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On Exogeneity of Savings in Feldstein-Horioka Equation: The Case of Pakistan

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ABSTRACT

Objective: The study aims to estimate the Feldstein-Horioka (hereafter, FH) equation, incorporating data led (both impulse and step) breaks and check the status of exogeneity of domestic savings within the estimated FH–equation in Pakistan.

Research Gap: Considering Pakistan, none of the previous available literature tried to check exogeneity status of savings in FH-equation using appropriate testing procedures. Further, the impact of data led breaks were completely ignored. Therefore, the study tries to fill this gap.

Design/Methodology/Approach: Stationarity and cointegration is checked through the lens of Augmented Dickey-Fuller (ADF) unit root test and Engle-Granger & Phillips-Ouliaris Residual Based Cointegration tests respectively. To avoid any hint of spurious relationship, appropriate methods are applied and then convergence/consistency of the estimated regression coefficients is verified with the help of Cochran-Orcutt GLS procedure. For weak exogeneity (WeExt), the Engle, Durbin-Wu-Hausman and Wu-Hausman tests are applied and the test for contemporaneity of errors is well documented. For strong exogeneity (StExt), in presence of WeExt, Granger Causality test is applied. Lastly, Engle and Hendry, Charemza-Király tests of super exogeneity (SuExt) are applied.

The Main Findings: The estimated coefficient of savings with no breaks indicates a low capital mobility in Pakistan. But, the inclusion of data led breaks reduced the magnitude, showing high capital mobility in Pakistan. The existence of weak, strong and super exogeneity indicates that the observed FH–equation can be used for inference, forecasting and policy simulations.

Theoretical / Practical Implications of the Findings: Pakistan had relatively low domestic savings in comparison with investment for the last fifteen years. Consequently, rates of return on capital have been relatively high. Therefore, the country might regard the persistent trade deficits, as the country remains dependent on external financing. It is concluded that domestic savings is exogenous in FH–equation.

Originality/Value: Testing exogeneity (*e.g.* WeExt, StExt & SuExt) in a regression context by any means considered to be one of the difficult task to perform both in theoretical as well as in applied econometrics. The study tries to simplify these testing procedures in a very simple and understandable manner.

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1. Introduction

Feldstein–Horioka (FH) puzzle is the mother of all puzzles in international economics. Theoretically, domestic savings finances all investment in a closed economy with minimal capital mobility, while domestic savings under higher capital mobility would not necessarily finance total investment. Nonetheless, FH-puzzle failed to explain higher correlation between investment and domestic savings that would indicate low level of capital mobility.

The puzzle posited in (Feldstein & Horioka, 1980) not only draws attention towards capital mobility but also towards the optimal savings and the changes in tax incidence (Akkoyunlu, 2020). Increased capital mobility is vital for achieving optimal levels of savings. Countries with higher investment needs and low domestic savings can attract capital from international markets. Pakistan like other developing countries with lower contagion in the global financial markets has lower capital mobility and higher correlation between domestic savings and investments.

Higher correlation between savings and investment is clearly a puzzle, since capital mobility between leading countries has already reached gain a high level (Frankel, 1992; Ghosh, 1995; Obstfeld & Rogoff, 2000; Sachs, 1982). This study is an attempt to envelop the paradox stated above in case of Pakistan using appropriate econometric techniques incorporating data led breaks as explained in (Ericsson, 2012; Johansen & Nielsen, 2008) and the status of exogeneity of domestic savings will be tested through the implementation of proper exogeneity testing procedures, for details (see, Section-III).

The key research questions guiding this study are: to what extent is domestic savings is exogenous in the FH–equation for Pakistan, and how do data-led (impulse and step) breaks influence the estimated relationship between savings and investment? While the FH hypothesis has been widely tested in various economies, existing literature on Pakistan has overlooked the exogeneity status of domestic savings using robust econometric testing procedures. Additionally, the role of structural breaks in affecting the savings-investment relationship remains unexplored. By addressing these gaps, this study aims to rigorously examine the stationarity and cointegration properties of the FH–equation, assess weak, strong, and super exogeneity of domestic savings, and analyze the impact of data-led breaks on capital mobility estimates, ultimately contributing to the existing literature in case of Pakistan.

Testing of exogeneity assumption originates from the fundamental assumptions of classical linear regression models, particularly the requirement that explanatory variables remain uncorrelated with the error term to ensure unbiased and consistent estimation. Violating exogeneity results in endogeneity, introducing bias in Ordinary Least Squares (OLS) estimators, making them inconsistent. Addressing exogeneity concerns is essential for ensuring the validity of causal inferences, thereby enhancing the reliability of policy and economic analyses.

Theory of exogeneity is required to derive policy implications from the cointegration analysis where cointegration exists and when it doesn't exist. So far, the existing literature missed out to determine the exogeneity status of domestic savings in FH–equation. The exogeneity of variable/s depends upon the parameters of interest and the purpose of the model (Favero & Hendry, 1992). The WeExt is being tested when a model is to be used only for statistical inference/analysis. The analysis of StExt will be tested if the purpose of modelling is forecasting. Finally, if the objective of the estimated model is to be used for policy analysis the concept of testing SuExt is more relevant (Engle et al., 1983; Pearl, 2000). This study is an effort to contour and to test all these three types of exogeneity, while modelling FH–equation in case of Pakistan.

In this paper, we test FH hypothesis by observing several features. First, we use the longest available data for annual frequency over the six decades. Second, by applying structural break methods to tackle spurious regression specification, we account for data led breaks that witnessed by several policy changes, financial integration and global crises, wars and military regimes etc. All these breaks significantly capture with the help of automatic break detection using Autometrics introduced by (Doornik, 2009); the consideration of techniques that has never been documented before in this context. Third, following a general-to-specific approach discussed by (Cuthbertson & Taylor, 1990) and (Hendry & Ericsson, 1991), we tried to capture significant lags in order to identify true data generating process (DGP). Fourth, several post estimation diagnostic tests are being performed for all the models which were completely ignored before considering Pakistan.

The structure of the study is outlined as follows: Section II provides a comprehensive review of the literature on estimating the FH equation both domestically and internationally. Section III will present the data, model, empirical methodology, results, and their interpretations. Finally, Section IV will summarize the conclusion and offer policy recommendations for determining an optimal national saving strategy.

2. Review of Literature

The FH-puzzle or paradox becomes a widespread topic of research and debate in international economics literature. A detailed survey of literature on the topic can be found in (Apergis & Tsoumas, 2009) and (Obstfeld & Rogoff, 2000). It is quite valuable to re-examine the FH-puzzle in the wake of saving – investment link by considering developing Asian economies (Bagheri et al., 2012; Horioka et al., 2015). Based on literature, several studies like (Bagheri et al., 2012; Eyuboglu & Uzar, 2020; Irandoust, 2019; Lam, 2012; Tasar, 2017; Yildirim & Orman, 2017) established that association between savings and investment is high and thus, supporting FH-hypothesis for developing economies due to low level of capital mobility (international).

A plethora of literature is available highlighting a weedy relationship between savings and investment taking developing economies into account (Bangaké & Eggoh, 2010; Chang & Smith, 2014; Horioka et al., 2015; Patra & Mohanty, 2020; Raheem, 2017; Shahbaz et al., 2010). A study by (Miller, 1988) for US showed that savings and investment were not cointegrated during the era of flexible exchange rate but were cointegrated amid fixed exchange rate regime. However, (Otto & Wirjanto, 1989) revealed that these two were not cointegrated for the US and Canada. Furthermore, Montiel (1994) addressed the FH hypothesis's susceptibility to an indirect relationship between savings and investment that did not take into account capital mobility. The twin-deficit theory and the FH-puzzle are related in the empirical literature, which presents two threads of arguments. One supporting FH-hypothesis that there is little international capital mobility due to the high correlation between domestic savings and investment (Bagheri et al., 2012; Lam, 2012) and few found to be against this hypothesis based on their results like (Baharumshah et al., 2009; Saeed & Khan, 2012).

The methodology opted in (Feldstein & Horioka, 1980) is well criticized on several grounds: in cross-sectional regressions using time-averaged data often leads to an overestimation or underestimation of the actual relationship; additionally, critics argue that the analysis failed to account for the nature of economic shocks and the structural differences across countries. The study's sample period, which was limited, also did not capture the significant increase in capital mobility that occurred during the latter half of the 1970s. Moreover, several other factors were overlooked, including the presence of outliers, endogeneity, regime changes, bias caused by omitting relevant variables, the intercept, and the non-stationarity of variables in levels. These issues could have been addressed more effectively through cointegration methods (Choudhry et al., 2014; De Vita & Abbott, 2002; Ho & Chiu, 2001; Jansen & Schulze, 1996; Katsimi & Zoega, 2016; Serletis & Gogas, 2007).

Therefore, to overcome the above mentioned drawbacks in a cross-sectional settings; many studies tried to estimate it using time series analysis like (Akkoyunlu, 2020; Ayad & Belmokaddem, 2020; Bineau, 2020; De Vita & Abbott, 2002; Madiha & Hicham, 2021; Sachsida & Cardoso de Mendonça, 2006; Yildirim & Orman, 2017).

So far, the existing literature has tried to contour the puzzle in different methodological framework like (Akkoyunlu, 2020; Ayad & Belmokaddem, 2020; Bineau, 2020; Madiha & Hicham, 2021; Mohsin & Rivers, 2011; Saeed & Khan, 2012; Shahbaz et al., 2010; Yildirim & Orman, 2017). None of them used the impact of data led structural breaks proposed in (Ericsson, 2012; Johansen & Nielsen, 2008), while modelling FH–equation and neither checked the exogeneity status of savings in the equation while modelling the correct form of the equation during the stipulated time frame. A recent study by (Felipe et al., 2024) highlights that analyzing sustainability of current account deficit can be an alternate way to determine a relationship between investment and savings.

The study is an encounter to reveal the correct form of equation under the shade of automatic model selection with break detection using Autometrics and then testing of exogeneity (WeExt, StExt & SuExt) first introduced in (Engle et al., 1983) and later on performed in (Favero & Hendry, 1992; Hendry & Ericsson, 1991; Jawad et al., 2022; Sachsida & Cardoso de Mendonça, 2006) in order to confirm the (in)validation of Lucas Critique posited in (Lucas, 1976). The main purpose of implementing the exogeneity testing is to determine the exogeneity of domestic savings and the ability of FH–equation for designing economic policies in case of Pakistan.

3. Data, Methodology, Results & Interpretations

The time series data of domestic savings and gross fixed capital formation (proxy for investment) spanning over the sample period (1960-2020) gathered from World Development Indicator (WDI) is used for analysis. The variables used here in the estimation process are transformed into their logarithmic form following (Ehrlich, 1996; Ehrlich & Gibbsons, 1977; Schrooten & Stephan, 2005; Seaks & Layson, 1983).

Table 1 shows descriptive statistics[1] with each having 61 observations, highlighting that more variation occurs in inv_t. The data seems to be right-skewed, as indicated by the fact that the mean is greater than the median, and this observation is further supported by the skewness measure. In terms of dispersion, the majority of the data points fall within the range of $(\bar{x} \pm 3\sigma)$. Additionally, the kurtosis value for both is below 3, with savings showing a negative kurtosis. This suggests that the data has lighter tails compared to a normal distribution.

Table 1: Descriptive Statistics

Descriptive Stat.\Variable	INV_t	SAV_t[2]
Mean	12.46	8.36
Median	6.95	5.39
Maximum	49.52	25.06
Minimum	0.40	0.26
Std. Dev.	13.18	7.70
Skewness	1.16	0.56
Kurtosis	0.170	-1.12

Source: Author's calculations

Now from Figure 1 (see; Appendix) one can easily see that certainly some similar features are being shared by these two series till 1990 and then a gradual increase from 1990s to 2005. However, the increase in the investment after mid-2000 is more sharp and pronounced than domestic savings Figure 1 (a & b). The lower panel (c) in Figure 1 represents their ratios to GDP. The first two panels in Figure 2 represents both variables in their logarithmic forms (Billion $US). The lower two panels of Figure 2 highlights the fact that after 2000, the changes in the savings are more explosive in comparison with investment.

3.1 Unit Root and Cointegration Analysis

Here we employ the ADF unit root test for order of integration. The critical values for the test have been computed and are readily available in (MacKinnon, 1996). If the ADF test statistic is smaller than the critical value at the 5% significance level, the null will be rejected, leading to the conclusion that the series under consideration is stationary. The results of the ADF unit root test, both at the level and first difference of the variables, are presented in Table 2. From these results, it is clear that the variables are non-stationary in their logarithmic form at the levels but become stationary at their first difference.

Table 2: Results of ADF-Test

Variable/Test Stat.	Levels				First Difference				
	K	τ [3]	τ_μ	τ_t	K	τ	τ_μ	τ_t	Specification
sav_t[4]	1	2.729	-1.762	- 2.300	0	-6.726*	- 5.891*	- 6.157*	C, No t[5]

---

[1]Investment is taken as Gross Fixed Capital Formation (Billion $US) while saving is Gross Domestic Savings (Billion $US). For analysis we used ratio of these with Gross Domestic Product (GDP).

[2] Both variables are in Billion $US.

3 τ (No intercept no trend), τ_μ (Intercept), τ_t (Intercept and trend).

[4]Small italic shows variables in their logarithmic form.

[5]While applying unit root test on difference series, we found no significant results for trend in both cases. So, we used a specification of intercept but no trend. The results were further cross check following (Stock & Watson, 1987).

inv_t	1	2.794	-1.437	-3.97	0	-5.284*	- 5.967*	- 6.008*	C, No t

Note: $H_0(\rho \geq 1)$: I(1) against $H_a(\rho < 1)$: I(0). For lag length *K*, we used Akaike Information Criterion (AIC). Also, * & ** indicate significance level 1% & 5% respectively.

Now in view of above discussion, we conclude that both series found to be non-stationary at levels and stationary at their first difference without time trend. Next, we will check whether these series are cointegrated on not. If the series are cointegrated then we can apply the exogeneity testing procedure as discussed in (Hendry, 1995). It was argued that, if variables are found to be cointegrated, followed by an error correction representation; else, the relationship would be spurious if we used a simple regression in that case as discussed in (Engle & Granger, 1987) and hence suggested a two-step procedure. In this study we used two residual based cointegration tests: i) Engle-Granger Test (EG) ii) Phillips-Ouliaris Test[6]. The outcomes of these two tests are presented in Table 3 which indicates that the variables found not to be cointegrated. As the residuals test statistics show that residuals are non-stationary at levels without intercept and trend. Since, the variables are not cointegrated, therefore, we can't apply (Hendry, 1995) procedure directly. This leads us not to use indicator saturation technique for DGP of marginal models (6 & 7) but in the conditional model (5) only. So, to implement exogeneity test we need to use some other methods that will be discussed in detail in subsection C.

Table 3: Results of Cointegration Tests
Ho: Series are not cointegrated

Cointegration Test	Test Statistic	Value *[p-val.]*	Residual Test-Stat. *[CVs]*
EG-Test	Tau-Stat.	**-2.548** *[0.27]*	**-2.548** *[-3.37]*
	Z-Stat.	**-12.001***[0.23]*	
Phillips-Ouliaris Test	Tau-Stat.	**-2.572** *[0.26]*	**-2.548** *[-3.37]*
	Z-Stat.	**-12.023** *[0.22]*	

Note: These critical values were calculated by (Engle & Yoo, 1987). The critical values for the case of 2 variables using 100 observations were calculated by (Phillips & Ouliaris, 1990) and can also be obtained from (Hamilton, 1994) page 766, Case 2.

Testing exogeneity remains crucial even when two time series are not cointegrated, as it helps determine causal direction, model specification, and forecasting accuracy. If a variable is found to be weakly exogenous, it can be used as an independent explanatory variable, while if it is endogenous, alternative estimation methods such as Instrumental Variables (IV) or Generalized Method of Moments (GMM) may be required. Additionally, if two series are not cointegrated, their relationship in a long-run equilibrium sense does not exist. However, they may still have a short-term relationship that needs to be examined to cater the concerns about spurious relationships. This discussion is explained in the next sub-section.

3.2 Tackling Spurious Regression

The problem of spurious regression was first coined in (Yule, 1926) and then the criteria to detect it through the lens of R^2 and Durbin-Watson (DW) was discussed in (Granger & Newbold, 1974) and later in (Charemza & Deadman, 1997). However, according to (Hamilton, 1994), the problem of spurious regression can be tackled by using three different ways. In this paper we opt these ways to address the problem of spurious regression with and without structural breaks. First, by adding lagged values of independent as well as dependent variables in the model. The OLS estimates of (1 & 2) will be consistent. Both equations differ with each other due to the inclusion of impulse saturation in the form of impulse and step dummies as pointed in (Ericsson, 2012; Johansen & Nielsen, 2008). However, the F-test for joint hypothesis that the parameters are zero has nonstandard distribution as discussed in (Hamilton, 1994).

$$inv_t = \alpha + \beta sav_t + \sum_{i=1}^{k} \varphi_i sav_{t-i} + \sum_{i=1}^{k} \delta_i inv_{t-i} + \varepsilon_{1t} \tag{1}$$

$$inv_t = \alpha + \beta sav_t + \sum_{i=1}^{k} \varphi_i sav_{t-i} + \sum_{i=1}^{k} \delta_i inv_{t-i} + \sum_{i=1}^{m} \tau_{i,\alpha_2} 1_{\langle t=t_i \rangle} + \sum_{i=1}^{m} \rho_{i,\alpha_1} 1_{\langle t \geq t_i \rangle} \tag{2}$$

Second, is to take difference of the data before estimating any model as in (3 & 4). Since, the regressors and

[6] The test was mainly due to (Phillips & Ouliaris, 1990) and is used to reconfirm the results obtained by EG-test.

error term are stationary when we took the first difference of data. Therefore, the usual t or F-test has the Gaussian or χ^2-distribution respectively, based on differenced regression, the corresponding parameters converge to standard Gaussian variables under the null hypothesis.

$$\Delta inv_t = \alpha + \beta \Delta sav_t + \mu_{1t} \quad (3)$$

$$\Delta inv_t = \alpha + \beta \Delta sav_t + \sum_{i=1}^{m} \tau_{i,\alpha_2} 1_{\langle t=t_i \rangle} + \sum_{i=1}^{m} \rho_{i,\alpha_1} 1_{\langle t \geq t_i \rangle} + \mu_{2t} \quad (4)$$

Last but not least, correct the residual's first order serial autocorrelation by using the Cochran-Orcutt method to estimate the equation. The Cochrane-Orcutt GLS approach is comparable to the differenced equation (3), according to (Blough, 1992). It is crucial to keep in mind that differencing the data can lead to an misspecified regression if the data are truly stationary (Hamilton, 1994).The following Table 4 (Panel A) shows the results of these three different scenarios while (Panel B) reports several post estimation diagnostic tests.

The result of estimating FH–equation at levels without breaks in column (4.1) reveals that estimated coefficients though statistically significant and the high value of the coefficient of domestic savings therein found to be 1.13, indicating low capital mobility. But, estimated model didn't pass any post estimation diagnostic test and even model has DW < R^2 (i.e. 0.36 < 0.85)[7]. This further indicates that estimating FH–equation at levels will lead to a spurious regression and a poor fit. To avoid this problem, we take log of the series and incorporating lags of both dependent and independent variables. The final model then obtained by using Autometrics explained in (Doornik, 2009) and outcomes are being available in column (4.2). The estimate of domestic savings (in logarithm) reduces significantly to 0.61 but model suffer from normality and heteroskedasticity though it passes the Ramsey's RESET misspecification test of functional form. The elasticity of domestic savings in the estimated FH–equation is found to be significant for the method, we applied. The outcomes are presented in columns (4.2, 4.3 & 4.7). The coefficients of savings estimated based on three methods seem to be very close to each other. Note that the impact of automatic structural break has not been incorporated yet. Furthermore, Table 4 displays the outcomes of the FH–equation estimated without correction in column (4.1).

The impact of structural breaks is well captured in column (4.4) — (4.6) using these three specifications with the help of Autometrics. Column (4.4) below highlights the fact that though data driven breaks i.e. 16 impulse and 9 step dummies were captured but model fail to pass Jarque-Bera normality test and test of functional form. The elasticity coefficient of domestic savings drastically decreases from 0.72 in (4.4) to 0.20 in (4.5) and to 0.22 in (4.6) as the specification changes from levels to logarithmic and then to difference respectively after correction has been made.

By way of comparison, the elasticity of savings estimated using appropriate methods with the one without correction in column (4.1), it is clear that the hypothesis about the relationship among investment and savings would be wholly erroneous, if the bias were not taken into account. If the savings coefficient is interpreted in terms of capital mobility, the biased elasticity without accounting for the effects of breaks specifies low capital mobility, whereas the elasticity assessed by the suitable estimators specifies a high capital mobility as indicated by (4.5) — (4.7) that account for the presence of data-driven breaks. This suggests that the estimated equation accounted for data led breaks might be applied to the development of economic policy.

The estimated coefficient of savings when no breaks were considered in (4.1) — (4.3) indicates a low capital mobility in Pakistan. But, the inclusion of data driven structural breaks reduced the magnitude of savings elasticity from 1.14 in (4.1) to 0.72 in (4.4), 0.68 in (4.2) to 0.20 in (4.5) and 0.63 in (4.3) to 0.22 in (4.6) respectively, and showing high capital mobility in case of Pakistan. The estimate of savings is significant for all the methods applied. Furthermore, the estimated savings elasticities converge to their results while using correction with breaks which can be verified with the equation estimated by using Cochran-Orcutt GLS procedure in (4.7). The savings elasticity coefficients estimated with these methods are found to be very similar. Taking into account (Horioka et al., 2015) explained that developing Asia's economies would have a high level

[7] No other specification fails the criteria of spurious regression other than (4.1).

of global capital mobility despite the low correlation between domestic savings and investment. Due to the high level of capital mobility, these countries are disposed to experience twin deficits, be it fiscal or current account deficit (Bagheri et al., 2012). The following Table 4 also strengthens these arguments as well. Lastly, the coefficient of domestic savings is not equal to unity which implies that there is perfect capital mobility that means there is no FH-puzzle present in Pakistan.

Table 4: Estimated FH–equations

Panel A: Coefficient Estimates for FH–equation							
Model Type	**Without Breaks**			**With Breaks**			
	Dependent Variable			Dependent Variable			
Method	**4.1** ***OLS***	**4.2** ***OLS***	**4.3** ***OLS***	**4.4** ***OLS***	**4.5** ***OLS***	**4.6** ***OLS***	**4.7** ***C.-Orcutt GLS***
Variables	$\mathrm{INV_t}$	inv_t	Δinv_t	$\mathrm{INV_t}$	inv_t	Δinv_t	inv_t
Const.	-3.39**	5.43*	0.05**	2.02*	-	-0.16**	7.78*
Trend	2.07***	0.02*	-	-	-	-	-
$\mathrm{SAV_t}$	1.13*	-	-	0.72*	-	-	-
sav_t	-	0.68*	-	-	0.20*	-	0.66*
inv_{t-1}	-	1.04*	-	-	0.63*	-	-
inv_{t-2}	-	-0.35*	-	-	-	-	-
sav_{t-1}	-	-0.27*	-	-	-	-	-
Δinv_t	-	-	0.63*	-	-	0.22*	0.21**
Δinv_{t-1}	-	-	-	-	-	-	-
Δinv_{t-2}	-	-	-	-	-	-	-
AR(1)	-	-	-	-	-	-	1.25*
AR(2)	-	-	-	-	-	-	-0.54*
AR(3)	-	-	-	-	-	-	0.26***
I:1972	-	-	-	-	0.27*	-	-
I:1974	-	-	-	-	0.70*	-	-
I:1975	-	-	-	-5.74*	-	-	-
I:1979	-	-	-	6.70*	-	-	-
I:1985	-	-	-	6.70*	-	-	-
I:1987	-	-	-	-6.07*	-	-	-
I:1991	-	-	-	-9.41*	-	-	-
I:1993	-	-	-	1.30*	-	-	-
I:1998	-	-	-	-2.47*	-	-	-
I:2000	-	-	-	9.52*	0.34*	0.28*	-
I:2001	-	-	-	7.19*	-	-	-
I:2005	-	-	-	-5.52*	-	-	-
I:2008	-	-	-	7.13*	-	-	-
I:2009	-	-	-	1.77*	-0.15*	-	-
1:2010	-	-	-	-	-0.15*	-	-
I:2015	-	-	-	-1.74*	-	-	-
I:2017	-	-	-	8.85*	-	-	-
I:2018	-	-	-	1.49*	-	-	-
I:2019	-	-	-	7.72*	4.32*	-	-
S1:1965	-	-	-	-	0.17*	0.18	-
S1:1971	-	-	-	-	0.49*	0.31*	-
S1:1973	-	-	-	-	-	-0.72*	-
S1:1974	-	-	-	-1.14*	-0.84*	-	-
S1:1975	-	-	-	-	-	0.27*	-
S1:1979	-	-	-	-1.42*	-	-	-
S1:1980	-	-	-	-	-	0.12*	-
S1:1995	-	-	-	-1.15*	-	-	-
S1:1997	-	-	-	-	0.09*	-	-
S1:1998	-	-	-	1.98*	-	-	-
S1:2002	-	-	-	-	-0.19*	-	-

S1:2004	-	-	-	-1.01*	-0.20*	-0.15*	-
S1:2008	-	-	-	-	-	0.23*	-
S1:2011	-	-	-	-6.24*	-	-0.15*	-
S1:2012	-	-	-	1.56*	-	-	-
S1:2014	-	-	-	-4.44*	-	-	-
S1:2016	-	-	-	1.27*	-0.17*	-	-
S1:2018	-	-	-	-	4.55*	0.25*	-
Panel B: Diagnostic Tests							
R^2	0.86	0.99	0.18	0.99	0.99	0.89	0.99
Adj.R^2	0.85	0.99	0.16	0.99	0.99	0.84	0.99
Log-Like.	-1447.98	39.18	31.09	-1144.8	94.37	70.25	33.48
$JB_{Norm.}$	14.02 [0.00]**	6.81 [0.03]*	5.20 [0.07]	7.89 [0.02]*	7.39 [0.01]*	4.04 [0.13]	5.46 [0.07]
$LM_{Auto.}$	58.64 [0.00]**	1.47 [0.24]	3.90 [0.03]*	0.42 [0.66]	2.19 [0.13]	1.80 [0.18]	-
$WT_{Hetro.}$	7.63 [0.00]**	6.86 [0.00]**	5.0860 [0.01]**	1.22 [0.32]	0.71 [0.72]	1.46 [0.18]	-
RESET	60.52 [0.00]**	1.96 [0.15]	1.85 [0.17]	5.05 [0.00]**	0.76 [0.48]	1.98 [0.15]	2.06 [0.14]

a) Where '*', '**', '***' represents 1%, 5% and 10% significance level w.r.t *t-ratios* respectively.

b) $JB_{Norm.}$, $LM_{Auto.}$, $WT_{Hetro.}$ and RESET are the Jarque-Bera normality test, Lagrange multiplier test Autocorrelation, White heteroscedasticity test and Ramsey's test for correct specification, respectively. Later, three tests are based on $\chi 2$-distribution with 2 *d.f.*

c) While '*', '**' in ***Panel B*** shows the model didn't pass the diagnostic tests at 5% and 1% level of significance respectively.

Note: Author's own calculations

3.3 Exogeneity of Domestic Savings in FH–equation

Based on a rigorous and detailed discussion on non-stationarity and cointegration in last two sub-sections (a) and (b), we came up with these conclusions: i) both investment and savings are non-stationary i.e. I(1) at levels; ii) we found no signs of cointegration among investment and savings; iii) the estimated FH–equation in (4.6) is no more spurious. So, in view of this we can't apply (Hendry, 1995) methodology directly to test exogeneity. Therefore, to perform exogeneity tests in this case, we will use the following equations:

$$\Delta inv_t = \alpha + \beta \Delta sav_t + \sum_{i=1}^{m} \tau_{i,\alpha_2} 1_{\langle t=t_i \rangle} + \sum_{i=1}^{m} \rho_{i,\alpha_1} 1_{\langle t \geq t_i \rangle} + \mu_t \quad (5)$$

$$\Delta inv_t = \sum_{i=1}^{T} \delta_{1i} \Delta sav_{t-i} + \sum_{i=1}^{T} \delta_{2i} \Delta inv_{t-i} + \mu_{1t} \quad (6)$$

$$\Delta sav_t = \sum_{i=1}^{T} \varphi_{1i} \Delta inv_{t-i} + \sum_{i=1}^{T} \varphi_{2i} \Delta sav_{t-i} + \mu_{2t} \quad (7)$$

According to our discussion in subsection-b and in view of the above equations, the equation (5) can be considered as true DGP or correct functional form to estimate FH–equation. We call this equation as conditional process/equation. Whereas, (6) and (7) are the marginal processes/equations. The condition which determines the failure of Granger-Causality of savings on investment is $\delta_{1i} \neq 0$ and $\varphi_{1i} = 0$. Furthermore, since we have unit root in our data, the Granger-Causality test will be biased if we estimate VAR at levels. Therefore, in this case we have to estimate VAR at first difference. At the end, to capture contemporaneous effects we will use the residuals from this differenced VAR model.

3.3.1 Weak Exogeneity and Contemporaneous Test

As mentioned above, both investment and savings series are not cointegrated, we can't apply (Hendry, 1995) methodology to test exogeneity. It is worth noting that the models estimated by a single equation will produce biased results, provided that the right hand side variables are not exogenous. So, to get unbiased estimates, one ought to check the exogeneity status of the variables being modeled in the equation. Furthermore, it is necessary for any statistical inference (Engle et al., 1983; Ericsson, 1991). In order to test the exogeneity of this type, statistical tests of WeExt are available in literature. One is the LM-test of WeExt proposed by (Engle, 1984) and the other one is named as Durbin-Wu-Hausman Test of WeExt mainly due to (Durbin, 1954; Hausman, 1978; Wu, 1973). In order to perform the Engle test of WeExt, we obtained the error of conditional equation (5) and used them in the marginal model of savings equation (6) as an independent variable. The results of this test are shown in Table 5 below, and as can be seen, the estimate of error term of conditional model is not statistically significant in the marginal model (6). A p-value of 0.482 in Engle's test supports the assumption that domestic savings is weakly exogenous in the FH–equation, meaning it is not significantly influenced by past investment shocks. This allows the variable to be used as an independent regressor in further econometric analysis. On the other side, the Durbin-Wu-Hausman test is a test for the endogeneity of some, or all variables in the model. This test is available for non-panel equations estimated by GMM or TSLS. However, in this study we used GMM technique and based on this test, we can't reject the null hypothesis that domestic savings is exogenous. While estimating test we used lags of differenced variables as instruments. Furthermore, the rejection of H0 highlights the fact that the endogenous regressors have meaningful impacts. The argument about the WeExt of domestic savings is further strengthen by applying another test of endogeneity named as Wu-Hausman test proposed by (Hausman, 1978; Wu, 1973)[8].

Table 5: Tests of Weak Exogeneity[9]

Test Name	**The Engle Test** LM-Stat. H0: Regressor is weakly exogenous	**The Durbin-Wu-Hausman Test** GMM estimation (IV Regression) H0: Regressor is exogenous	**The Wu-Hausman Test** H0: Regressor is exogenous
Test Statistics	Coefficient *(p-value)* = 0.293 *(0.482)*	Diff. in J-stat.[10] *(p-value)* = 1.272 *(0.259)*	t-stat. *(p-value)* = 1.044 *(0.307)*
	Test for Contemporaneity H0: Correlation is zero *i.e.* $Corr.(\mu_t,\ \mu_{1t}) = 0$ t-stat. *(p-value)* = 0.718 *(0.476)*		

Note: Author's own calculations

For Wu-Hausman test, we estimate (5) first, and run the suspect variable i.e. domestic savings on the instruments (Δinv_{t-1} and Δsav_{t-1}). Then estimate residual from this equation and make these residuals as independent variable in the original estimated equation (5) and check its significance by using usual t-test. The insignificance shows that there is no endogeneity bias in the OLS estimates making domestic savings is weakly exogenous. All outcomes are being accessible above in Table 5.

The test that verify the correlation between the errors of equation (5) and (7) is a test of contemporaneity discussed in (Engle, 1984). This test is used to determine whether the errors of both equations are contemporaneously correlated or not? For that, we first estimate our conditional model (5), estimate its residuals μ_t. Then estimate the marginal model (6) and call its residuals μ_{1t}. After that we performed regression using OLS and the estimated t-test highlighted the fact that we can't reject the null hypothesis and therefore, according to this there is no contemporaneous effect between residuals. The results are being discussed above in Table 5. Based on these results, we can say that the model can be used for statistical inference.

3.3.2 Testing Strong Exogeneity

Whether an econometric model can be used for forecasting purpose or not? The answer lies in whether independent variable is strongly exogenous or not. If it is so, then the estimated model can be used to make better forecasts. Otherwise, it can't be used to makes forecasts (Engle et al., 1983). The StExt of domestic savings depends upon two conditions i) Savings is Weakly Exogenous ii) Investment doesn't cause savings in Granger sense. The Granger Causality (GC) test was introduced in (Granger, 1969). It is worth noting that the GC-test is in-fact not a true sense of causality test but it is just a predictability test as suggested by (Hoover, 2001). Since in last section, we have shown that domestic savings is weak exogenous. Therefore, it is sufficient enough to check the direction of causality only. Now, both the variables are I(1), so VAR at levels will produced biased results (Hamilton, 1994). Therefore, in order to apply GC-test, we first estimate difference VAR with lag length one[11]. After that we will apply GC-test to test the StExt status of savings in estimated FH–equation. The outcomes of GC-test are given below in Table 6. Clearly, it can be seen that domestic savings

[8] This test is only as good as the instruments used and is only valid asymptotically. This may be a problem in small samples and so generally this test is used only when sample size is above 100.

[9] All these estimations have been done in OxMetrics and E-Views (Version 9).

[10] Diff. in J-Stat. = (Restricted J-statistic) – (Unrestricted J-statistic) = 3.044 - 1.771= 1.272

[11] All information criteria report the lag length of one except Final Prediction Error (FPE) for estimating VAR with differenced variables.

granger cause investment but converse is not true. Therefore, the FH–equation can be helpful to make future predictions about Pakistan's economy. The existence of StExt of savings highlights that the model can be helpful for forecasting purpose. The Granger causality findings on savings drive investment suggests that policies should focus on enhancing domestic savings, improving financial sector efficiency, and ensuring stable macroeconomic conditions. This will help boost capital accumulation, reduce reliance on foreign borrowing, and enhance economic growth in Pakistan. In the next section, we will test whether the FH–equation can be used for policy changes or not, will be verified through the lens of SuExt tests.

Table 6. Test for Causality

Equation	Omitted	χ^2	No. of Lags	Prob. > χ^2
Δinv_t	Δsav_t	0.976	1	0.0009
Δinv_t	All	0.976	1	0.0009
Δsav_t	Δinv_t	0.331	1	0.945
Δsav_t	All	0.331	1	0.945

Note: Author's own calculations

3.3.3 Testing Super Exogeneity

The SuExt of the variables of interest ensures valid policy simulations (Engle et al., 1983; Hendry, 1995). In a seminal paper (Lucas, 1976), argued that, the agent changes their behavior whenever a policy maker changes the policy. Therefore, economic policy based on any econometric model faced under rational expectations could not be used. Consequently, the parameter estimate would not be the same before and after the policy/regime change. However, in seminal work by (Davidson et al., 1978) on UK's consumption function named as DHSY model, provided several conditions under which Lucas' critique is invalid. The variables fulfill these conditions were then called super exogenous with respect to parameters of interest against the relevant class of interventions, leads to help in designing economic policies. Two tests of SuExt, first by (Engle & Hendry, 1993) and other by (Charemza & Király, 1990) are used.

These tests examine whether the distribution of savings remains stable despite changes in the policy environment. If savings fails the super exogeneity test, it suggests that policy changes (e.g., capital account liberalization, interest rate deregulation) affect savings behavior, rendering traditional FH–equation estimates unreliable for policy simulation. Thus, applying the Lucas' critique through SuExt testing ensures that the savings-investment relationship remains valid for inference, forecasting, and policymaking in Pakistan.

Now to implement the first testing procedure, we consider the marginal model of savings following the process described in (Engle & Hendry, 1993) with four lags. We used general-to-specific modelling to get the final model along with two significant impulse dummies[12]. After estimating the marginal model (8) we stored its residuals and calculate the square of those residuals.

$$sav_t = 0.723 + 0.809sav_{t-1} + 0.155sav_{t-4} + 0.345IIS2000 - 0.319IIS2008 + \mu_{3t} \tag{8}$$

R2 = 0.98 LMAuto.χ2 (2) = 0.55(0.54) JBNorm.χ2 (2) = 1.05(0.59)
ARCHHetro.χ2(2) = 2.11(0.13) BPGHetro.χ2(4) = 4.83(0.004)
DW stat. = 1.82

Once we get the squared residuals, we use these residuals and their lags as independent variables in our estimated conditional model (5) and check their joint significance. If the squared residuals and its lags were insignificant in (5), then we say that domestic saving super exogenous with respect to parameters of interest. The test of joint significance is being reported below in Table 7, showing that the squared residuals and its lags are insignificant. Therefore, implementing the test proposed in (Engle & Hendry, 1993) showing that the domestic savings are super exogenous.

The other test of SuExt is based on (Charemza & Király, 1990) and unlike to the previous test, this test has the

[12] IIS2000 is for Musharraf era and IIS2008 for Global Financial Crisis.

benefit that it does not necessitate the pre-estimation of the marginal model. The idea behind this test is to calculate a regression in which the forecast error of conditional equation (5) is the dependent variable. Domestic saving's first difference and lags of it, taken as independent variables. These independent variables must be insignificant in order to accept SuExt. Therefore, the test accepts the fact that domestic saving is super exogenous for the estimated FH–equation. The results of both tests are reported below in Table 7. Lastly, this discussion leads us to conclude about the nonexistence of Lucas critique in case if FH–equation for Pakistan. Therefore, the estimated FH–equation can be used for policy models based on simulations. Nonetheless, for more detailed overview, a simulation study on the performance of these tests showing that the test proposed by (Engle & Hendry, 1993) performs better than that of (Charemza & Király, 1990) have been well documented in (Jawad, 2023).

Table 7: Tests of Exogeneity

Name	**Engle and Hendry Test**	**Charemza-Király Test**
Test Statistics	F-test (Prob. > F) = 0.22 (0.80)	F-test (Prob. > F) = 0.68 (0.61)

Note: Author's own calculations

4. Conclusion

Unlike other studies in the literature, this research reveals no evidence of cointegration between domestic savings and investment. As a result, it becomes necessary to explore the exogeneity of domestic savings in the FH–equation. Various exogeneity testing procedures were employed to assess this relationship, ultimately concluding that domestic savings are exogenous in the FH–equation. For the past fifteen years, Pakistan has experienced relatively low domestic savings compared to its investment levels. As a result, the rates of return on capital have remained high. This imbalance suggests that the country may have been dealing with persistent trade deficits. The FH hypothesis posits that under perfect capital mobility, domestic savings and investment should be uncorrelated across national boundaries, a theory supported by the contemporaneity test (Subsection C (i), Table 5). An increase in the budget deficit typically leads to a decline in both domestic savings and investments. This, in turn, triggers capital inflows, such as remittances, to help offset the fiscal shortfall. Consequently, foreign currency flows in as international financial assistance, leading to an appreciation of the real exchange rate. This appreciation causes exports to decline and imports to rise, ultimately worsening the current account deficit.

The FH–equation findings provide valuable insights into Pakistan's capital mobility and the relationship between domestic savings and investment. As in the case when breaks were not taken into account, the results indicate low capital mobility–meaning investment is largely financed by domestic savings–Pakistan must focus on strengthening its domestic savings rate. Policies should encourage long-term savings through pension funds, tax incentives, and financial literacy programs to enhance savings behavior. Additionally, financial sector reforms should improve credit allocation efficiency, ensuring that saved capital is effectively funneled into productive investments such as infrastructure, manufacturing, and technology-driven industries. Enhancing the role of capital markets by developing corporate bonds and mutual funds can provide alternative investment avenues, reducing reliance on traditional bank financing.

On the other side, when breaks were considered, the FH–equation results suggest high capital mobility, implying that investment is less constrained by domestic savings, Pakistan should focus on attracting foreign direct investment (FDI) and external financing while managing associated risks. Policies should improve the ease of doing business, strengthen investment protection frameworks, and offer sector-specific incentives to foreign investors. However, excessive reliance on foreign capital inflows can lead to external vulnerabilities, necessitating prudent debt management strategies and exchange rate stability measures to prevent financial crises. Pakistan must also prioritize high-return sectors, such as export-oriented industries and technology, to ensure that foreign capital is utilized efficiently, ultimately driving sustainable economic growth and stability.

This paper serves as a foundation for cross-country analyses of the FH-hypothesis, enabling the examination of regional disparities and their impact on the hypothesis's validity across different geographic areas. While this study provides valuable insights into capital mobility in Pakistan, several limitations should be acknowledged.

The reliance on the savings-investment correlation as a measure of capital mobility could be complemented by alternative approaches, such as gross capital flows or interest parity conditions. Although exogeneity tests confirm the robustness of savings as an independent variable, the potential for reverse causality between savings and investment suggests the need for further analysis using simultaneous equation models like 3SLS or GMM. Future research could also explore sectoral dynamics by distinguishing between household and corporate savings or private and public investment to provide more granular policy insights. Moreover, expanding the sample period or employing rolling regressions may also provide a more dynamic view of how savings-investment dynamics evolve over time.

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Author's Contribution

Conceptualization, M.J., M.A.K. and M.S.; Methodology, M.J. M.A.K; Software, M.J.; Investigation, M.J, M.S.; Writing and Original Draft Preparations, M.J., M.A.K. and M.S.; Review and Editing, M.J., M.A.K and M.S.

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Data Availability

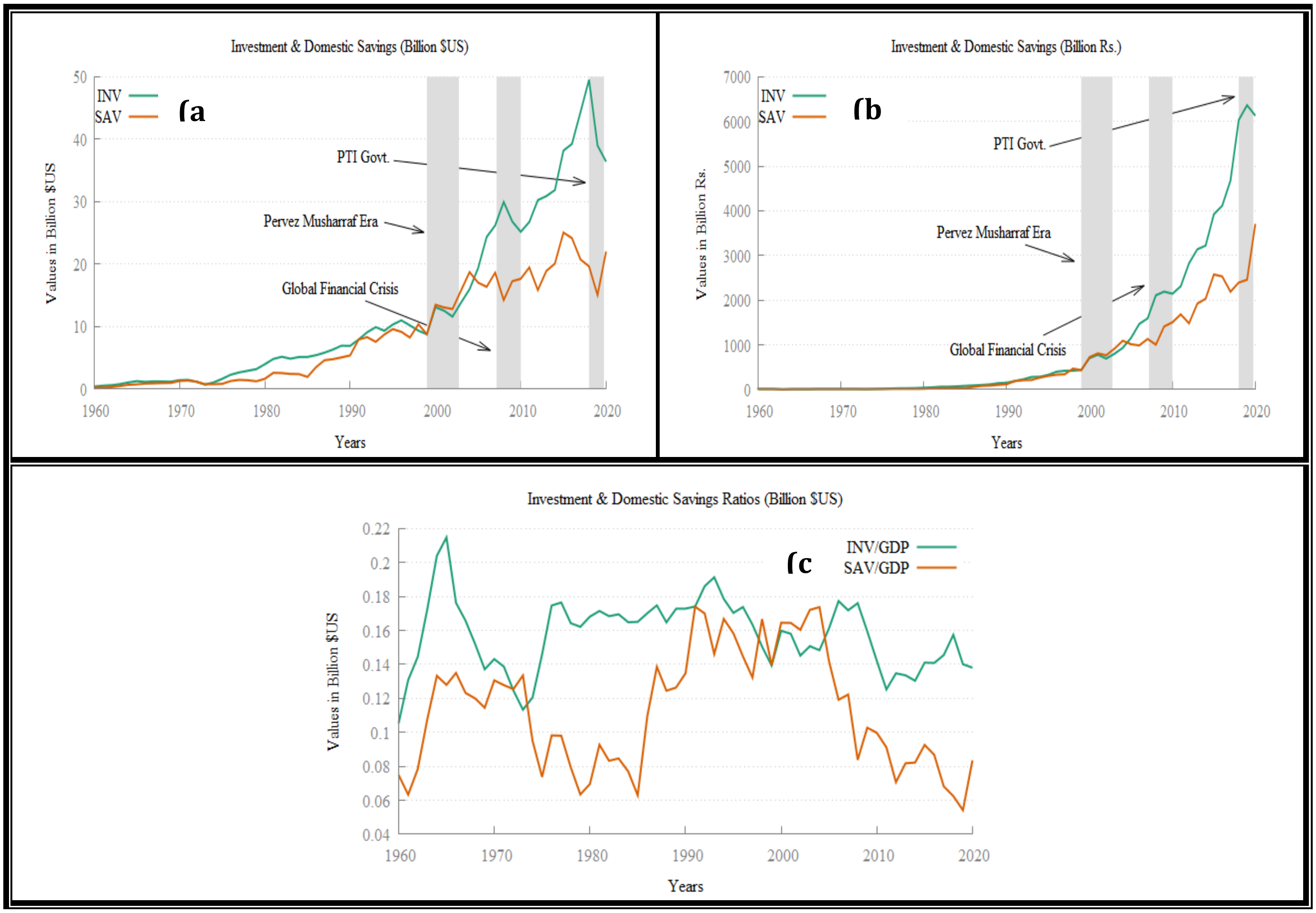
Available on the sources mentioned in the text.

Disclaimer

The views and opinions expressed in this paper are those of the author alone and do not necessarily reflect the views of any institution.

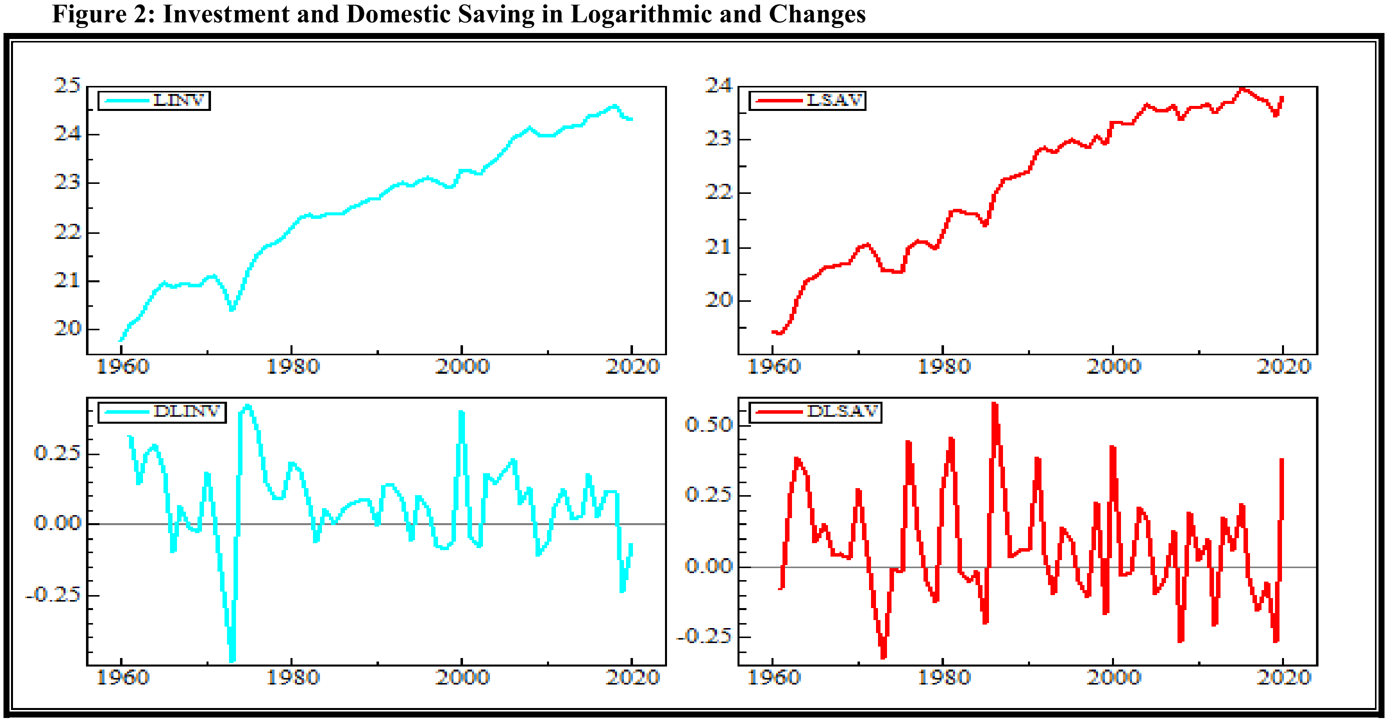
Appendix-I

Figure 1: Investment and Domestic Saving in Levels with Possible Break Regimes



Sources: *World Bank Development Indicator, SPB & PBS*

Figure 2: Investment and Domestic Saving in Logarithmic and Changes



Source: *Author's own calculations*