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Testing the validity of the Feldstein-Horioka Puzzle: New evidence from structural breaks for Turkey

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Abstract. *The purpose of this study is to test the validity of Feldstein-Horioka Puzzle using time series data covering the period of 1960-2014 for Turkey. In order to test this relationship, the recently proposed multiple-break cointegration test of Maki (2012) was employed. After detecting the existence of a cointegration between domestic saving by allowing for endogenous structural breaks, Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimation procedures are used to obtain long run coefficients. The empirical results indicate that the saving retention coefficient is equal to 0,377 and 0,406 in the DOLS and FMOLS for Turkish economy, respectively. These results imply relatively high capital mobility in Turkey.*

Keywords: Feldstein-Horioka Puzzle, Savings and Investments, Cointegration, Structural Breaks, Capital Mobility.

JEL Classification: C22, F32, F41.

1. Introduction

The identification of the relation between savings and investments is of great importance especially for emerging countries; if there is a relation between these variables then, policies aiming to increase the domestic savings must be implemented for a sustainable investment. In the absence of barriers to capital movements, there is no reason to expect correlation between savings and investments. The Feldstein-Horioka Puzzle examine the association between these variables and find that saving and investments are strongly correlated, contrary to theoretical expectations, which makes it one of the six puzzles in macroeconomics literature (Obstfeld and Rogoff, 2000: pp. 349).

The purpose of this study is to empirically investigate the validity of Feldstein-Horioka hypothesis for Turkish economy during the period of 1960-2014 under structural breaks. To this end, firstly, unit root test under structural breaks proposed by Carrion-i-Silvestre, Kim and Perron (2009) is employed. Secondly, in order to test for the long-run relationship between the variables, we employed Maki (2012) test for cointegration which allows up to five unknown endogenous structural breaks. Thirdly, error correction model was established for the short run analysis. Finally, long run coefficients were estimated with fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS).

This paper structured as follows. Section two presents the theoretical framework for the hypothesis. Data and methodology are described in the third section. Results of the empirical estimations are shown in the fourth section, while the fifth is reserved for conclusion.

2. Feldstein-Horioka Puzzle and Literature Review

The Feldstein-Horioka (hereafter F-H) hypothesis is an extensively discussed subject in macroeconomics and international finance. In their seminal study, Feldstein and Horioka (1980) examined the cross-sectional association between saving and investment rates for a sample of 16 industrialized OECD countries during the period of 1960-1974. To assess this relation, they estimated the following equation:

$$\left(\frac{I}{Y}\right)_i = \alpha + \beta\left(\frac{S}{Y}\right)_i, \qquad (1)$$

where: $(I/Y)_i$ and $(S/Y)_i$ are, respectively, the ratios of gross domestic investment to GDP and gross domestic saving to GDP observed for the i^{th} country. Also, coefficient β in the above equation is known as saving retention coefficient and indicates the degree of capital mobility. According to the economic theory, if there is perfect capital mobility, the value of coefficient β must be close to zero; conversely, if there are impediments to capital mobility, the value of coefficient β must be close to one. The main reason of this situation is that an increase in the saving rate in a country under perfect capital mobility causes marginal product of capital in that country to fall below other countries. The country's residents therefore are willing to invest abroad. In this case, the investment resulting from the increased saving will spread uniformly over the world. Thus, under the perfect capital mobility, there is no reason to expect relationship between domestic saving and investment (Feldstein and Horioka, 1980: pp. 317-321; Romer, 2012: pp. 36-37).

The empirical results of F-H (1980) state that the value of coefficient β is equal to 0,887 and statistically significant. According to this finding, there is a strong relation between domestic saving and investment rate, which is contrary to economic theory. They base this evidence on structural factors, such as the lack of information, investors' risk aversion and differences in legal systems. However, OECD countries' comparative observations indicate that an arbitrage in similar risk-free assets comes very close to perfection, thus making the estimated high values of β a puzzling piece of evidence. These controversial results gave start to widespread debates in the economic literature (Obstfeld and Rogoff, 2000: pp. 349).

A large and growing body of literature has investigated F-H puzzle using different econometric methods; however, the results are inconsistent(1). In general, the F-H puzzle has been mainly examined using cross-sectional regressions (Feldstein, 1983; Penati and Dooley, 1984; Murphy, 1984; Feldstein and Bachetta, 1991; Obstfeld, 1995), while some other empirical studies investigate the F-H puzzle by using time series approach (Pelagidis and Mastroyiannis, 2003; Sinha and Sinha, 2004; Caporale et al., 2005; Narayan, 2005; Altintas and Taban, 2011). The majority of the studies investigate using panel data approach (e.g., Coakley et al., 1996; Krol, 1996; Corbin, 2001; Ho 2002; Kim et al. 2005; Adedeji and Thornton, 2006; Narayan and Narayan, 2010; Bangake and Eggoh, 2011; Ketenci, 2013). Recently, some researchers have focused on the effect of structural breaks (Ho 2000; Özmen and Parmaksiz, 2003; Telatar et al., 2007; Hatemi-J and Hacker, 2007; Kejriwal, 2008; Ketenci, 2012; Dursun and Abasız, 2014; Chen and Shen, 2015).

3. Data and Methodology

In this study, we used time series covering the period of 1960-2014 to test F-H Puzzle for Turkey. We utilized gross capital formation (% of GDP)(2) as an indicator of domestic investment and gross domestic savings (% of GDP)(3) as an indicator of domestic savings. Both of the series were obtained from World Development Indicators of World Bank.

Our empirical analysis consists of four steps. In the first step, stationary properties of the series were investigated with both conventional and structural break unit root tests and. Secondly, in order to explore the existence of the long run relationship between the series, cointegration analysis was conducted developed by Maki (2012). Thirdly, error correction model was established for the short run analysis. Finally, long run coefficients were estimated with fully modified ordinary least squares and dynamic ordinary least squares.

3.1. Unit Root Tests

According to Granger and Newbold (1974), if the variables are non-stationary and included in the regression equation, spurious regression problem will occur. Thus, it is important to investigate whether the series has a unit root. Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests are commonly used in the applied econometric literature. These tests do not take into account the presence of structural breaks in the series and therefore, tend to accept the unit root hypothesis which should be, in fact, rejected (Perron, 1989). Carrion-i-Silvestre et al.

(2009) (CKP) propose a solution to this issue which allows for multiple structural breaks in the level and/or slope of the trend function under both the null and alternative hypotheses.

The break dates in CKP test are estimated following Bai and Perron (2003) by using dynamic programming approach. CKP test contains the feasible point optimal statistic (Elliott et al., 1996) and M-class unit root tests, introduced by Stock (1999) and analyzed by Ng and Perron (2001). Following Elliott et al. (1996) and Perron and Rodriguez (2003), the feasible point optimal statistic is given by:

$$P_T^{GLS}(\lambda^0) = \left\{ S(\bar{\alpha}, \lambda^0) - \bar{\alpha}, S(1, \lambda^0) \right\} / s^2(\lambda^0), \quad (2)$$

where: λ denotes the estimate of the break fraction, $\bar{\alpha}$ equals to 1+ $\bar{c}$/T ($\bar{c}$ is the noncentrality parameter) and $s^2(\lambda^0)$ is an estimate of the spectral density at frequency zero of υ_t. Additionally, M-class statistics are computed as follows:

$$MZ_\alpha^{GLS}(\lambda^0) = \left(T^{-1}\tilde{y}_T^2 - s(\lambda^0)^2\right)\left(2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{-1} \quad (3)$$

$$MSB_T^{GLS}(\lambda^0) = \left(s(\lambda^0)^{-2}T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{\frac{1}{2}} \quad (4)$$

$$MZ_T^{GLS}(\lambda^0) = \left(T^{-1}\tilde{y}_T^2 - s(\lambda^0)^2\right)\left(4s(\lambda^0)^2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{\frac{-1}{2}}, \quad (5)$$

with $\tilde{y}_t = y_t - \hat{\psi}' z_t(\lambda^0)$, where $\hat{\psi}$ minimizes the objective function(4) and $s(\lambda^0)^2$ is an autoregressive estimation function(5). Following Ng and Perron (2001), Carrion-i-Silvestre et al. (2009) used another statistic known as modified feasible point optimal test. This test is computed as follows:

$$MP_T^{GLS}(\lambda^0) = \left[c^{-2}T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2 + (1-\bar{c})T^{-1}\tilde{y}_T^2\right] / s(\lambda^0)^2. \quad (6)$$

3.2. Maki Cointegration Analysis with Multiple Structural Breaks

Cointegration test developed by Maki (2012), allows to analyzing cointegration relationships for an unknown number of breaks. The Maki test is based on the Bai and Perron (1998) test for multiple structural breaks and on the unit root test with m-structural breaks introduced by Kapetanios (2005). Four different type of regression models depending on whether the shifts affect the level, the slope or the trend are formed as:

$$y_t = \mu + \sum_{i=1}^{k}\mu_i D_{i,t} + \beta' x_t + u_t, \quad (7)$$

$$y_t = \mu + \sum_{i=1}^{k}\mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^{k}\beta_i' x_t D_{i,t} + u_t, \quad (8)$$

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta' x_t + \sum_{i=1}^{k} \beta_i ' x_t D_{i,t} + u_t , \qquad (9)$$

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta_i ' x_t D_{i,t} + u_t , \qquad (10)$$

where: t = 1, 2,…,T. y_t and x_t represent observable *I(1)* variables, and u_t is the equilibrium error. μ_i, β'_i and γ_i denote shifts in the level, slope and trend coefficients, respectively. $D_{i,t}$ is dummy variable and takes the value of 1 if t is greater than T_{Bi} (i = 1,…, k) and 0 otherwise, where k is the maximum number of breaks and T_{Bi} represents the time period of the break. Eq. (7), level shift model, captures changes in the level (μ) only. Eq. (8) which is called the regime shifts model, considers for structural breaks in the level (μ) and slope (β). Eq. (9) is regime shift model with trend (γ) and finally eq. (10) accounts for structural breaks in levels, trends and regressors. The null hypothesis is no cointegration against the alternative hypothesis cointegration under structural breaks (Maki, 2012: pp. 2011-2012).

4. Empirical Results

Prior to testing for cointegration, stationary properties of the variables are investigated with conventional unit root tests (ADF, P-P and KPSS). ADF and P-P unit root tests are based on the null hypothesis of non-stationarity of the tested time series, whereas the KPSS unit root test on the null hypothesis of stationarity. The robustness of unit root test results with respect to alternative null hypotheses are investigated by considering these kinds of tests. The results of the conventional unit root tests are given in the Table 1 below:

Table 1. *ADF, P-P and KPSS Unit Root Test Results*

Varia-bles	Level/First Difference	Augmented Dickey-Fuller (ADF) Unit Root Test		Philips-Perron (P-P) Unit Root Test		Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	
		Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
I/Y	Level	-2.595 (0)	-2.977 (0)	-2.595 (0)	-2.828 (2)	0.648 (5) *	0.185 (5) *
	First Difference	-9.506 (0) ***	-9.506 (0) ***	-10.265 (5) ***	-10.913 (7) ***	0.162 (7) ***	0.064 (8) ***
S/Y	Level	-2.127 (0)	-2.060 (0)	-2.048 (7)	-1.933 (5)	0.567 (5) *	0.182 (5) *
	First Difference	-6.627 (1) ***	-6.730 (1) ***	-7.013 (15) ***	-8.552 (20) ***	0.201 (13) ***	0.142 (18) **

Notes: The values in parentheses indicate optimum lag levels and Newey-West Bandwidth method used in P-P and KPSS tests. *, **, and *** denote rejection of the null hypothesis at the 10%, 5% and 1% significance levels respectively (acceptation for KPSS test).

According to Table 1, all of the unit root test results revealed that both of the variables are non-stationary at their levels and stationary at their first differences at 1% significance level, meaning that all the variables are integrated of order one, *I (1)*. Given the low power of the conventional unit root tests in the presence of structural breaks, we further investigate with CKP unit root test, which allows for endogenous structural breaks. CKP test allows up to five structural breaks but by taking into account the structure of the variables and time period, we proceed with three structural breaks.

Table 2. *Carrion-i-Silvestre et al. (2009) Unit Root Test Results*

I/Y	Break in level			Breaks in level and slope of time trend		
Tests	**Test Stat**	**Critical Value**	**Break Date**	**Test Stat.**	**Critical Value**	**Break Date**
PT Test	8.470	6.712	1976	10.795	7.114	1985
MPT Test	8.694	6.712	1985	10.157	7.114	1997
MZA Test	-24.904	-32.115	1987	-22.910	-32.216	2008
MSB Test	0.140	0.125		0.147	0.124	
MZT Test	-3.511	-3.980		-3.372	-4.009	
S/Y						
PT Test	7.296	5.953	1985	11.433	7.723	1982
MPT Test	7.255	5.953	1988	10.954	7.723	1988
MZA Test	-24.276	-28.944	1990	-24.217	-33.732	1996
MSB Test	0.142	0.133		0.141	0.120	
MZT Test	-3.459	-3.781		-3.431	-4.087	

Note: Critical values obtained from 5% significance level.

Table 2 presents the estimated $P_T^{GLS}(\lambda^0), MZ_a^{GLS}(\lambda^0), MSB^{GLS}(\lambda^0), MZ_t^{GLS}(\lambda^0)$ and $MP_T^{GLS}(\lambda^0)$ statistics and the break dates of CKP unit root test results for I/Y and I/S. Our findings indicate that the null hypothesis of unit root cannot be rejected for both of the variables because the estimated test statistics are greater than the critical values for all tests. In other words, M-class unit root tests provide clear evidence of *I(1)* with three structural breaks for both variables. These results are also consistent with conventional unit root test results. Moreover, this test method, which was used to analyze unit root, successfully detected structural breaks in Turkey such as 1990 the Gulf crisis; 1997, the Asian financial crisis and 2008 the subprime U.S. mortgage crisis. Although none of these crises occurred in Turkey, they had an impact on Turkish economy.

After determining all variables are integrated of order one, we continue with the cointegration analysis to analyze the long run relationship between the domestic investment and saving rates. Given the importance of structural breaks in the cointegration analysis, we utilized the Maki cointegration test which allows multiple structural breaks. The results are reported in Table 3.

Table 3. *Maki (2012) Cointegration Test Results*

Models	Test statistics	Break Dates	Critical Values		
			%10	%5	%1
Model 0: Level shift	-8.309 ***	1977 1989 2007	−4.784	−5.083	−5.563
Model 1: Regime shift	-8.751***	1977 2001 1974	−5.106	−5.373	−5.833
Model 2: Regime shift with trend	-8.195 ***	1977 1996 2000	−5.402	−5.703	−6.251
Model 3: Level, trend & regime shift	-8.577 ***	1977 1984 2007	−6.267	−6.524	−7.082

Notes: Critical values are taken from Maki (2012), Table 1, p. 2013. *** denotes cointegration in 1% significance level.

According to Table 3, the absolute values of the test statistics are greater than the absolute values of the critical values at 1% significance level for each model. Hence, the null hypothesis of no-cointegration between domestic investment and saving is strongly rejected. These results reveal important evidence that the domestic investment and saving rates have long-run relationship under structural breaks. These break dates obtained from the analysis are consistent with the Turkish economy. In 1977, the effects of the oil crisis were still lasting. 1989 was the peak year of liberalization and this year Turkey witnessed significant economic challenges. The impacts of the April 5, 1994 decisions were seen at 1996 and finally, banking and currency crisis occurred in 2000-2001.

Engle and Granger (1987) indicate that in a system of two variables, if a long run equilibrium relationship exists, the short term disequilibrium relationship between the two variables can be represented within the framework of Error Correction Model (ECM). The ECM detects whether a portion of the disequilibria from one period is corrected in the next period. Therefore, ECM is estimated for F-H equation. Table 4 shows the results of estimated ECM.

Table 4. *Error Correction Model*

Δ(I/Y)	Constant Term	ECTt-1	Δ(S/Y)	R^2
	0.156	-0.910 [-5.458] ***	0.544 [3.975]***	0.456

Notes: *** denotes 1% statistical significance level. The values in brackets indicate t statistic.

According to the ECM results, the estimated coefficient of error correction term is negative (-0.91) and statistically significant at the 1% level. Therefore, the ECM analysis states that error correction model corrects its previous period's level of disequilibrium by 91% each year.

After detecting the cointegration relationship, we analyze cointegration estimators in order to obtain long run coefficients of the F-H models. In this sense, we used FMOLS and DOLS estimation methods, which account for serial correlation and endogeneity problems. While DOLS is implemented with leads and lags determined according to Schwarz information criterion (SIC), FMOLS is performed using the Bartlett Kernel with Newey-West bandwidth. We first estimated regime shift with trend model (model 2 in Maki test) by taking into account the variables structure (see Table 5). Since the obtained coefficients from the regime shift with trend model are statistically insignificant, the level shift with trend model in Table 6 was estimated instead of regime shift with trend model.

Table 5. Long Run Coefficient Estimation Results (Regime Shift with Trend Model)

I/Y	Con-stant Term	S/Y	Dummy-1977 (D1977)	Dummy-1996 (D1996)	Dummy-2000 (D2000)	S/Y *D1977	S/Y *D1996	S/Y *D2000	Trend (τ)	R^2
DOLS	3.429 [1.020]	0.633 [1.984] *	-2.409 [-0.573]	31.032 [0.863]	-50.707 [-1.409]	-0.141 [-0.497]	-1.944 [-1.009]	2.700 [1.377]	0.399 [4.599] ***	0.908
FMOLS	4.480 [1.507]	0.581 [2.000] *	-1.509 [-0.393]	1.834 [-0.205]	-4.746 [-0.480]	-0.152 [-0.580]	-0.100 [-0.229]	-0.008 [-0.015]	0.375 [4.552]	0.851

Note: The values in brackets indicate t statistic. *, **, *** denote 10% 5% and 1% statistical significance levels respectively.

According to the level shift with trend model results, the saving retention coefficient is equal to 0,377 in the DOLS and 0,406 in the FMOLS procedures. It can be seen that the result obtained from the DOLS procedure is very close to those of the FMOLS, confirming the robustness of the results. Also, the coefficients are statistically significant in all cases. This implies that the F-H puzzle exists in a weaker form with a lower saving retention coefficient for Turkey. Following the interpretation of F-H, this moderate correlation between domestic investment and saving rate is an evidence for relatively high capital mobility in Turkey. The effects of the 1980s financial reforms and liberalization on investment are also significant but only temporary for Turkish economy.

Table 6. *Long Run Coefficient Estimation Results (Level Shift with Trend Model)*

I/Y	Constant Term	S/Y	Dummy-1977 (D1977)	Dummy-1996 (D1996)	Dummy-2000 (D2000)	Trend (τ)	R^2
DOLS	6.164 [5.644] ***	0.377 [3.574] ***	-3.546 [3.039] ***	-4.675 [-3.822] ***	-4.638 [-3.334] ***	0.424 [6.372] ***	0.859
FMOLS	6.178 [6.164] ***	0.406 [4.405] ***	-3.151 [-2.864] ***	-4.439 [-3.844] ***	-4.207 [-3.281] ***	0.391 [6.447] ***	0.851

Notes: *** denotes 1% statistical significance level. The values in brackets indicate t-statistic.

5. Conclusions

This paper re-examines the validity of Feldstein-Horioka puzzle for Turkey spanning the period 1960-2014. To this end, a wide range of unit root tests have been employed in an effort to obtain inferences that are robust to problems associated with nonstationary data. Also, recently proposed econometric methods were utilized in order to estimate the saving retention coefficient, taking into account the presence of structural breaks. According to the results, there is a strong cointegration relationship between domestic saving and investment for Turkey. In other words, a stable relationship between the variables in the long run is detected. Furthermore, the saving retention coefficient is found 0,377 and 0,406 in DOLS and FMOLS, respectively. These results imply that F-H hypothesis exists in Turkey in a weaker form. In addition, our findings confirm previous studies on the F-H puzzle in developing countries, which indicates that capital mobility is relatively high for developing countries (e.g., Adedeji and Thornton, 2006; Bangake and Eggoh, 2011). A key message from our paper is that capital mobility is relatively high compared to developed countries. These results have important policy implications. Turkey has current account deficit resulting from high domestic saving gap which became a structural problem for the aggregate economy over the decades. Turkey can finance this deficit with foreign savings thanks to high capital mobility, as our analysis reveals. However, even if in the short-run this can be managed with foreign savings, in the long run this is not sustainable. Therefore, policies must be weighted in favor of technological development and innovation so as to reach sustainable growth in the long run.

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Notes

(1) Interested reader can refer to Apergis and Tsoumas (2009) for a more detailed survey.
(2) Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. A detailed description about the dataset is available in http://data.worldbank.org/indicator/ne.gdi.totl.zs

(3) Gross domestic savings are calculated as GDP less final consumption expenditure. http://data.worldbank.org/indicator/ny.gds.totl.zs

(4) See eq. (4) in Carrioni-Silvestre et al., 2009, p. 1759.

(5) See eq. (6) in Carrioni-Silvestre et al., 2009, p. 1759.

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