to estimate the long run equilibrium, the Carrion-I-Silvestre-Sanso cointegration test [4] was employed which can be used to detect the presence of structural break. The results of the study using OLS and FMOLS estimations provided a weak evidence of FHP in the post-crisis period.

Reference [16] studied international capital mobility and its extent by the use of Granger causality tests on saving-investment puzzle. The study sampled 7 industrialised economies for the best part of the post-war era which are

Australia, Canada, Germany, Japan, Netherlands, United Kingdom and United States of America. The findings of the study show that there is little convincing evidence of capital mobility for the 7 industrialised countries.

Reference [2] revisited the analysis of FHP in an institutional sector dimension within Organisation for Economic Co-operation and Development (OECD) countries. The results of the study show that national Feldstein-Horioka coefficient is approximately 0.5, but sectoral coefficients are much lower than 0.5.

Reference [13] studied the famous FHP for a heterogeneous panel of 14 Latin American and five Caribbean countries. The study used Pedroni panel cointegration and FMOLS cointegrating estimator to determine the long run and degree of impact between saving and investment. The results of the study show that these countries indicate a moderate degree of capital mobility during the period 1960 to 2002.

Reference [11] studied how various integration agreements have affected capital mobility in Africa. The study adopted four blocs in Africa which are SACU, UEMOA, COMESA and ECOWAS. The results indicate that international capital mobility has only marginally increased in these African countries. Reference [5] studied capital mobility in sub-Saharan countries. The study examined 36 countries for the period 1980-2000. The study applied basic stationary panel techniques to investigate saving and investment in sub-Saharan countries. The results of the study show that sub-Saharan countries display a low saving rate which would then imply higher capital mobility in the region.

Reference [1] investigated the FHP in 37 African countries. The study applied the recent panel data techniques such Pool Mean Group (PMG), FMOLS and DOLS to examine the relationship between saving and investment in African Countries. The study discovered that capital mobility is relatively high in these Africa countries.

According to the existing literature, there is a steadily increasing share of empirical studies on testing FHP globally. It is notable that only [10] and [3] studied FHP in BRICS countries. The current study takes the opportunity to study saving and investment in BRICS countries using advance panel techniques adopted by [1]. As far as the above literature is concerned it is presumed by present study that those techniques were never used by previous studies in BRICS countries. Therefore, the objective of this study is to determine the long run equilibrium and examine the degree of impact between saving and investment in BRICS countries.

### IV. MODEL SPECIFICATION

To investigate the level of capital mobility in BRICS countries, this paper adopts the famous F-H model. Although the model was vastly used in the literature, this study adopts the model modification from [4]. The adoption of this model is on the basis of that majority of BRICS countries they are still an emerging economies. Therefore, the study expresses the empirical model as:

$$\ln RGCF_t = \alpha_{it} + \ln RGDS_{it} + \ln LR_{it} + \ln FA_{it} + \ln RCAB_{it} + \theta_{it} \quad (1)$$

where:  $\ln RGCF_t$ : Ratio of gross capital formation,  $\ln RGDS_{it}$ : Ratio of gross domestic saving,  $\ln LR_{it}$ : Lending rate,  $\ln FA_{it}$ : Foreign aid,  $\ln RCAB_{it}$ : Ratio of current account balance.

#### Lending Rate and Investment

According to [7], GDP growth is made possible by prompting the level of investment. This is done through policies that affect the rate of interests, where the underlying assumption is that investment is negatively related with lending rate.

#### Foreign Aid and Investment

There are three schools of thoughts on the usefulness of foreign aid on investment especially for the developing countries. Such schools of thought referred to positivist approach, pessimist approach and conditionality approach. Reference [5] indicated that low investment especially in developing economies is accelerated by low levels of saving. Also foreign exchange and capital are other factors that hinder investment growth; therefore, foreign aid is seen as a source of financing domestic investment, which assumed to bridge capital shortage as well as hard currency problems of aid recipient country.

#### Ratio of Current Account Balance and Investment

Current account imbalances are caused by a mismatch between savings and investment. According to [14], large periods of capital inflows are usually associated with increased rates of investment. If international capital inflows are used to increase domestic investment, assuming savings is hold constant, this may imply an increase in the current account deficit.

#### Data and Source

To carry out this study, an annual time series data for the period 2001-2014 were obtained. This study sample consists of 5 emerging countries which are Brazil, Russia, India, China and South Africa. Data for this study is obtained from World Bank under database World Development Indicators (WDI) [18]. The study applies several macroeconomic data to estimate FHP. The variables used in this study are:  $\ln RGCF_t$  ratio of gross capital formation,  $\ln RGDS_{it}$  ratio of gross domestic saving,  $\ln LR_{it}$  lending rate,  $\ln FA_{it}$  foreign aid,  $\ln RCAB_{it}$  ratio of current account balance.

### V. ECONOMETRIC METHOD

Prior to estimation of (1), it is important for the study to investigate the panel unit root of each series adopted in the study. Unit root is a common problem in time series data of which inability to detect it may lead to inappropriate use of econometric methods leads to spurious results. Therefore, for this study, unit root test by [12] and [8] are used to investigate the panel unit root involved in the series. After a successful detection of unit root, the study will use a recent panel technique to determine the long run among the variables

adopted by the study. Furthermore, to examine the degree of impact between saving and investment, estimators such as DOLS and FMOLS are used.

#### Pedroni Cointegration Test

Once the order of integration has been investigated, the study applies the Pedroni cointegration test. The application of Pedroni's cointegration test requires first to estimate the static equation (1), and then produce the residuals as follows:

$$e_{it} = \rho_i e_{it-1} - u_{it} \quad (2)$$

Reference [15] proposed seven different statistics to test panel data for cointegration. Of these seven statistics four are based on within-dimension and the three are based on between-dimension. The test describes that for the within-dimension statistics, the null hypothesis of no cointegration for the panel is as:

$$H_0: y_i = 1 \text{ for all } i \text{ against} \\ H_0: y_i = 1 < 1 \text{ for all } i.$$

The alternative hypothesis under within-dimension estimation assumes a common value for  $y_i = \rho$ . This implies that the estimation does not allow an additional source of possible heterogeneity across individual members of panel data. The between-dimension statistics its null hypothesis of no cointegration for the panel cointegration is:

$$H_0: y_i = 1 \text{ for all } i \text{ against} \\ H_0: y_i < 1 \text{ for all } i$$

Here, under alternative hypothesis the between-dimension estimation does not assume a common value for  $y_i = \rho$ . Therefore, an additional source of possible heterogeneity across individual members of panel data is investigated. Pedroni allows for two types of test to know the existence of heterogeneity of cointegrating of vector. The first test is based on within-dimension which includes four tests such as panel v-statistics, panel p-statistics, panel pp-statistics and panel ADF-statistics. Secondly, the test is based on between-dimension which includes group statistic tests.

#### Panel Cointegration Estimation

Although Pedroni's method determines long run equilibrium, unfortunately the test does not provide the long run coefficients. It is well documented in the literature that there are several estimators proposed in the presence of cointegration Such as DOLS and FMOLS [16].

### VI. EMPIRICAL RESULTS

The panel unit root test results for all variables adopted are given in Table I. The results indicate that based on LLC gross capital formation ( $\ln RGCF$ ), gross domestic saving ( $\ln RGDS$ ) and lending rate ( $\ln LR$ ) they are I(0). Whereas foreign aid ( $\ln FA$ ) and current account balance ( $\ln RCAB$ ) they are stationary at first difference. Therefore, the results for LLC

produce the mixture of I(1) and I(0) variables. For robustness check, the study also used Hadri panel unit root test. The results indicate that gross capital formation, gross domestic saving, lending rate and foreign aid are I(0), and current account balance is I(1). Since both panel unit root tests produced a mixture of I(1) and I(0) order of integration for variable under study. It is therefore important to determine the long run equilibrium of variables.

TABLE I  
PANEL UNIT ROOT RESULTS FOR BRICS COUNTRIES

Panel unit root tests	Levin, Lin & Chu t-statistics (p-value)	Hadri z-statistics (p-value)
lnRGCF	-2.86167 (0.0021) ***	3.31600 (0.0005) ***
lnRGDS	-5.14405 (0.0000) ***	2.30966 (0.0105) **
lnLR	-2.30474 (0.0106) **	4.57123 (0.0000) ***
lnFA	-0.58980 (0.2777)	3.78179 (0.0001) ***
ΔlnFA	-3.05280 (0.0011) ***	1.69869 (0.0447) *
lnRCAB	-4.23730 (0.0000) ***	1.20061 (0.1150)
ΔlnRCAB	-3.24197 (0.0006) ***	1.82348 (0.0341) **

Notes: \*\*\*/1 % significance level, \*\*/5 % significance level, \*/10 % significance level.

TABLE II  
PETRONI COINTEGRATION RESULTS

Within-dimension	Statistic	p-value
Panel v-Statistic	-1.003	0.842
Panel rho-Statistic	0.511	0.695
Panel PP-Statistic	-3.602	0.000 ***
Panel ADF-Statistic	-2.530	0.005 ***
Between-dimension	Statistic	p-value
Group rho-Statistic	1.494	0.932
Group PP-Statistic	-6.838	0.000 ***
Group ADF-Statistic	-4.606	0.000 ***

Notes: \*\*\*/1 % significance level, \*\*/5 % significance level, \*/10 % significance level.

To examine whether a panel cointegration exists between investment and savings, modern developed method pioneered by Petroni [15] is employed. The test employs four panel statistics and three group panel statistics. The technique tests the null hypothesis of “no cointegration” among the variables against the alternative hypothesis of “cointegration”. Table II presents the results for panel cointegration. The result shows that four panel and statistics confirm the existence of cointegration between investment, savings, leading rate, foreign aid and current account balance. The p-values reported suggest that the null hypothesis of no cointegration is rejected at 5%. The existence of a long run equilibrium among the variables (investment, savings, leading rate, foreign aid and current account balance) in the panel BRICS economies is economically meaningful. This suggests that BRICS countries meet the long run solvency condition. After validating the existence of panel long run cointegration of variables, it is customary to estimate the coefficients of each exogenous variable using FMOLS and DOLS panel estimators.

The study estimates the coefficients of panel cointegration by applying FMOLS and DOLS. Table III shows the coefficients of each exogenous variable, where investment is treated as the dependent variable.

The results obtained applying the FMOLS are relatively similar to those estimated in using DOLS. The results from FMOLS indicate that there is a positive relationship between

saving and investment. The coefficient for saving is 0.850 and it is statistically significant at 1%. Leading rate shows that it has a negative impact on investment for a panel of BRICS economies. Foreign aid variables have a positive association with investment with the coefficient of 0.001. The results from FMOLS also show that there is a negative relationship between current account balance and investment in BRICS economies. The findings from FMOLS are quite the same as those of estimated coefficients of DOLS model. The signs of each variable are the same except in DOLS model. It is only observed that savings and current account balance are statistically significant at 1%.

TABLE III  
PANEL LONG RUN ESTIMATION RESULTS DEPENDENT VARIABLE:  
INVESTMENT

	FMOLS	DOLS
LOGRGDS	0.850 (0.000)***	0.743 (0.000)***
LOGLR	-0.069 (0.000)***	-0.067 (0.246)
LOGFA	0.001 (0.046)**	0.001 (0.501)
LRCAB	-0.094 (0.000)***	-0.090 (0.000)***
R-squared	0.990	0.993
Adjusted R-squared	0.988	0.988

Notes: \*\*\*/1 % significance level, \*\*/5 % significance level, \*/10 % significance level.

## VII. DISCUSSION OF RESULTS

The study applied the panel cointegration techniques to estimate the FHP in BRICS countries. The study found that there is strong positive relationship between savings and investment in a panel of BRICS countries. This positive result between the saving and investment implies that a 1% increase in savings will lead to 0.85% increase to investment in the long run. These results between saving and investment in BRICS economies also have an implication on capital mobility within this BRICS block. The results indicated that the parameter coefficient of saving is 0.850 for FMOLS and 0.743 for DOLS method, this finding implies that there is greater capital immobility within BRICS countries. The results show that there is negative association between lending rate and investment. This finding implies that 1% increase in lending rate will lead to 0.069% decrease in investment. The results show that there is a positive association between foreign aid and investment in the long run. This finding implies that a 1% increase in foreign aid will increase investment by 0.001 percent. The findings of the study indicated that a 1% increase in current account balance will decrease investment by 0.094%.

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