TESTING THE VALIDITY OF THE FELDSTEIN-HORIOKA PUZZLE FOR CROATIA

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Abstract

The relationship between savings and investment is one of the fundamental issues in international economics. This topic comes in the centre of attention after pioneering work of Feldstein and Horioka (1980). The aim of the paper is testing of the Feldstein-Horioka puzzle in the case of Croatia since 1994. Johansen's cointegration approach and Granger causality test were used. In order to determine the dynamics of the savings-investment relation econometric VAR model was introduced. Using innovation analysis impulse response functions and variance decomposition analysis of the observed variables were given.

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1 *INTRODUCTION*

Savings and investment are the key factors for growth and economic development. Lack of savings and investment is often the case in developing countries which finance that deficit by borrowing abroad. On the other hand, a well known fact in the international economics is the existence of high correlation between domestic savings and investment in highly industrialized countries. Traditional view on this issue says that the level of domestic savings determines domestic investment from the impact on the interest rates and the cost of capital, which affects the demand for a new capital. In this regard, the low level of investment is related to the low level of domestic savings. In the work of Feldstein and Horioka (1980) high correlation between savings and investment is interpreted as an indicator of capital immobility. This interpretation represents the puzzle[1] in the field of international economics, the so-called Feldstein-Horioka puzzle that examines the relationship between savings and investment in the conditions of capital (im)mobility. The aim of this paper is testing the interdependence between savings and investment using econometric methods of analysis. For this purpose the Johansen approach to cointegration and Granger causality were used. VAR model was formed and variance decomposition and impulse response functions were presented. Theoretical part of the paper provides an overview of empirical studies featuring Feldstein-Horioka puzzle. With the help of econometric analysis the characteristics of relationship between savings and investments in Croatia in the period between 1994 and 2010 were given and Feldstein-Horioka puzzle tested. At the end of the paper the most important research findings and concluding remarks were presented.

[1] The term puzzle considers the empirical results from the economics practice that are inconsistent with economic theory and needed validation.

2 THEORETICAL FEATURES OF THE FELDSTEIN - HORIOKA PUZZLE AND REVIEW OF EMPIRICAL STUDIES

Feldstein-Horioka puzzle is one of the most important questions in the field of macroeconomics and international finance[2]. Ideological founders are Martin Feldstein and Charles Horioka in their work "Domestic saving and international capital flows" from 1980. Feldstein and Horioka argued that if there is perfect capital mobility, there should be a low correlation between domestic investment and savings. Investors in this case does not depend on resources from the domestic savings, because they can borrow on international markets at world prices. With the same logic, domestic savers can fully borrow the entire amount of domestic savings to foreign investors.
The equation for the Feldstein-Horioka Puzzle is presented as follows:

$$(I/Y)_i = \alpha + \beta(S/Y)_i \tag{1}$$

where $(I/Y)_i$ and $(S/Y)_i$ are the share of gross domestic investment and gross domestic savings to gross domestic product in country i. In the case that the value of coefficientβ is equal to one, domestic savings are the main source of financing for domestic investment. On the other hand, if the value of coefficientβ is equal to zero, capital is perfectly mobile and international sources of financing supstitute domestic savings. According to the standard economic theory, in the absence of government regulations on the movement of international capital, the savings should be moving toward country with the most productive investment opportunities. In this case, the domestic savings rate was uncorrelated with the rates of domestic investment. The results of Feldstein-Horioka studies the sample of 16 OECD countries during the period from 1960 to 1974 have shown

[2]Maurice Obstfeld and Kenneth Rogoff classify it among the six major puzzles in international economics. The others are the home bias in trade puzzle, the equity home bias puzzle, the consumption correlations puzzle, the purchasing power and exchange rate disconnect puzzle and the Baxter-Stockman neutrality of exchange rate regime puzzle (Obstfeld, M., Rogoff, K. (2000)).

a low capital mobility between them which is contrary to the standard economic theory .[3]

According to Feldstein and Horioka, if capital is perfectly mobile investors take into account only the rate of return on investment and are indifferent as to which country to invest. Problem of Feldstein-Horioka puzzle is that the high correlation between savings and investment implies a low mobility of capital which not necessarily might be the case. Numerous studies have attempted to tackle the Feldstein-Horioka puzzle. The development of econometric time-series analysis techniques in the 1980s and 1990s has opened new opportunities to explore the relationship between savings and investment. Existing empirical research on the relationship between savings and investment by the application of different methods of research can be divided into two basic groups.

The first group of research was based on non time series regression analysis. After the original work of Feldstein and Horioka (1980), early empirical studies often use a simple cross-section regression analysis to assess the relationship between investment and savings. This is evident in the work of Feldstein (1983), Murphy (1984), Penate and Dooley (1984), Obstfeld (1986) and Dooley *et al* (1987), which largely confirmed Feldstein and Horioka findings that two ratios are highly correlated. This hypothesis is also confirmed in the paper of Haque and Montiela (1991), Tesar (1991), Feldstein and Bacchetta (1991), Sinha and Sinha (1998), Narayan (2005), Ang (2007) and Jiranyakula and Brahmasrene (2008).

The second group of studies uses time-series techniques when examining the relationship between savings and investment. According to Miller (1988) US savings and investment rates are I(1) processes. He uses cointegration techniques to examine long-term relationship between the variables and founds that the two series are cointegrated under the fixed exchange rate regime and not under the flexible exchange rate regime. Ozmen (2004) points out significant effect of globalization on the relationship between savings and investment. Each economy is integrated with the rest of the world either from financial or politi-

[3] Value of the coefficijent was in the range between 0,85 and 0,95 (Feldstein and Horioka (1980)).

cal point of view. The relationship between savings and investment is stronger under the fixed exchange regime, while under the floating exchange regime, this relationship is weaker. Using the same methodology, Jansen (1996), Coakley and Kulas (1997) also show positive long-run equilibrium relationship between savings and investment in OECD countries. These studies highlighted the potential problem of spurious regression in time series of savings and investment. Kim (2001), Kim *et al* (2007) concluded that the development of time series analysis allowed a broader range of regression coefficients for the relationship between savings and investment. In recent decades, when examining the relationship between savings and investment, panel regression analysis were often used. Krol (1996) uses panel data for 21 OECD countries. Through empirical testing he gets regression coefficient of 0,2 which is considerably less than the estimated regression parameter obtained in earlier studies. Jansen (2000) notes that the results from Krols analysis were unexpected due to the inclusion of Luxembourg in the sample. After the exclusion of Luxembourg from the analysis the ratio increased to 0,6. Coiteux and Olivierar (2000) also used panel cointegration techniques and found long-term correlation between savings and investment of 0,6 for 21 OECD countries.

After the 1980s new theories about the relationship between savings and investments were not supporting the Horioka and Feldstein findings. They poined out that this relationship is influenced by several important factors such as size of the country, characteristics and structure of the financial sector, immobility of factors, endogenous and exogenous shocks, exchange rate regimes and others. Fouquau *et al* (2008) formed theoretical framework when testing the impact of various factors on the relationship between investment and savings. They used panel regression model for 24 OECD countries during the period from 1960 to 2000 and concluded that the most important factors are the degree of country's openness, the size of the country and the current account balance. In spite of varied estimation techniques employed, these time series studies all start from the same premise: namely that the saving and investment rates are non-stationary, unit root processes (Grier *et al* (2008)). However, when making decisions about stationarity of time series we should take into account the

sample size and structural breaks that can occur in series, which can lead to the phenomenon of spurious regression and imprecise results.

3 ECONOMETRIC ANALYSIS

In this chapter the validity of the Feldstein-Horioka puzzle for Croatia is tested. Variable of interest are gross domestic savings (SAVINGS) and gross domestic investment (INVESTMENT) for the period since 1994 to 2010. Gross domestic savings are calculated as gross national income less total consumption, plus net transfers. Both variables are presented as a shares of gross domestic product (% of GDP). The data on variables are obtained from the website Economy Watch. Years 1992 and 1993 are not included into analysis because they were war years in Croatia. Values of variables for that years would significantly deviate from "normal" values and would represent outliers in the reference model. In conducting the econometric analysis Johansen approach for testing the cointegration, Granger causality and innovation analysis using a VAR model will be used.

Figure 1 shows the time series variables of investment and savings as a percentage of gross domestic product (% GDP). Investments were on average larger than the savings by about 5% in the whole observed period, except for the year 1994.

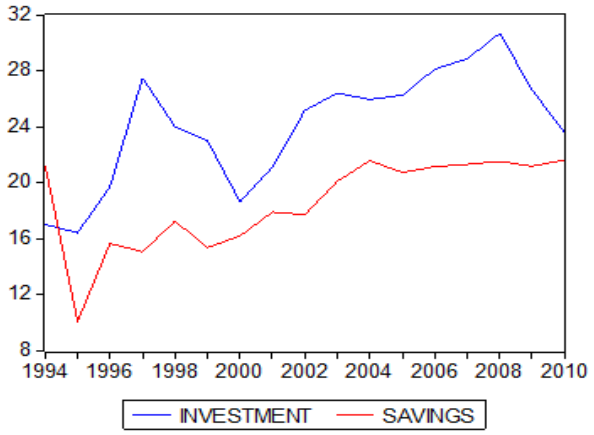

FIGURE 1 - Display of time series of variables investment and savings (% GDP)

Source: Author calculation

It indicates that domestic savings were not sufficient to cover the entire investment and the rest was compensated by borrowing abroad. It can be seen two structural brakes in investment in years 1998 and 2008. To decline in investment in the period between 1998 and 2001 came due to slow economic recovery after the war, while the fall in investment after the year 2008 came due to the global world economic crisis.

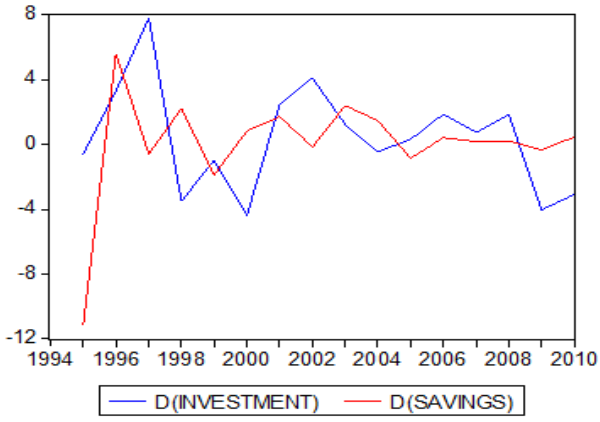

FIGURE 2 - Display of time series of variables investment and savings (% GDP) in first difference

Source: Author calculation

Both time series of variables show a trend component during the observed period which gives the hint that they are integrated of order one I (1). Structural break of savings is significant in 1995. Cointegration between saving and investment is present during observed period except in the case of a structural break in 2008 when there was a sharp decline in investment, while the savings did not significantly changed. Figure 2 shows time series of variables investment and savings (% GDP) in their first differences. The initial step in the analysis is determination of integration order of variables included in the analysis using Augmented Dickey-Fuller unit root test. Dickey-Fuller unit root test (Dickey and Fuller (1979)) is the simplest and most common unit root in economic practice. The null hypothesis of test assumes non-stationarity of the process, while the alternative hypothesis argues that the process is stationary. Results of ADF unit root tests on variables in their levels and first differences are presented in tables 1 and 2 . Test statistics for the ADF unit root test is $t = \frac{\hat{\lambda}}{SE(\hat{\gamma})}$. Critical values of ADF unit root test under the significance of 1%, 5% and 10% are -3,92035, -3,06558 and -2,67346 respectively. If the absolute value of the t-test statistics is greater than the absolute value of the critical value, it can be con-

cluded that the variable is stationary. For each variable, a test was conducted including constant and constant and trend. Dickey-Fuller unit root test is actually a lower limit test. From Figure 1 we can see the existence of a trend in all time series indicating the non-stationarity of variables in levels.

TABLE 1- ADF unit root test (variables in levels)

	ADF unit root test	
Variable	Constant, no trend	Constant and trend
INVESTMENT	-2,151988	-3,599992
SAVINGS	-2,223065	-9,476037*

Source: Authors calculation

Note: Number of lags in the model was determined by minimizing Schwarz information

That confirms the results of ADF unit root tests conducted on selected variables in levels and their first differences with included constant and constant and trend.

TABLE 2- ADF unit root test (variables in first differences

	ADF unit root test	
Variable	Constant, no trend	Constant and trend
INVESTMENT	-4,494495*	-4,227710*
SAVINGS	-16,71442*	-16,51693*

Source: Authors calculatons

Note: indicates first differences, indicates rejection of H0 at the significance of 5%*

First differences of the variables showed that investment and savings are integrated of order one I (1). After determination of integration of the time-series next step in analysis is testing the cointegration among the variables.[4] In the case of nonstationary of data series classical method of linear regression can not apply be applied but linear combinations of these nonstationary series can still be stationary. Cointegration of these series can be determined since the unit root tests showed stationary of variables in first differences. In order to determine the cointegration relationship for testing the existence of long-term relationship between savings and investments Johansen procedure is used (Johansen, 1988; Johansen and Juselius, 1990; Johansen, 1995). For this purpose we use of λ *trace* statistics (trace of matrix eigenvalue) and λ *max* statistics

[4] Maurice Obstfeld and Kenneth Rogoff classify it among the six major puzzles in international economics. The others are the home bias in trade puzzle, the equity home bias puzzle, the consumption correlations puzzle, the purchasing power and exchange rate disconnect puzzle and the Baxter-Stockman neutrality of exchange rate regime puzzle (Obstfeld, M., Rogoff, K. (2000)).

(maximum eigenvalue). Under the λ *trace* statistics null hypothesis requires that the number of cointegrating vectors is less than or equal to r as opposed to the alternative hypothesis. On the other hand, under the λ *max* statistics null hypothesis requires that the number of cointegrating vectors is equal to r as opposed to the alternative hypothesis.

TABLE 3- Results of Johansen cointegration method (λ_{trace} test) for a determination the number of cointegrating vectors

Number of cointegrating vectors	Eigenvalue	λ_{trace} statistics	Critical value	Probability**
None*	22.58968	15.49471	0.0036	22.58968
At most one	1.126203	3.841466	0.2886	1.126203

Source:Authors calculatons
*Note: * indicates rejection of H0 at the significance of 5%*
*** p-value under MacKinnon-Haug-Michelis (1999)*

TABLE 4- Results of Johansen cointegration method (λ_{max} test) for a determination the number of cointegrating vectors

Number of cointegrating vectors	Eigenvalue	λ_{max} statistics	Critical value	Probability**
None*	0.760906	21.46348	14.26460	0.0031
At most one	0.072331	1.126203	3.841466	0.2886

Source:Authors calculatons
*Note: * indicates rejection of H0 at the significance of 5%*
*** p-value under MacKinnon-Haug-Michelis (1999)*

In tables 3 and 4 are presented the results of Johansen method for determining the number of cointegrating vectors using the λ *trace* and λ *max* statistics. The maximum number of cointegrating vectors is one. Under the significance of 5%, the results from tables 3 and 4 indicates the existence of one cointegrating vector which is defined by the following equation: (2)

$$\begin{aligned} INVESTMENT &= -8,633427 + 0,880187 * SAVINGS \\ &\quad (12,2892) \end{aligned} \tag{2}$$

It can be concluded that there is a long-term equilibrium relationship between the variables gross domestic saving and gross domestic investment. The increase in savings by one percentage shown by the ratio in gross domestic product would result in long-term average increase in domestic investment by 0,88 percentage points shown by the ratio in gross domestic product[5]. The regression coefficientβ in the case of Croatia is 0,88 and indicates that there is a strong positive correlation between savings and investment. Having proven the existence of cointegration among the variables next step in analysis is determining the direction of causality between variables, because cointegration among the variables can not exist if there is no causality between them (Bahovec, V., Erjavec, N. 2009). The analysis is conducted using the Granger causality test (Granger, C., W., J. (1969), Granger, C., W., J., and Newbold, P. (1974)). Granger causality shows how change in one variable causes change in another variable and is often used in econometric researches.

[5] The high t-value of the variable savings (12.2892) indicates that is statistically significant in the model

TABLE 5- Granger causality test

Null hypothesis	Number of observations	F-stat.	p-value
SAVINGS does not Granger cause INVESTMENT	15	**6,40716**	**0,01618**
INVESTMENT does not Granger cause SAVINGS	15	1,28809	0,76010

Source: Authors calculatons

The results of Granger causality test (Table 5) showed that there is a causal relationship between the variable SAVINGS and INVESTMENT[6]. Figure 3 shows the impulse responses of variables investment and savings with the help of impulse response function (IRF). Impulse response function represents the dynamic response of each endogenous variable to the shock in other variable.

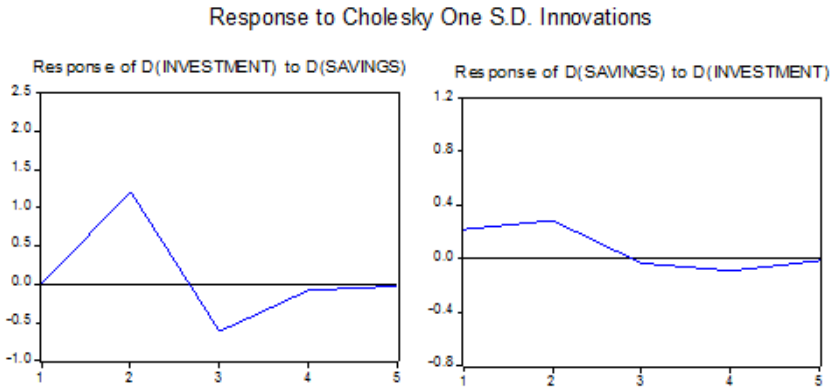

FIGURE3- Impulse responses of variables INVESTMENT and SAVINGS
Source: Authors calculation

[6] Under the significance of 5% optimal number of lags in the model is two

Increase in domestic savings by one standard deviation would increase domestic investment during the first two periods after which there would be decline in investment during the third period. On the other hand, increase in domestic investment by one standard deviation would lead to a slight increase in current savings during the first two periods after which there would be decline in savings.

TABLE 6- Variance decomposition of the variable D(SAVINGS)

Lag	S.E.	DINVESTMENT	DSAVINGS
1	2,457	100,000	0,000
2	2,775	80,888	19,111
3	2,904	78,028	21,972
4	2,921	78,205	21,794
5	2,923	78,226	21,774

Source: Authors calculatons

Variance decomposition of the variable D(SAVINGS) is presented in the table 6[7]. Decomposition of variance shows the relative proportion of individual variable in explaining other variables in future periods. From the table 6 it can be seen that the variable DINVESTMENT has no significant effect in explaining variations of the forecasting error of the variable DSTEDNJA. That contribution is 3,499%. Upon the expiration of the fifth period, this contribution increases and amounts to7,693%.

From the table 7 it can be seen that in the next period (k = 1) variable DINVESTMENT explains 100% of its own variance. After two periods, variable DSAVINGS significantly explains the variations of the forecasting error of the variable DINVESTMENT. That contribution is 19,111%. Upon the expiration of the fifth period that contribution is still significant and amounts to 21.774%.

[7] VAR model is defined in the first differences of variables which are stationary

TABLE 7- Variance decomposition of the variable D(INVESTMENT)

Lag	S.E.	DSAVINGS	DINVESTMENT
1	1,168	96,500	3,499
2	1,292	92,257	7,742
3	1,328	92,601	7,398
4	1,342	92,312	7,687
5	1,343	92,306	7,693

Source: Authors calculatons

4 CONCLUDING REMARKS

The aim of the paper was testing the validity of the Feldstein-Horioka puzzle for Croatia through exploring the interdependence between savings and investment with the help of econometric methods of analysis. For this purpose we use Johansen cointegration approach, Granger causality, variance decomposition and impulse response functions using innovation analysis and VAR model. In the work of Feldstein and Horioka (1980) high correlation between savings and investment was interpreted as an indicator of capital immobility. This interpretation represents an enigma in the field of international economics, the so-called Feldstein-Horioka puzzle which states that developed countries should have a higher degree of capital mobility.

Econometric analysis started with testing the stationarity of variables. Augmented Dickey-Fuller unit root test was used. It showed that all variables in the model are integrated of order one I (1). After that, with the help of Johansen procedure, cointegration between the time series is examined. The results showed that in Croatia exist a long-term cointegration relationship between the variable gross domestic savings and gross domestic investment in the period after 1994. The maximum number of cointegrating vectors was estimated to one. Regression coefficientβ was estimated to 0,88 . It indicates

that there is a strong correlation between savings and investment in the country. Having proven the existence of cointegration between the variables, next step in the analysis was determining the causality between the variables using Granger causality test. The results of Granger causality test showed that there is a causal relationship between the variable SAVINGS and INVESTMENT in direction from variable SAVINGS to INVESTMENT. In order to explore the dynamics between variables econometric VAR model was established. The results of impulse response functions shown that the increase in domestic savings by one standard deviation would increase domestic investment during the first two periods after which there would be decline in investment during the third period. On the other hand, increase in domestic investment by one standard deviation would lead to a slight increase in current savings during the first two periods after which there would be decline in savings. Decomposition of variance confirmed the results of Granger causality test; variable SAVINGS significantly explains variations of the forecasting error of the variable INVESTMENT.
Testing the validity of the Feldstein-Horioka puzzle for Croatia has shown that it is still a puzzle. Specifically, cointegration relationship between savings and investment in Croatia indicates a strong dependency of domestic investment to domestic savings in the long run. This is contrary to the standard economic theory which states that in perfect capital mobility conditions, changes in domestic savings do not affect domestic investments.

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TESTIRANJE FELDSTEIN-HORIOKINE ZAGONETKE NA PRIMJERU HRVATSKE

Sažetak

Odnos izmeu štednje i investicija predstavlja jedno od temeljnih pitanja na području meunarodne ekonomije. Posebno dobiva na značaju tijekom 80-ih godina prošlog stoljeća zahvaljujući naporima Feldsteina i Horioke (1980). Cilj rada je testiranje Feldstein-Horiokine zagonetke na primjeru Hrvatske analizom meuovisnosti štednje i investicija u razdoblju od 1994. do 2010. godine. Pri tome se koristi Johansenov pristup kointegracije i Grangerov test uzročnosti. U svrhu odreivanja dinamike pojava formiran je ekonometrijski VAR model. Inovacijskom analizom daju se funkcije impulsnog odziva i analiza dekompozicije varijance promatranih varijabli.

Ključne riječi: *štednja, investicije, Feldstein-Horiokina zagonetka, kointegracija, VAR model*