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The Feldstein-Horioka Hypothesis: Co-Integration and Causality Results for Selected Countries

Santiago Grullon[1]

Abstract

This study investigates the validity of the Feldstein-Horioka hypothesis, which suggests that with perfect world capital mobility there should be no correlation between domestic savings and domestic investment, for the Bahamas, Belize, Bolivia, Nicaragua, and Panama. Results from 'bounds' test for co-integration for all five countries confirm the presence of a long-run association between domestic savings rates and domestic investment rates, and thus failing to support the Feldstein-Horioka theory. However, Pairwise Granger tests for the first four countries do not show any causal linkages between domestic savings and domestic investment and in the case of Panama the evidence shows bi-directional causality between the two variables.

Keywords: Feldstein-Horioka hypothesis, domestic savings, domestic investment, 'bounds' test for co-integration, Granger Pairwise causality

JEL Classification: C22, F41, E20, E21, E22, 054, 057

1. Introduction

Feldstein and Horioka (1979) examined the relationship between domestic savings and investment rates in 16 industrialized countries of the Organization for Economic Cooperation and Development (OECD) during the period 1960-1974 and concluded that with perfect world capital mobility there should be no relation between the amount of domestic savings generated in a country and the domestic investment in that country. Results from recent empirical studies of the Feldstein-Horioka (F-H) hypothesis for a number of countries have been mixed. Mehraral and Musai (2014) investigated the causal link between gross domestic investment and saving rates for 40 Asian countries using panel unit root tests and panel co-integration analysis for the period 1970-2010. Their results in favor of the F-H hypothesis indicated no long-run relationship as well as no causalities between these two variables in these countries. Ogbokor and Musilika (2014) applied the Johansen test for co-integration and Pairwise Granger causality tests to annual data for Namibia during the period 1995 to 2011. Their results show did not find a long-run relationship between gross domestic savings and investment, suggesting a high degree of international capital mobility. Furthermore, Pairwise Granger tests showed unidirectional causality from savings to investment. Using panel co-integration analysis and an error correction model, Hamdi and Sbia (2013) found a long-run equilibrium relationship between savings and investment for a panel of countries consisting of Bahrain, Iran, Kuwait, Oman, Saudi Arabia, and Tunisia at the individual level for five countries, except Saudi Arabia. Granger causality tests validated the presence of bi-directional causal relationships between savings and investment. However, the short-run estimation showed no causality between the two variables for the entire sample. At the individual level, savings Granger caused investment for Bahrain and Saudi Arabia only. Nasiru and Usman (2013) examined the association between savings and investment for Nigeria over the period 1980–2011. Results from the bounds test for co-integration revealed evidence of a long-run relationship between the two variables.

[1]Senior Economic Analyst in New York City, USA

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Adebola and Dahalan (2012) tested the validity of the F-H hypothesis for Tunisia during the period 1970-2009 using an Autoregressive Distributed Lag (ARDL) Model and Granger causality test. They found the existence of long-run relationship when investment is taken as the dependent variable. The results of Granger causality test indicated two-way causality. Kumar et al. (2012) used five time series techniques to data for Australia over the period 1960-2007. Their findings revealed that the Feldstein-Horioka puzzle exists in a weak form with a lower saving retention coefficient. Moreover, results from Granger causality tests showed that savings Granger causes investment both in the short-run and in the long-run. Ramakrishna and Rao (2012**)** applied the Johansen co-integration methodology in Ethiopia and did not find a long-run relation between savings and investment. Their analysis revealed that investment is dependent largely on foreign aid and finance. Solarin and Dahalan (2012) examined the degree of capital mobility in Tunisia during the period 1970-2009. Results from the bounds test for co-integration showed the existence of a long-run relationship between savings and investment when either of these two variables is used as the dependent variable. Moreover, Granger causality tests showed bi-directional casual linkages between the variables. Combined, these results imply low capital mobility in Tunisia. Dar and Amirkhalkhali (2011) employed a varying coefficients error correction model to quantify the influence of the degree of openness and the regulatory framework on domestic savings and investment in 25 emerging economies over the 1985-2006 period. Their findings showed that countries with the highest degree of openness and the best regulatory environment achieved high investment rates independently of the domestic saving effort. Onafowara et al. (2011) studied the link between savings and investment in eight advanced economies of the European Union. Results from the bounds test and an unrestricted error correction model showed evidence of co-integration between the two variables in Belgium, Denmark, Germany, Luxemburg, Netherlands, and the United Kingdom. In addition, they found evidence of long-run causality running from savings to investment in the Netherlands and the UK, reverse causality in Denmark, Germany and Luxemburg, bi-directional causality in Belgium, and neutrality in France and Italy. Esso and Keho (2010) explored the F-H hypothesis in Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal, and Togo. Results from the bounds test for co-integration proved that domestic savings play an active role in the financing of investment in Benin and Niger. No long-run relationship was found for the other five countries. Applying the Toda and Yamamoto causality test, the evidence showed causality running from savings to investment for Benin, Côte d'Ivoire, and Niger. Mishra et al. (2010) used the Johansen's co-integration test and found evidence of a long-run equilibrium relationship between savings and investment in India for the period 1950-51 to 2008-09. Results from the Granger causality test showed bi-directional causality between the two variables.

Table 1 shows the growth rate of gross domestic product (GDP), the average ratio of gross domestic savings to GDP and of gross domestic investment to GDP, and the average saving-investment gap for the Bahamas, Belize, Bolivia, Nicaragua, and Panama. The respective average annual growth rates of gross domestic product ranged from a low of 2.2 percent in the Bahamas to a high of 5.6 percent in Belize. The savings rate varied from a high of 16.567 in Panama to a low of 10.640 in Nicaragua. Meanwhile, the investment rate varied from a low of 16.043 in Bolivia to a high of 24.417 in the Bahamas. The average savings-investment gap ranged from a low of -1.755 in Bolivia to a high of -13.225 in Nicaragua.

Table 1: GDP and Gross Domestic Savings Rates & Gross Domestic Investment Rates

Country	Period	GDP (%)	Savings	Investment	Savings-Investment Gap
Bahamas	1980-2013	2.2	16.020	24.417	-8.397
Belize	1980-2013	5.6	15.954	22.324	-6.371
Bolivia	1981-2013	2.8	14.289	16.043	-1.755
Nicaragua	1991-2013	2.1	10.640	23.865	-13.225
Panama	1980-2013	5.0	16.567	21.078	-4.511

The excess of investment rates over savings rates in these countries makes this an ideal case to empirically test the validity of the Feldstein-Horioka hypothesis. The approach is as follows. First, we use the bounds testing approach to the analysis of level relationship of Pesaran et al. (2001) to test for the existence of a co-integration relationship between gross domestic savings and gross domestic investment. Second, we use Granger Pairwise causality tests to determine the direction of causality among the two variables of interest. The rest of this paper is organized as follows: the model specification, variables, and data sources are presented in Section 2; the empirical results are summarized and discussed in Section 3; and the last section summarizes the findings and discusses their policy implications.

2. The Model, Variables, and Data Sources

To assess the relationship between the domestic savings rates and investment rates, Feldstein and Horioka (1979) proposed estimating the following equation:

$$(I/Y)_i = \alpha + \beta(S/Y)_i \qquad (1)$$

where: $(I/Y)_i$ is the ratio of gross domestic investment to gross domestic product in country i and $(S/Y)_i$ is the corresponding ratio of gross domestic savings to gross domestic product. The empirical analysis uses annual statistics. Data on GDP, gross domestic savings and gross domestic investment are from the IMF's World Economic Outlook database, April 2015.

The methodological framework for conducting the empirical analysis uses the bounds testing approach to the analysis of level relationships of Pesaran et al. (2001). This technique uses an autoregressive distributed lag (ARDL) model to estimate an unrestricted error correction model (UECM) and can be reliably used to estimate and test hypotheses on the long-run coefficients irrespective of whether the underlying regressors are purely $I(0)$, purely $I((1)$, or mutually co-integrated. Therefore, unlike other applications of co-integration analysis, which require that the order of integration of the underlying regressors be ascertained prior to testing the existence of a long-run relationship between the dependent variable and the independent variables, this method does not necessitate a precise identification of the order of integration of the underlying data. It thus eliminates the uncertainty associated with pre-testing the order of integration; this can be particularly troublesome in studies that have a small sample size as is the case in the present study. Thus, the relationship between domestic savings and domestic investment, can be represented by the following ARDL/UECM equation:

$$\Delta \log I = \alpha_0 + \alpha_1 \log S_{t-i} + \alpha_2 \log I_{t-i} + \sum_{i=0}^{p} \alpha_3 \Delta \log S_{t-i} + \sum_{i=1}^{q} \alpha_4 \Delta \log I_{t-i} + u_t \qquad (2)$$

where I and S stand for the gross domestic investment rates and the gross domestic savings rates, respectively, and e is the error term. In performing the ARDL/UECM estimation, the maximum number of lags of the levels variables is set equal to one, and on the first-differenced variables the process starts off from a maximum of four lags, then the optimum number is chosen based on the Akaike's Information Criterion (AIC), the Ramsey RESET test, and the adjusted R^2. Thus, the formulation with the lowest AIC, the Ramsey RESET test results for the best-fit specification, and the highest adjusted R^2 is selected. The test for the existence of co-integration between the terms in levels is conducted by means of a Wald F-test as follows:

$$H_o: \chi_1 = \chi_2 = 0 \text{ (no co-integration exists)}$$

$$H_A: \chi_1 \neq \chi_2 \neq 0 \text{ (co-integration exists)}$$

Pesaran et al. (2001) provide two sets of critical value bounds covering the two polar cases of the included lagged level explanatory variables (Table 2 below). If the computed Wald F-statistic falls below the lower bound (indicating that $\chi_1 = \chi_2 = 0$), then this would lead us to conclude that there is no co-integration between savings and investment. If, on the other hand, the computed F-statistic exceeds the upper bound of the critical value (signifying that $\chi_1 \neq \chi_2 \neq 0$), then the alternative hypothesis of co-integration between savings and investment is accepted.

Table 2: Critical Value Bounds for the Wald *F*-statistic

Level of Significance	Lower Bound Value $I(0)$	Upper Bound Value $I(1)$
1%	6.84	7.84
5%	4.94	5.73
10%	4.04	4.78

Source: Pesaran et al. (2001), Table C1.iii: Case III: Unrestricted intercept and no trend.

After establishing a co-integration relation between savings and investment, the study will then proceed to apply Pairwise Granger causality tests to determine whether there is a causal association between the two variables. Engle and Granger (1987:259) point out that a two-variable co-integrated system must have a causal ordering in at least one direction. To implement the Granger causality test, the following model based on Granger (1969:431) will be estimated:

$$S_t = \sum_{j=1}^{m} a_j S_{t-j} + \sum_{j=1}^{m} b_j I_{t-j} + \varepsilon_t,$$

$$I_t = \sum_{j=1}^{m} c_j S_{t-j} + \sum_{j=1}^{m} d_j I_{t-j} + \eta_t \qquad (3)$$

where S and I are as previously defined and are assumed to be two stationary time series with zero means, and ε_t and η_t are taken to be two uncorrelated white-noise series. Granger's definition of causality expressed by Equation (3) implies that S_t is causing I_t provided some b_j is not zero. Likewise, I_t is said to be causing S_t provided some c_j is not zero. If either of these cases exists, then there is one-way causality between S_t and I_t. However, if both of these events occur, there is a two-way causal relationship between S_t and I_t.

3. Empirical Results

Table 3: Wald *F*-Test Results for Co-integration between Savings and Investment

Country	Period	Wald *F*-Test
Bahamas	1980-2013	6.39
Belize	1980-2013	6.45
Bolivia	1981-2013	6.02
Nicaragua	1991-2013	9.09
Panama	1980-2013	7.96

The econometric results summarized in Table 3 show the existence of a long-run co-integration relationship between gross domestic savings and investment spending for all five countries. The Bahamas has a Wald *F*-statistic that exceeds the upper bound value at 5 percent and 10 percent levels of significance (see Table 2 above). The Wald *F*-statistic for Belize also exceeds the upper bound value at 5 percent and 10 percent levels of significance. Bolivia has the third lowest Wald *F*-statistic of the five countries studied but exceeds the upper bound value at 5 percent and 10 percent levels of significance. Nicaragua shows the highest Wald *F*-statistic and exceeds the upper bound value at all three levels of significance. Panama has the second highest Wald *F*-statistic and it exceeds the upper bound value at all three levels of significance.

Table 4 presents the results of the Pairwise Granger causality tests, using one lag. The findings for the Bahamas, Belize, Bolivia and Nicaragua fail to show any causal linkages between domestic savings and domestic investment. However, in the case of Panama we have bi-directional causality between the two variables.

Table 4: Pairwise Granger Causality Tests

Null Hypothesis:	***F*-Statistics**	**Probability**	**Conclusion**
Bahamas:			
log*S* does not Granger Cause log*I*	0.946	0.3384	Accept
log*I* does not Granger Cause log*S*	0.247	0.6228	Accept
Belize:			
log*S* does not Granger Cause log*I*	0.661	0.4227	Accept
log*I* does not Granger Cause log*S*	0.770	0.3872	Accept
Bolivia:			
log*S* does not Granger Cause log*I*	0.603	0.4436	Accept
log*I* does not Granger Cause log*S*	0.678	0.4169	Accept
Nicaragua:			
log*S* does not Granger Cause log*I*	1.374	0.2572	Accept
log*I* does not Granger Cause log*S*	3.827	0.0671	Accept
Panama:			
log*S* does not Granger Cause log*I*	4.666	0.0391	Reject
log*I* does not Granger Cause log*S*	7.598	0.0010	Reject

4. Summary Discussion, Suggested Extensions, and Policy Implication

This study has employed the 'bounds' testing approach to co-integration and Granger Pairwise causality tests to quantify the importance of domestic savings for domestic investment in the Bahamas, Belize, Bolivia, Nicaragua, and Panama. While the results for co-integration for all five countries confirmed the presence of a long-run association between domestic savings rates and domestic investment rates, the evidence from Granger Pairwise causality tests for the first four countries failed to show any causal linkages between these variables. In the case of Panama the findings showed bi-directional causality between domestic savings and domestic investment.

The results of this study suggest the need for further empirical research. Over the course of the period under analysis, the Bahamas, Belize, Bolivia, Nicaragua, and Panama all had an excess of domestic investment over domestic savings. It would thus be interesting to empirically test for the existence of long-run and causal relationships between the savings-investment gaps and interest rates, inflation, exchange rates and the trade balance. Neoclassical economics posits a causal association running from savings to investment to economic expansion. On the other hand, Keynesian theory argues that investment causes economic growth, thereby increasing savings. Thus, one line of future study would be to empirically examine these two competing propositions for this sample of countries.

The conclusions of this study also suggest that policy makers in these five nations should be cautious about attempting to close the savings-investment gaps by implementing policy measures that can lead to reductions in private investment in plant and equipment and in government spending on education, health, and infrastructure, as this course of action could have an adverse effect on economic competitiveness.

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APPENDIX

Table A1: Results for the Savings-Investment Nexus, Bahamas 1980-2013

Dependent Variable: Share of Gross Investment in GDP included observations: 29 after adjustments

Regressor	Coefficient	*t*-Statistic	Probability
Constant	2.53	3.46	0.00
Log*S* (-1)	-0.31	-1.93	0.07
Log*I* (-1)	-0.52	-3.33	0.00
Dlog*S* (-1)	0.27	1.91	0.07
Dlog*S* (-4)	-0.07	-0.62	0.54
Dlog*I* (-1)	0.24	1.30	0.21
Model Criteria			
R^2	0.37		
Adjusted R^2	0.23		
DW	2.05		
SER	0.11		
F-statistic	2.67		
Wald *F*-Test	6.39		0.01
Diagnostic Tests	[1]	[2]	[3]
Breusch-Godfrey LM	0.36 (0.95)	0.33 (0.72)	0.24 (0.87)
ARCH	0.17 (0.68)	0.78 (0.47)	2.98 (0.53)
Ramsey RESET	2.85 (0.11)	4.04 (0.03)	3.55 (0.03)

Table A2: Results for the Savings-Investment Nexus, Belize 1980-2013

Dependent Variable: Share of Gross Investment in GDP included observations: 29 after adjustments

Regressor	Coefficient	*t*-Statistic	Probability
Constant	2.10	2.96	0.01
Log*S* (-1)	0.20	2.10	0.05
Log*I* (-1)	-0.85	-3.46	0.00
Dlog*S*	0.31	1.87	0.07
Dlog*S* (-1)	-0.29	-1.57	0.13
Dlog*S* (-4)	-0.29	-1.88	0.08
Dlog*I* (-1)	0.61	2.67	0.01
Dlog*I* (-2)	0.33	1.49	0.15
Dlog*I* (-3)	0.55	2.68	0.01
Dlog*I* (-4)	0.25	1.12	0.27
Model Criteria			
R^2	0.51		
Adjusted R^2	0.28		
DW	2.10		
SER	0.25		
F-statistic	2.19		
Wald *F*-Test	6.45		0.01

Diagnostic Tests	[1]	[2]	[3]
Breusch-Godfrey LM	0.48 (0.50)	0.24 (0.79)	1.49 (0.26)
ARCH	0.00 (0.98)	0.87 (0.43)	0.59 (0.63)
Ramsey RESET	0.87 (0.36)	0.46 (0.64)	0.72 (0.55)

Table A3: Results for the Savings-Investment Nexus, Bolivia 1981-2013

Dependent Variable: Share of Gross Investment in GDP included observations: 29 after adjustments

Regressor	Coefficient	*t*-Statistic	Probability
Constant	1.48	3.08	0.01
Log*S* (-1)	0.08	1.53	0.14
Log*I* (-1)	-0.61	-3.40	0.00
Dlog*S* (-2)	-0.04	-0.66	0.52
Dlog*I* (-1)	0.21	1.10	0.28
Dlog*I* (-3)	0.27	1.64	0.11
Model Criteria			
R^2	0.36		
Adjusted R^2	0.22		
DW	2.00		
SER	0.14		
F-statistic	2.62		
Wald *F*-Test	6.02		0.01
Diagnostic Tests	[1]	[2]	[3]
Breusch-Godfrey LM	0.02 (0.90)	0.53 (0.59)	0.34 (0.80)
ARCH	3.05 (0.09)	2.29 (0.12)	2.23 (0.10)
Ramsey RESET	0.10 (0.76)	1.50 (0.25)	1.96 (0.15)

Table A4: Results for the Savings-Investment Nexus, Nicaragua 1991-2013

Dependent Variable: Share of Gross Investment in GDP included observations: 17 after adjustments

Regressor	Coefficient	*t*-Statistic	Probability
Constant	4.42	3.65	0.01
Log*S* (-1)	0.37	3.59	0.01
Log*I* (-1)	-1.65	-3.99	0.00
Dlog*S*	0.23	1.95	0.08
Dlog*S* (-1)	-0.37	-2.38	0.04
Dlog*I* (-3)	0.45	2.68	0.02
Dlog*I* (-3)	0.92	2.86	0.02
Model Criteria			
R^2	0.81		
Adjusted R^2	0.70		
DW	2.37		
SER	0.08		
F-statistic	7.23		
Wald *F*-Test	9.09		0.01
Diagnostic Tests	[1]	[2]	[3]

Breusch-Godfrey LM	1.72 (0.22)	0.80 (0.48)	0.64 (0.61)
ARCH	0.08 (0.79)	0.07 (0.3)	0.20 (0.90)
Ramsey RESET	5.33 (0.05)	5.44 (0.15)	1.79 (0.24)

Table A5: Results for the Savings-Investment Nexus, Panama 1980-2013

Dependent Variable: Share of Gross Investment in GDP included observations: 30 after adjustments

Regressor	Coefficient	*t*-Statistic	Probability
Constant	2.23	3.97	0.00
Log*S* (-1)	-0.65	-2.10	0.05
Log*I* (-1)	-0.15	-0.64	0.53
Dlog*S* (-3)	-0.40	-1.47	0.16
Dlog*S* (-1)	0.44	2.18	0.04
Dlog*S* (-3)	0.51	1.83	0.08
Model Criteria			
R^2	0.41		
Adjusted R^2	0.29		
DW	1.66		
SER	0.36		
F-statistic	3.36		
Wald *F*-Test	7.96		0.00
Diagnostic Tests	[1]	[2]	[3]
Breusch-Godfrey LM	2.35 (0.14)	2.35 (0.14)	1.54 (0.23)
ARCH	0.17 (0.69)	0.12 (0.89)	0.16 (0.92)
Ramsey RESET	9.64 (0.01)	4.61 (0.02)	4.15 (0.02)