



## Testing the Feldstein Horioka puzzle in Algeria: Maki co-integration and hidden causality analysis

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**Abstract.** *The aim of this paper is to test the existence of Feldstein Horioka puzzle in the case of Algerian economy for the period 1970-2019 by examining the link between domestic savings and investments, we use in this paper both the co-integration tests under Gregory-Hansen (1996), Hatemi-J (2008) and Maki (2012) tests in the context of structural breaks, and the symmetric and asymmetric causality (hidden causality) proposed by Hacker-Hatemi (2010) and Hatemi (2012) respectively, the results suggest that there is a co-integration relationship between saving and investment with five endogenous structural breaks, and the saving retention coefficient is equal to 0.324 which means the existence of Feldstein-Horioka puzzle in a weaker form and high capital mobility, on the other hand, the results indicate asymmetric causal relationship between savings and investments.*

**Keywords:** Feldstein-Horioka puzzle, Savings, Investments, Co-integration, Asymmetric causality.

### Introduction

According to Obstfeld and Rogoff (2001) there are six major puzzles in the international macroeconomics which is a field replete with truly perplexing puzzles (Obstfeld, 2001, p.01), the first puzzle is the home bias in trade, this puzzle ask the question why do people have such a strong preference for their home goods? it was first documented by John T. McCallum in 1995 showing that in USA and Canada inter-province trade is larger than international trade by 20 times which is not concordant with the economic theory (McCallum, 1995, p.619), the second puzzle is the home bias in equity portfolios which assumes that despite the rapid growth of international capital markets the investors hold only modest amounts of foreign equity, this puzzle was first documented by French and Poterba (1991) in Japan with 98% of the equity portfolio of Japanese investors is held domestically (94% in USA and 82% in UK) (French, 1991, p.01), the third puzzle is the international consumption correlations or as named Backus-Kehoe-Kydland puzzle and was first presented in 1992 by calculating the correlation of Hodrick-Prescott filtered consumption and output for USA relative to eleven advanced countries, the results showed that the average for consumption correlation was 0.19 against 0.31 for output average correlation (Backus et al. (1991), p.18), in this case and according to the theory we should find that consumption is more correlated across countries than output, the fourth and fifth puzzles are the purchasing power parity (PPP) and exchange rate disconnect puzzles, these puzzles focus on persistent deviations from PPP and how little

large fluctuations in exchange rates affect real outcomes other than the real exchange rate and it was first presented by Dornbush in 1976 (Eaton et al. 2016, p.09).

The last and the sixth puzzle named the mother of all puzzles is the Feldstein-Horioka puzzle and was first presented in 1980, in the economic theory it assumes that investors can easily invest anywhere in the world their capitals to get the highest return, this what allows for a large movement of capitals across countries and as a logical result for all of this the private saving must be uncorrelated with the private investment according to the foreign capitals inflow, but for the period 1960-1974, Feldstein and Horioka in 16 OCDE countries found the correlation between the two variables was 0.89 (Feldstein, 1980, p.08) (Obstfeld and Rogoff found it 0.60 for the period 1990-1997 for the same sample) which means a strong correlation between private investment and private saving in very open economies in the world, because in a closed economy with zero foreign capitals all domestic saving finances the domestic investment with full correlation (100%) in contrast of an open economy with high capital mobility (Ceasay et al.2019, p.19).

This study contribute to the existing body of literature in two ways, first, many existing studies used various technics such as co-integration tests using Johansen test and ARDL procedure with bounds test in addition to traditional symmetric causality tests depending on Granger and Toda-Yamamoto tests, however, to our knowledge, only a small body of literature examined the FH puzzle using co-integration tests under structural breaks especially the modern Maki (2012) test and the asymmetric causality tests dealing with positive and negative shocks, so, unlike the previous studies we will use Maki co-integration test with five structural breaks in addition to Gregory-Hansen and Hatemi-J tests and Hacker-Hatemi-J asymmetric causality test, the second contribution of this paper is that until now no study has emphasized the importance of this subject in the context Algeria especially in these last years with the deteriorate of oil prices in international markets, for this reason we aims to fill this gap.

The present study examines the Feldstein-Horioka puzzle in the case of Algerian economy over the period 1970-2019 to get a clear idea about the capital movements in one of most important oil exporter country in the Arab region, in doing so, the paper uses yearly data for private savings and private investments using various econometric tests as NG-Perron and Kapetanios tests for unit root test and Gregory-Hansen, Hatemi-j and Maki tests for co-integration with regime shift test and Hacker-Hatemi bootstrap causality in addition to Hatemi-J asymmetric causality for hidden causality, this paper is organized as follows, section one is for the introduction where the problematic was raised and the objectives were clarified, section two throws light at the relevant literature, section three describes the data set and explains the econometric tests, section four presents the empirical results and section five concludes the paper with policy recommendations.

## Literature review

Over the last four decades, the studies that care out of the capital mobility unedr the Feldstein-Horioka puzzel have been very widespread in all countries (developed or developing countries), in the leterature, the relationship saving-investment has two different directions of views, the first is the measuring of the degree of capital mobility, like Sinn (1992), Obstfeld and Fogoff (1995), Coakley et la. (1996) and Summers (1998) where they argued that since the current account balance equals to the gap between the two variables (saving and investment) a big correlation index between theme doesn't mean anything but

on the other hand the long-run solvency of current account balance can be a determinant key of the degree of capital mobility, on the other extreme, the second direction is to measure the country size effect, according to Baxter and Crucini (1993), Coakley et al. (1998) and Ho (2003) the country which can influence the interest rates any increase in national savings will directly reduce the world interest rates and increase investment in its economy, for this reason, a big correlation index between saving and investment doesn't mean all the times the high capital mobility (Yildirim, 2016, p.05).

**Table 1. Some studies about the Feldstein Horioka puzzle**

| Study                             | Period and sample                                   | Methodology                                   | Results                                                                                                                         |
|-----------------------------------|-----------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Ho (2002)                         | 12 different countries 1950-1992                    | Panel co-integration test                     | Low correlation between savings and investments                                                                                 |
| Blanchard and Giavazzi (2002)     | OECD and Euro area 1975-2001)                       | Estimation techniques                         | FH doesn't exist                                                                                                                |
| Pelagidis and Mastroiannis (2003) | Greece 1960-1997                                    | Co-integration analysis                       | Long run relationship between savings and investments                                                                           |
| Payne (2005)                      | Mexico 1960-2002                                    | Co-integration analysis                       | Long run relationship between savings and investments after 1982 crises                                                         |
| Telatar et al. (2007)             | 10 European countries 1970-2002                     | Markov Switching model                        | Correlation coefficients are not invariant to policy regime                                                                     |
| Christopoulos (2007)              | 13 OECD countries 1885-1992                         | Panel co-integration test                     | Low degree of capital mobility in the short run term                                                                            |
| Fouquau et al. (2008)             | 24 OECD countries                                   | Panel smooth transition regression approach   | Degree of openness, country size and current account to GDP ratios have a great influence on the investment-saving relationship |
| Murthy (2009)                     | 19 Latin American and Caribbean countries 1960-2002 | Panel co-integration test                     | High degree of capital mobility                                                                                                 |
| Brahmasrene and Jiranyakul (2009) | 7 Asian countries 1970-2007                         | ARDL model                                    | FH doesn't exist                                                                                                                |
| Esso and Keho (2010)              | 7 African countries 1965-2005                       | ARDL model and Toda Yamamoto causality        | Capital mobility exists in Burkina Faso, Mali, Senegal and Togo not in Benin, Cote d'Ivoire and Niger                           |
| Guzel and Ozdemir (2010)          | Japan and USA 1960-2003                             | Co-integration with regime shift test         | Structural shifts eliminates the FH puzzle both for Japan and USA                                                               |
| Josic and Josic (2012)            | Croatia 1994-2010                                   | Johansen co-integration and Granger causality | Strong dependency of domestic investment to domestic savings in the long run                                                    |
| Kumar et al. (2012)               | Australia 1960-2007                                 | Johansen co-integration and Granger causality | FH puzzle exists in a weak form with a lower saving retention coefficient (0.5)                                                 |
| Erdem et al. (2016)               | Turkey 1960-2014                                    | Maki co-integration                           | High capital mobility with low saving retention coefficient (0.377 and 0,406)                                                   |
| Yildirim and Erdem (2016)         | China 1970-2013                                     | Gregory Hansen and Maki co-integration        | FH exists just during the period 1994-2013                                                                                      |

|                          |                                    |                                                 |                                                                                                    |
|--------------------------|------------------------------------|-------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Shabbir Ahmad (2017)     | South Asia and KSA 1965-2014       | ARDL model                                      | FH exists in India and KSA and doesn't exists in Bangladesh, Sri Lanka and Pakistan                |
| Kaur and Sarin (2018)    | Selected Asian countries 1980-2016 | Panel co-integration test                       | The FH puzzle exists with high correlation between saving and investment (0.968)                   |
| Pata (2018)              | E7 countries 1989-2015             | Panel co-integration and asymmetric causality   | FH puzzle is valid for the E7 countries                                                            |
| Tursoy and Faisal (2019) | Cyprus 1983-2012                   | ARDL model and Bayer-Hanck test                 | FH puzzle is valid in the long run and short run terms                                             |
| Patra and Mohanty (2019) | South Asian countries              | Regime switching approach                       | The FH puzzle exists                                                                               |
| Dash (2019)              | 118 countries 1981-2013            | ARDL model                                      | Adjustment coefficient for individuals is higher than the panel data and the country size is mixed |
| Phiri (2019)             | South Africa 1960Q1-2017Q1         | Asymmetric co-integration analysis              | The international capital mobility has increased in the post-crisis period (2008-2016)             |
| Ko And Funashima (2019)  | 9 different countries 1885-2010    | Time frequency domain analysis                  | Large economies (USA and Italy) show higher correlations between saving and investment             |
| Ceesay et al. (2019)     | Gambia 1983-2005                   | Gregory Hansen and ARDL co-integration analysis | FH puzzle exists in the short run not in the long run                                              |

Source: Authors' own research.

It's clear from the table above the absence of studies in the case of Algeria and Arabic countries, so in this paper, we shall try to fill the gap of the absence of the studies about the saving-investment nexus under FH puzzle in the context of Algeria using modern econometric methods such as the co-integration in the presence of various structural breaks and causality tests under bootstrapping technique and hidden causality.

## Methodology

Back to Westerlund and Edgerton (2006) the existence of structural breaks in non-stationary series can provide biased results using the conventional co-integration tests as Engle-Granger test, Johansen test or Bound test under ARDL model (Shaeri, 2018, p.689), for this reason and to avoid the spurious regression we use different tests of co-integration with regime shifts as follows.

### 1. Gregory-Hansen (1996) test

The Gregory Hansen (1996) procedure can solve this issue (biased results) by accounting for structural breaks in the co-integration equation as follows:

1. The level shift model (C)

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 x_t + \varepsilon_t \quad (01)$$

Where  $\varphi_{t,\tau}$  is a dummy variable such that  $\varphi_{t,\tau} = 1$  if  $t > n\tau$  or 0 if  $t \leq n\tau$ , and  $\tau \in (0,1)$  denotes the relative timing of the break point, the effect of the regime shift in this case in on the intercept  $\mu_0$  (before the break) and  $\mu_1$  is the change in intercept (at the break time).

2. The level shift with trend model (C/T): in this model the break still on the intercept but with the existence of a trend (t) in the series

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 t + \mu_3 x_t + \varepsilon_t \quad (02)$$

3. Regime shift with changes in the intercept and the slope (C/S): for this model the structural break is on both intercept and slope coefficient where  $\mu_2$  is the co-integration slope coefficient before the break where  $\mu_3$  is the coefficient of co-integration slope at the time of the break.

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 x_t + \mu_3 x_t \varphi_{t,\tau} + \varepsilon_t \quad (03)$$

4. Regime shift with changes in intercept, slope and trend (C/S/T): in this case the structural break affects all the components (intercept, slope and the trend).

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 t + \mu_3 t \varphi_{t,\tau} + \mu_4 x_t + \mu_5 x_t \varphi_{t,\tau} + \varepsilon_t \quad (04)$$

And for each equation, we perform the unit roots tests on the residuals series using three tests ADF,  $Z_\alpha$  and  $Z_t$ .

## 2. Hatemi-J (2008) test

As pointed by Hatemi-J (2008) the traditional co-integration tests are based on the assumption that the co-integrating vector remained the same during the period of study (Hatemi, 2008, p. 489), but the presence of economic crises, technological shocks, policy and regime changes can cause big changes in this co-integrating vectors in the long run term, for this reason Hatemi (2008) propose the following procedure based on Gregory-Hansen (1996) test to examine the co-integration relationship in the presence of two different structural breaks:

To account for the effect of two structural breaks on the intercept and the slopes, we have the following equation:

$$y_t = \alpha_0 + \alpha_1 D_{1t} + \alpha_2 D_{2t} + \beta'_0 x_t + \beta'_1 D_{1t} x_t + \beta'_2 D_{2t} x_t + \mu_t \quad (05)$$

Where  $D_{1t}$  and  $D_{2t}$  are dummy variables defined as:

$$D_{1t} = \begin{cases} 0 & \text{if } t \leq [n\tau_1] \\ 1 & \text{if } t > [n\tau_1] \end{cases}$$

And

$$D_{2t} = \begin{cases} 0 & \text{if } t \leq [n\tau_2] \\ 1 & \text{if } t > [n\tau_2] \end{cases}$$

With the unknown parameter  $\tau_1 \in (0,1)$  and  $\tau_2 \in (0,1)$  signifying the relative timing of the regime change point and the bracket denotes the integer part.

## 3. Maki (2012) test

When the number of breaks are more than three, the tests of Gregory Hansen (1996) and Hatemi-J (2008) would perform poorly (Maki, 2012, p. 2011), for this reason, Maki suggested four equations to test the co-integration relationship under maximum of five structural breaks as follows:

$$y_t = \mu + \sum_{i=1}^k \mu_i D_{i,t} + \beta' x_t + \varepsilon_t \quad (06)$$

$$y_t = \mu + \sum_{i=1}^k \mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^k \beta'_i x_t D_{i,t} + \varepsilon_t \quad (07)$$

$$y_t = \mu + \sum_{i=1}^k \mu_i D_{i,t} + \gamma_t + \beta' x_t + \sum_{i=1}^k \beta'_i x_t D_{i,t} + \varepsilon_t \quad (08)$$

$$y_t = \mu + \sum_{i=1}^k \mu_i D_{i,t} + \gamma_t + \sum_{i=1}^k \gamma_t t D_{i,t} + \beta' x_t + \sum_{i=1}^k \beta'_i x_t D_{i,t} + \varepsilon_t \quad (09)$$

Where equation (06) is the model with level shifts, eq. (07) called the regime shifts model, eq. (08) is model (07) with a trend and eq. (09) constitutes structural breaks of levels, trends and regressors;  $D_{1,t}$  takes a value 1 if  $t > T_{B1}$  ( $i=1, \dots, k$ ) and 0 otherwise, where  $k$  is the maximum number of breaks and  $T_{B1}$  denotes the time period of the break.

## Results and discussions

This section introduces the empirical model, which use in this study and presented by Feldstein and Horioka (1980) as follows:

$$\left(\frac{I}{GDP}\right)_t = \mu + \gamma \left(\frac{S}{GDP}\right)_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma^2) \quad (10)$$

Where  $I$  is the gross domestic capital formation index as an investment proxy,  $S$  is the domestic savings,  $GDP$  is the gross domestic product and  $\gamma$  denotes the retention coefficient of investment to saving and finally  $\mu$  and  $\varepsilon_t$  are the constant term and the white noise respectively.

The first step in our study is to describe the changes and the behavior of the saving and investment series in Algeria for the period of study 1970-2018, and the figure 1 shows that before 1994 the two variables have the same changes and behavior which means that in this period the domestic saving finances the domestic investment, but after 1994 the year which knows a lot of changes in the Algerian economy by new roles and in this year the government abandoned the socialist system by buying the national companies to the private sector, for this reason we should use the co-integration test with regime shifts analysis to avoid this big change in the economic society in Algeria in 1994.

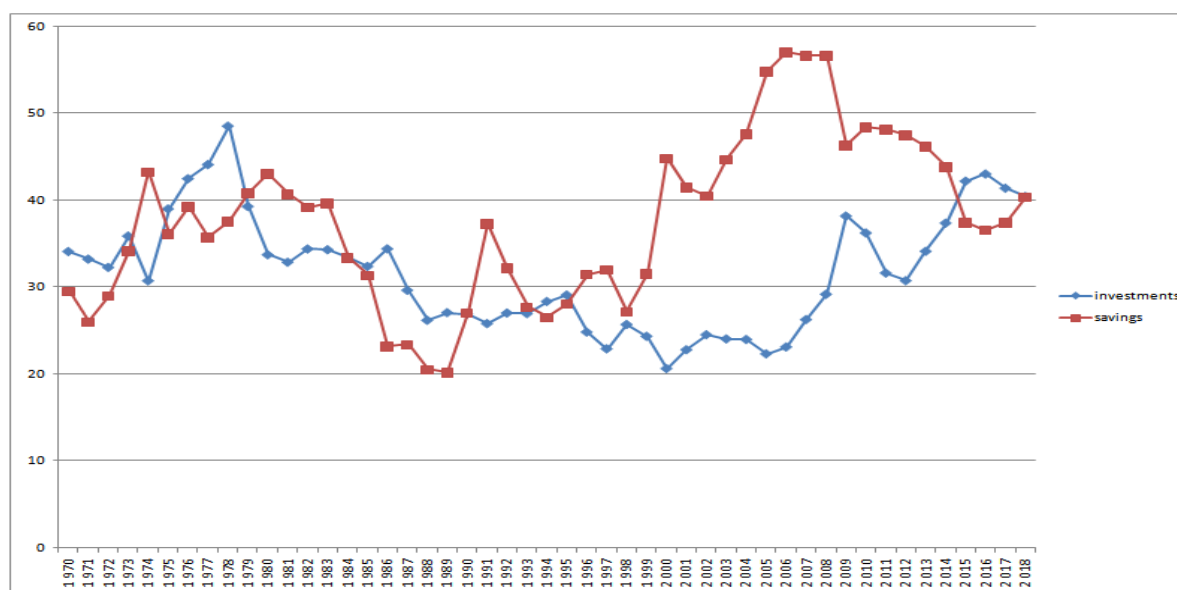


**Figure no. 1. Domestic saving and domestic investment changes in Algeria**

Source: Author's work depending on World Bank database September 2019.

### 1. Unit root tests results

As usual the unit root tests are the first step at any time series analysis, for this purpose, two tests have been conducted; the NG-Perron (2001) test without structural breaks and Kapetanios (2005) test with structural breaks (5 structural breaks), the results inspired from tables (02) shows that both of the series are  $I(1)$  series under NG-Perron test because they

become stationary after the first differences in all the four tests, by passing to Kapetanios test results, both of the series have at least five structural breaks in their levels this what means that are not stationary at the level, but they are stationary at their first differences, for this reason, both of the series are  $I(1)$  series with at least five structural breaks.

**Table 2. Unit root test results**

| <b>NG-Perron test</b>  |                 |        |                          |       |        |      |                   |      |
|------------------------|-----------------|--------|--------------------------|-------|--------|------|-------------------|------|
| Variables              | MZ <sub>a</sub> |        | MZ <sub>t</sub>          |       | MSB    |      | MPT               |      |
|                        | Stat            | Crit   | Stat                     | Crit  | Stat   | Crit | Stat              | Crit |
| I/GDP                  | -5.33           | -17.30 | -1.55                    | -2.91 | 0.29   | 0.16 | 16.80             | 5.48 |
| S/GDP                  | -7.03           | -17.30 | -1.85                    | -2.91 | 0.26   | 0.16 | 12.98             | 5.48 |
| $\Delta(I/GDP)$        | -32.55**        | -17.30 | -4.02**                  | -2.91 | 0.12** | 0.16 | 2.85**            | 5.48 |
| $\Delta(S/GDP)$        | -23.64**        | -17.30 | -3.43**                  | -2.91 | 0.14** | 0.16 | 3.88**            | 5.48 |
| <b>Kapetanios test</b> |                 |        |                          |       |        |      |                   |      |
| Variables              | t- statistic    |        | Break dates              |       |        |      | 5% critical value |      |
| I/GDP                  | -6.125          |        | 1978-2006-1991-1998-1985 |       |        |      | -8.343            |      |
| S/GDP                  | -7.771          |        | 1999-1983-2008-1989-1976 |       |        |      | -8.343            |      |
| $\Delta(I/GDP)$        | -8.884**        |        | 1978-2007-2013-1986-1995 |       |        |      | -8.343            |      |
| $\Delta(S/GDP)$        | -8.775**        |        | 1989-2008-1998-1983-1976 |       |        |      | -8.343            |      |

\*\* denote significance at 1% and 5%;  $\Delta$  denote the first difference series.

Source: Authors' calculations.

## 2. Co-integration tests results

The next step in our study, is to test the long run relationship among the variables, and since the variables are  $I(1)$  series with one structural break we cannot apply the traditional methods of co-integration as Engel-Granger and Johansen-Juselius, consequently the Gregory Hansen (1996), Hatemi-j (2008) and Maki (2012) tests are the best solution in our study with the estimation of equation (04) (C/S/T model) for Gregory Hansen and equation (05) for Hatemi-j test and the four equations for Maki test.

Table (03) shows the results of Gregory Hansen test; and it's clear from the results that we cannot reject the hypothesis of no co-integration relationship with one structural break for the three tests which means there is no long run relationship between the two variables or there exists more than one structural break in the co-integration relationship.

**Table 3. Gregory Hansen co-integration test results**

| Tests          | Test statistic | Breakpoint | 1% critical value | 5% critical value |
|----------------|----------------|------------|-------------------|-------------------|
| ADF            | -3.92          | 2009       | -6.02             | -5.50             |
| Z <sub>t</sub> | -4.40          | 1998       | -6.02             | -5.50             |
| Z <sub>a</sub> | -26.18         | 1998       | -69.37            | -58.58            |

Source: Authors' calculations.

The second test is the Hatemi-J (2008) test for co-integration with two structural breaks; table (04) shows the results of the test, and we have conflicting results between modified ADF (Augmented Dickey-Fuller) test and modified Phillips tests, we cannot reject the hypothesis of no co-integration relationship under the first test but we reject it (the hypothesis of no co-integration relationship) only under Z<sub>t</sub> test, according to this results we must apply the Maki (2012) test to avoid this conflicting results.

**Table 4. Hatemi-J co-integration test results**

| Tests          | Test statistic | Breakpoints     |                 | 1% critical value | 5% critical value |
|----------------|----------------|-----------------|-----------------|-------------------|-------------------|
|                |                | 1 <sup>st</sup> | 2 <sup>nd</sup> |                   |                   |
| ADF            | -4.288         | 1982            | 1989            | -6.503            | -6.015            |
| Z <sub>t</sub> | -8.695**       | 1976            | 1991            | -6.503            | -6.015            |
| Z <sub>a</sub> | -63.347        | 1977            | 1990            | -90.749           | -76.003           |

\*\* denote significance at 1% and 5% levels based on the critical values taken from Hatemi-J (2008).

Source: Authors' calculations.

The final test in co-integration relationship is the modern test of Daiki Maki (2012) test with five structural breaks, table 5 shows the results for all the equations 06, 07, 08 and 09, the results inspired from table (05) is that there is a co-integration relationship between the two variables with 5 structural breaks (1978, 1984, 2001, 2007 and 2012) under equation (07) which means the existence of the long run relationship between domestic saving and domestic investment in Algeria for the period 1970-2018, so the two variables have the same behavior in the long run term, this result can provide the existence of the FH puzzle, and to get the retention coefficient  $\gamma$  both in short run and long run terms we must estimate the ECM (Error Correction Model), the FMOLS (Fully Modified Ordinary Least Squares).

**Table 5. Maki co-integration test results**

| Equations    |              | Test statistic | Breakpoint s                    | 1% critical value | 5% critical value |
|--------------|--------------|----------------|---------------------------------|-------------------|-------------------|
| Equation(06) | K = 3        | -4.05          | 2001-1989-1977                  | -5.563            | -5.083            |
|              | K = 4        | -11.9**        | 2012-2001-1989-1977             | -5.320            | -5.776            |
|              | K = 5        | -12.4**        | 2012-2001-1995-1989-1977        | -5.426            | -5.959            |
| Equation(07) | K = 3        | -5.28          | 2012-2001-1978                  | -5.373            | -5.833            |
|              | K = 4        | -5.44          | 2012-2007-2001-1978             | -5.508            | -6.059            |
|              | <b>K = 5</b> | <b>-5.97*</b>  | <b>2012-2007-2001-1984-1978</b> | <b>-5.699</b>     | <b>-6.193</b>     |
| Equation(08) | K = 3        | -4.02          | 2001-1996-1989                  | -6.251            | -5.703            |
|              | K = 4        | -5.01          | 2001-1996-1989-1978             | -6.596            | -6.011            |
|              | K = 5        | -5.97          | 2012-2001-1996-1989-1978        | -6.915            | -6.357            |
| Equation(09) | K = 3        | -6.31          | 2002-1992-1981                  | -7.082            | -6.524            |
|              | K = 4        | -6.31          | 2002-1992-1981-1975             | -7.553            | -7.009            |
|              | K = 5        | -6.31          | 2002-1992-1987-1981-1975        | -8.004            | -7.414            |

\*\* denote significance at 1% and 5% levels based on the critical values taken from Maki (2012); and K denote the number of structural breaks.

Source: Authors' calculations.

### 3. Short run estimation (ECM)

As declared by Engle and Granger (1987) the best way to estimate the short run relations and effects for the co-integrated variables is the error correction model (ECM) to get also the speed of adjustment between the variables (Engel, 1987, p.275), according the results obtained from table (06) the coefficient of the error correction term is negative and significant at 5% significance level which confirms the existence of the long run relationship between the two variables, but it's clear from the ECT parameter that the speed of adjustment is very low which means that the system take a long time to back to the equilibrium after any disruption, on the other hand, it seems that the PH puzzle doesn't exist in the short run term

because the insignificance of the saving parameter which means that the savings doesn't affect the investment in the short run term.

**Table 6. Short run estimation (ECM)**

| Parameters                                                                                                       | Coefficients | Student statistic | Probability |
|------------------------------------------------------------------------------------------------------------------|--------------|-------------------|-------------|
| ECT                                                                                                              | -0.098**     | -2.834            | 0.001       |
| D(I/GDP)                                                                                                         | 0.071        | 0.435             | 0.825       |
| D(S/GDP)                                                                                                         | -0.065       | -0.522            | 0.914       |
| Constant                                                                                                         | 0.153        | 0.324             | 0.681       |
| ** denote significance at 1% and 5% levels; D denote the first difference; ECT denote the error correction term. |              |                   |             |

Source: Authors' calculations.

#### **4. Long run estimation (FMOLS)**

The most important result inspired from table (07) is the existence of FH puzzle in the long run term in a very weak form, whereas the saving retention coefficient is equal to 0.324 in FMOLS estimation procedure and is significant in 5% significance level, this implies that the FH puzzle exists in a weaker form with a lower saving retention coefficient for Algeria which means a high capital mobility in the long run term in Algeria for the period of study.

**Table 7. Long run estimation (FMOLS)**

| Parameters                                                                                                        | Coefficients | Student statistic | Probability |
|-------------------------------------------------------------------------------------------------------------------|--------------|-------------------|-------------|
| S/GDP                                                                                                             | 0.324*       | 2.159             | 0.037       |
| D <sub>1</sub> =1978                                                                                              | 104.953**    | 4.851             | 0.000       |
| D <sub>2</sub> =1984                                                                                              | -94.954**    | -4.492            | 0.000       |
| D <sub>3</sub> =2001                                                                                              | -8.890       | -1.232            | 0.225       |
| D <sub>4</sub> =2007                                                                                              | 51.953**     | 4.017             | 0.000       |
| D <sub>5</sub> =2012                                                                                              | 2.351        | 0.171             | 0.864       |
| D <sub>1</sub> * S/GDP                                                                                            | 2.045**      | 3.867             | 0.000       |
| D <sub>2</sub> * S/GDP                                                                                            | 2.045**      | 3.867             | 0.000       |
| D <sub>3</sub> * S/GDP                                                                                            | 0.222        | 1.351             | 0.184       |
| D <sub>4</sub> * S/GDP                                                                                            | -8.38**      | -3.273            | 0.678       |
| D <sub>5</sub> * S/GDP                                                                                            | -0.121       | -0.417            | 0.687       |
| Constant                                                                                                          | 25.342**     | 4.789             | 0.000       |
| ** denote significance at 1% and 5% levels. D <sub>i</sub> denotes the dummy variables for each structural break. |              |                   |             |

Source: Authors' calculations.

#### **5. Causality test (symmetric and asymmetric tests)**

The final step in this study is to test the causal relationship between investment and saving using symmetric causality based on Hacker-Hatemi (2010) procedure with bootstrap technique and the asymmetric causality based on Hatemi-J (2012) procedure, it's clear from table (08) that there is no evidence of any causal relationship between saving and investment for the symmetric causality which means we cannot use any of the two variables to predict the other variable, but by passing to the asymmetric causality, there is a causal relationship running from both positive and negative cumulative components of investment to saving and a causal relationship running from negative cumulative components of saving to investment,

this implies the existence of a hidden causality between the two variables so we can use the positive and negative shocks for the two variables to predict the other variable.

**Table 8. Causality results (ECM)**

| Direction of causality                            | Statistic | Critical values with 10000 repetitions |        |        |
|---------------------------------------------------|-----------|----------------------------------------|--------|--------|
|                                                   |           | 1%                                     | 5%     | 10%    |
| Symmetric causality                               |           |                                        |        |        |
| S/GDP to I/GDP                                    | 3.824     | 10.272                                 | 6.574  | 5.013  |
| I/GDP to S/GDP                                    | 2.632     | 10.273                                 | 6.557  | 4.944  |
| Asymmetric causality (Hidden causality)           |           |                                        |        |        |
| I/GDP <sup>+</sup> to S/GDP                       | 13.762**  | 15.180                                 | 9.183  | 7.017  |
| I/GDP <sup>-</sup> to S/GDP                       | 78.948*** | 19.344                                 | 12.231 | 8.711  |
| S/GDP <sup>+</sup> to I/GDP                       | 4.559     | 33.371                                 | 16.606 | 11.927 |
| S/GDP <sup>-</sup> to I/GDP                       | 12.503**  | 16.278                                 | 10.218 | 7.708  |
| *** denote significance at 1%, 5% and 10% levels. |           |                                        |        |        |

\*\*\* denote significance at 1%, 5% and 10% levels.

Source: Authors' calculations.

## Conclusion

This study explored the validity of Feldstein-Horioka (FH) puzzle in the context of Algeria for the period 1970-2019, using an econometric procedure with various methods as the unit root tests under structural breaks using Kapetanios test in addition to NG-Perron test for unit root test without structural breaks, on the other extreme, we used the co-integration technique with regime shifts (with structural breaks) as Gregory-Hansen test with one structural break, Hatemi-J test with two structural breaks and the new procedure proposed by Maki with until five structural breaks, and finally the causality test both symmetric and asymmetric procedures presented by Hacker and Hatemi-J and Hatemi-J respectively.

The results of this paper showed a long-run relationship between investment and saving with five structural breaks in 1978, 1984, 2001, 2007 and 2012 tracking the oil prices shocks 1976, 2000, 2007 and 2012, according to the ECM estimation it's clear that there is any evidence of an effect of saving on investment which means the absence of FH puzzle in the short-run term, in addition to this the speed of adjustment in the model was very slow which means that it will be difficult to return to the equilibrium state, by passing to the long-run estimation using FMLOS (Fully Modified Ordinary Least Squares) the saving retention coefficient is found 0.324, this result imply that FH puzzle exists in Algeria in a weaker form, this result confirm the previous studies in this area in developing countries where we found a high capital mobility (e.g., Murthy (2009); Ezzo and Kehu (2010) and Erdem (2016)), finally, the causal relationship revealed that there is no symmetric causal relationship between saving and investment unlike the asymmetric causality where we found a hidden causality running from both positive and negative shocks of investment to saving and from negative shocks of saving to investment.

These results can be very important for the policy implications in Algeria especially with deteriorate in the oil prices since 2015 which puts the Algerian economy in the dilemma of current account deficit since the same year, for this reason Algeria can finance this deficit with the foreign savings and foreign direct investments thanks the high capital mobility getting from our results in the long-run term, on the other extreme, this deficit can be covered by stimulates the domestic savings to finance the domestic investments and fill this gap

which appeared after 1994 by encourage the Algerian people to invest their savings by high interest rates.

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