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**REM Working Paper 0110-2019**

December 2019

### **REM – Research in Economics and Mathematics**

Rua Miguel Lúpi 20,  
1249-078 Lisboa,  
Portugal

ISSN 2184-108X

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# The Short-Run and Long-Run Determinants of Household Saving: Evidence from OECD countries.

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## Abstract

This paper examines the relationship between interest rates and household saving rates for an uneven panel of 19 OECD countries during the period 1995 to 2018. Unlike earlier studies, it uses the pooled mean group (PMG) methodology to investigate which of the interest rate effects, income or substitution, dominates in the short run, long run, or both periods. With the baseline estimations, I find that the income effect outweighs the substitution effect in the short run, and vice versa in the long run. I also find that inflation (both expected and actual), household wealth through housing prices, unemployment rate, current taxes on income and wealth, and general government debt have significant negative impact on household saving in the long run. I find that financial development has a positive effect on household saving in the long run. Current taxes on income and wealth has a strong negative impact on household saving in the short run.

*Keywords:* household saving, interest rates, inflation, taxation, unemployment rate, dynamic heterogeneous panel data model

*JEL codes:* E21, E24, E43, C23

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## 1. Introduction

Perhaps the most crucial assumption underlying recent years policy approach of adopting negative interest rates by some major central banks (see table 1) relates to the commonly perceived positive interest rate effect on saving. Most economist would share the view that, at least in the short run, monetary policy can significantly influence the consumption and saving decisions of households. However, they pay lip service to what happens in the interim regarding the relationship between saving and interest rate, thereby forcing empirical investigations to focus on long-run estimations and conclusions. In this paper, I do not attempt to engage in a theoretical discussion of short-run mechanisms. Instead, I examine

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\*I thank Paulo Brito, Antonio Afonso and participants of INFER Workshop on New Challenges for Fiscal Policy for helpful comments and discussions. This paper represents the authors' personal opinions and does not reflect the views of the affiliated institution.

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in a dynamic heterogeneous panel framework the short- and long-run impact of interest rate on household saving. The goal is to test empirically which of the interest rate effects, income or substitution, dominate in the short- or long-run, or both periods, and to emphasize that such a distinction can contribute to the identification of most appropriate policy responses for short- and long-run purposes.

[Table 1 about here.]

Moreover, I examine the impact of other economic factors like inflation, taxation, unemployment, financial development, household wealth and general government debt on household saving, and whether the empirical results obtained are robust to variables choice and alternative specifications of the model. Given this, I apply the Pooled Mean Group Method (PMG) proposed by Pesaran, Shin, and Smith [1] to a panel of 19 countries for over two and a half decades (1995-2018) in order to test these hypotheses. The PMG method uses the Autoregressive Distributed Lag (ARDL) model as the basic structure in conducting estimations and offers the advantage of being able to detect any long-run equilibrium relationship, as well as the short-run dynamics.

It is known a priori that two ambiguous forces are likely to interplay when one considers the interest elasticity of saving. The debate on this has long been a severe bone of contention among economists and policy-makers. Gylfason [2] notes that the classical view that aggregate saving is an increasing function of the interest rate may not be correct because the substitution effect and the income effect may go in opposite directions, thus rendering the net effect ambiguous. Thus, on the one hand, a fall in interest rate renders future consumption more expensive, hence, can discourage saving (substitution effect) while on the other hand, can encourage saving at the present as households would require more money for the same amount of consumption in the future (income effect). In an extremely low-interest-rate environment such as one faced by some economies today, the income effect is likely to outweigh the substitution effect. In such a case, for example, individuals may be worried about the possibility of not being able to meet their planned future objectives such as pensions, hence, may try to overcome this low return by increasing the aggregate amount of saving.

The disparities in household saving rates across and within many industrialized and developing economies overtime, in view of the trends in the nominal interest rates and inflation rates, cast more doubt on the link between the saving rate and interest rate, and calls for the need to broadly re-examine the factors that impact household saving in the short -and long-run period. Such disparities may suggest different institutional settings and the tendency of some countries to rely more on foreign savings to finance domestic investments making these countries more vulnerable to external shocks (Rocher and others [3]). Moreover, a re-examination of the nexus between household saving rates and other macroeconomic factors such as interest rate, taxation, government debt et cetera is significant for assessing the impact that both monetary and fiscal policy have on consumption and saving in the short- and long-run periods.

Previous works focused mainly on the United States and reported mixed evidence of long-run estimates or some support for positive interest rate effects. This heavy focus of many

studies on the United States means that much of the existing body of empirical evidence on saving behaviour has been dominated by the specific characteristics and circumstances of a single country and may, therefore, lack cross country generality (Zee and Tanzi [4]). Evidence on short- and long-run estimates of the magnitude of such effects using a panel data approach is minimal. Also, those studies ignored the significance of the possibility that a particular variable, say, the interest rate could exert different significant effects (in terms of magnitude and sign ) on household saving in the short- or long-run period. Short-run effects are likewise crucial as long-run effects. For instance, whether policy interest rates and saving rates have a positive or negative relationship in the short term, also refers to the kind of impact a monetary policy would have on consumption and saving and is therefore related to the question of stabilization measures (Aizenman and others [5]). If theoretical evidence (see, for example, Diamond [6]; Summers [7]; Gylfason [8]) is a guide, then one would expect that in the long run, the interest rate, saving and capital accumulation will all be interrelated in a manner such that current consumption and saving would be impacted. Therefore the interest elasticity of the saving rate can be an essential channel for long-term economic growth.

I report results which confirms some of the literature findings and also unveil some novel features. First and most importantly, given the goal of this paper, I detect that the income effect of the short-term nominal interest rate dominates the substitution effect in the short run, and vice versa in the long run. I also find evidence that almost all the macroeconomic variables considered in this study impact household saving in the long run. When the long-term nominal interest rate is used instead of the short-term nominal interest rate, I find a consistent positive long-run effect, but no short-run relationship with the household saving rate. When I examined for the impact of Inflation on household saving, I find that the inflation rate (expected or actual) is inversely related to the household saving rate in the long run. Household wealth proxied in this study with real housing prices also has an inverse relationship with the household saving rate in the long run. I also find that the unemployment rate, which represents the effect of diminished actual resources, is inversely related to the household saving rate in the long run.

To examine the effect of government policies on household saving, I extend the conventional approaches, notably by including fiscal policy variables such as current taxes on income and wealth, and general government debt in the specification. I find that these two variables likewise do have an inverse relationship with household saving rates in the long run. Availability of domestic credit often associated with financial development or liberalisation process is found to be positively related to the household saving rate in the long run, a result which contradicts with theory, although other empirical studies have reported similar findings. Second, among the variables considered, I find that only the short-term nominal interest rate and current taxes on income and wealth have significant short-run effects on household saving and are robust to alternative specifications. The findings also highlight the importance of short-run heterogeneous characteristics of the countries in the sample, and why household saving rates vary across these countries.

This paper makes three significant contributions to the literature on the determinants of household saving. First, the novel feature of this study is that more attention is devoted to

isolate short-run effects from long-run effects in order to test the validity of the hypothesis that the income effect outweighs the substitution effect in the short run, and vice versa in the long run. It is one of the few studies to introduce dynamics and to also take into account the view that the disparities in household saving behaviour might be as a result of diversity in institutional structures across countries.<sup>1</sup> Second, this study is among the few studies, in a panel framework, to rigorously examine nominal interest rates and the expected rate of inflation consistently in order to obtain reliable estimates of the effects of real interest rates on household saving. Many of the previous studies only focused on the effects of real interest rates and ignored expected inflation. Third, the study also incorporates other potential household saving determinants identified by theory but not previously considered in the empirical literature.

The remainder of this paper is organized as follows: Section two reviews previous work on saving behaviour. Section three presents the empirical strategy and the data used for estimations. Section four reports the estimation results, and section 5 concludes.

## 2. Previous Empirical Work on Household Saving Behaviour

Until the mid-twentieth century, the notion that saving is unresponsive to the rate of interest received widespread acceptance among empirical and policy-oriented macroeconomists. Keynes [9], in *The General Theory of Employment, Interest and Money*, noted

...the main conclusion suggested by experience...that the short-period influence of the rate of interest on individual spending out of a given income is secondary and relatively unimportant, except, perhaps, where unusually large changes are in question (1936, p. 94).

David and Scadding [10] examined "Denison's Law"[11], and reported evidence in support of the proposition that the gross private saving ratio (GPSR) has been very stable in the United States except for World War I, World War II, and Great Depression years. The notion of ultrarationality, in which households subsume corporate and government spending and saving in their budget decisions, was used to explain the stability of the GPSR despite the significant changes in its composition.

Boskin's [12] estimation of interest elasticity of saving parameter value of 0.4 for the United States changed the narrative and led to a proliferation of studies in the 70s and 80s questioning Boskin's finding. Summer's argument, based on his life-cycle simulation model that saving is much more interest-elastic than economist have generally thought to be rekindled the debate, particularly among empirical macroeconomists. Majority of those studies reported evidence of a positive relationship between aggregate saving and interest rates (see, for example, Juster and Wachtel [13]; Juster and Taylor [14]; Boskin). Some studies also

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<sup>1</sup>Haque and others, Hüfner and Koske all observe that institutional constraints tend to be more binding in the short-run and may thus cause saving ratios across countries to respond differently to changes in the underlying fundamentals.

presented evidence of an inverse relationship between saving and interest rate (see, for example, Houthakker and Taylor [15]; Weber [16]). The sign and statistical significance of the interest rate coefficient are quite sensitive to how the interest rate variable is constructed (Carlino [17]). Estimation results of the impact of other variables on saving say inflation, had often come as a by-product of other studies, with conflicting results in a similar manner as interest rate effect. Howard[18] reported evidence of a positive inflation effect on saving for the United States but found no evidence of interest rate effects. Similarly, Howrey and Hymans [19] reported evidence of adverse effects of inflation on the saving rate and a positive nexus between saving and inflation uncertainty but found no evidence of interest rate effects on saving rates for the United States.

The studies mentioned above focused on individual country-basis, particularly the United States.<sup>2</sup> Saving represent household intertemporal decision, often related to life-cycle considerations, the relatively short period for which time-series data is available (often less than one generation) means that information contained in the data is unlikely to be rich enough to adequately capture the influences on lifetime saving decisions (Callen and Thimann [20]). Panel approaches, through the inclusion of many countries of different saving characteristics, have the advantage over individual country time-series studies, of being able to overcome this problem, and can lead to a more precise parameter estimation. However, most panel studies in the early 90s focused on the relationship between growth and aggregate private saving behaviour (see, for example, Carroll and Weil [21]; Attanasio and others [22]). Panel studies of the relationship between the interest rate and saving began somehow in the late 90s and are very limited.

From a theoretical point of view, based either on the permanent income or the life cycle hypothesis, the sign of the effect on saving of many of these macroeconomic variables is ambiguous. Therefore heavy reliance is placed on empirical findings to throw more light on the issue. However, empirical studies differ in terms of the country sample, estimation method, and more importantly, the definition and proxies for the variables used, and as a result, have led to conflicting findings. These disparate results highlight the challenge in understanding and estimating the relationship between saving and macroeconomic factors. A selective summary of some empirical evidence in Table 2 indicates mixed findings regarding the relationship between saving and its determinants.<sup>3</sup>

[Table 2 about here.]

Some studies (see Schmidt and others [23]; Edwards [24]) find evidence of no effect of real interest rate on saving. Callen and Thimann study a panel of 21 OECD countries and find important roles for public and private saving, taxes, real interest rate, inflation, unemployment, demography, and financial deregulation in influencing household saving. Masson and others [25] examine a panel of industrial and developing countries and find that the government's fiscal position, GDP as well as *per capita income growth*, the real interest

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<sup>2</sup>See Gylfason (1981) for a tabulated historical overview of the effects of interest rates and inflation on aggregate consumption and saving in the United States.

<sup>3</sup>See Hübner and Koske for an overview of the determinants of household saving rates in panel studies.

rate, inflation, demographics and changes in terms of trade all do have significant effects on household saving rates, although the results differ for the two sets of countries considered in their study.

Bandiera and others [26] find for a panel of eight developing countries that real interest rate and inflation positively influences saving, while financial liberalisation have detrimental effects. Loayza and others [27] report evidence of negative financial liberalisation effect, positive inflation effect, and negative effect of real interest rate on private saving. De Mello and others [28] for a panel of 21 OECD countries confirm the relevance of fiscal policy for private saving decisions. They further find wealth effects, through rising equity and housing prices, to have an essential complementary impact on private saving. Horioka and Wan [29] find evidence of a positive effect on the saving rate of real interest rate and inflation. Salotti [30] focuses on the role of wealth and find for a panel of 18 countries that wealth negatively impacts household saving.

Ferrucci and Miralles [31] find public-sector saving rates, the demographic structure of the population (as measured by the old-age dependency ratio), the growth rate of labour productivity, changes in terms of trade and the real interest rates to significantly influence private-sector saving rates in OECD economies. Nabur [32] examine provincial data for China between 1996 and 2009 and find household saving to respond negatively to a change in the real interest rate. They claim that Chinese households are target level savers. Mody and others [33] find for a panel of advanced economies that the real interest rate, and labour income uncertainty, measured in terms of the unemployment rate have significant adverse effects, while the net financial worth have positive effects on household saving.

Haque and others [34] criticise majority of the studies mentioned above on their parameter homogeneity assumption across countries regarding the influence of explanatory variables and lack of modelling dynamics. They argue that this may lead to misleading inferences about the key determinants of saving.<sup>4</sup> Their result indicate that fiscal variables, particularly the general government surplus as a proportion of GDP and the ratio of government consumption to GDP, as well as the terms of trade, are the critical determinants of private saving rates in the industrial countries in the post World War II period.

Given the criticism by Haque and others, of neglected heterogeneity and dynamics in cross country saving regressions of previous works, some studies estimate country-by-country relationship, without pooling (e.g. Bandiera and others; Ferrucci and Miralles, though they maintain the homogeneity restrictions for the long-run coefficients). A study by Hufner and Koske [35] allows for heterogeneity in the long- and short-run parameters across G7 countries in their specification, and explicitly distinguishes between financial liberalisation effects and wealth effects. They find that income development as well as real interest rates and inflation influence household savings in most of the countries, and that wealth effects through housing and stock prices play a role in many countries.

The approach of this paper in distinguishing among short- and long-run effects is in line

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<sup>4</sup>Haque and others show that ignoring cross-country differences can result in the overestimation of the effects of certain factors on the private saving rates and at the same time obtain highly significant, but spurious, non linear effects for some of the potential determinants.

with the contributions by Haque and others and is shared by De Serres and Pelgrin [36], who allow for country-specific short-and long-run coefficients for those variables where homogeneity is rejected. De Serres and Pelgrin find that public-sector saving rates, demographics (as measured by the old-age dependency ratio), the growth rate of labour productivity, changes in terms of trades and the real interest rates have all been significant in influencing private-sector saving rates in OECD countries.

A recent study by Aizenman and others use an uneven panel of 138 countries to investigate the link between interest rate and private saving. They find evidence of a substitution effect, although its estimate is significant only for the full sample and marginal for the sub-sample of Asian economies.<sup>5</sup> Given this result, they conduct further investigations to find whether the real interest rate affects private saving differently depending on whether the real, or nominal, interest rate is below a certain threshold. They find evidence that the impact of the real interest rate on private saving changes when the nominal interest rate is below a relatively low level, suggesting that a low-interest-rate environment can yield different effects on private saving across country groups under different economic environments. They did not provide an empirical estimate to support this proposition. This paper goes a step further to explore some validity of their key findings and to test the hypothesis that the effect could likewise vary in different periods, short- and long-run period, in particular.

### 3. Data and Empirical Strategy

#### 3.1. The Data Set and Stylized Facts

This study uses annual data set comprising of 19 OECD countries (see Appendix A for the list of countries) and spans the period 1995 - 2018. These countries were selected in order to construct a panel that possesses different characteristics. The description of the variables (dependent variable: real gross household saving rate ( $s^{rg}$ ) and explanatory variables: short-term nominal interest rate ( $i^{sn}$ ), expected rate of inflation ( $\pi^e$ ), real housing prices ( $hpr$ ), current taxes on income and wealth ( $t$ ), unemployment rate ( $u$ ), domestic credit to the private sector as a percentage of GDP ( $dcr$ ) and general government gross debt (as a percentage of GDP( $gd$ )) can be found in Appendix B at the back of the paper. The primary sources of the data include the annual macro-economic database of the European Commission's Directorate-General for Economic and Financial Affairs (AMECO), OECD database and World Development Indicator database. I follow the approach of Gylfason to construct series for the one-year expected rate of inflation and the actual rate of inflation (see Appendix B for a description of the procedures used)<sup>6</sup>. A detailed descriptive statistic can be found in Table 3. The table present mean values of the variables, along with standard deviations, for the full sample period.

[Table 3 about here.]

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<sup>5</sup>See Aizenman and others for a detailed discussion of the theoretical predictions of private saving.

<sup>6</sup>See Gylfason for an elaborative procedure and defence of the use of adaptive expectations rather than rational expectations. Although, a market based expected inflation is preferable, survey data is not available for all countries in the panel, hence, the use of adaptive expectation method.



Table 4 shows the average household saving rate for 19 OECD countries considered in this study, as well as the European Union (EU) average. One could notice the disparities in average household saving rates across these countries, with 12 of these countries having household saving rates below the EU average rate of 11.3 percent. Switzerland, Luxembourg, Germany, Belgium and Austria are the top five countries, with household saving rates above 15 percent whiles Greece remains at the bottom of the ranking.

[Table 4 about here.]

Figure B.1 shows the trends in the mean of the variables for the panel over the sample period 1995-20018. Panel(a) shows that the real gross household saving rate has been trending downwards from about 18.8 percent in 1995 to about 10.4 percent by 2018. A similar trend could be noticed of the average EU household saving rate, which dipped below 10 percent in the year 2017 and is showing sign of improvement. The average short-term nominal interest rate for the panel has also been trending downwards and has neared zero in recent times. One could notice the sharp drop in the short-term nominal interest, a stabilization measures adopted by policy-makers in response to the Great Financial Crisis (GFC) in 2008. Panel (b) shows that the long-term nominal interest rate has also been trending downwards and is now a little above 12 percent. An inspection of other for other macroeconomic variables (see other graphs in Figure B.1) considered in this study provides more highlights about some of the stylized facts known in the literature regarding the relationship between these variables and household saving rates. Some of the variables, for example, current taxes on income and wealth (Panel (d)), and general government gross wealth (Panel (f)) have all been stable in recent years. The rate of expected and actual inflation (Panel (c)) shows signs of fluctuations, but stable over time. The average unemployment rate (Panel (e)) after attaining high levels during and after the GFC period has been on a continuous decline since 2013. Domestic credit to the private (Panel (g)) sector has been on a continuous decline for some time now while real housing prices (Panel (h)) has been trending upwards.

[Figure 1 about here.]

### 3.1.1. Panel Unit Root Test

I employ panel unit root tests of Levin, Lin and Chu [37] and Im, Pesaran, and Shin [38] in order to determine the stationarity properties of the variables. The Levin, Lin and Chu procedure tests the hypothesis that all cross-sectional units are stationary with the same autoregressive parameter across units (the homogeneous alternative hypothesis) against the hypothesis that they are all non-stationary. On the other hand, the test by Im, Pesaran, and Shin procedure allows for residual serial correlation and heterogeneous dynamics and error variances across units. In such a case, some variables for individual units may be stationary. The result of these test are likely to be influenced by the chosen number of lag length, therefore, a common lag length of one was used. The tests are estimated both in levels and first differences, with and without a trend. Table B.5 reports the results of the tests. Except for real household gross saving rate, unemployment rate, inflation rate (both

expected and actual) that are  $I(0)$  in levels under the two tests, the rest of the variables are  $I(0)$  in first difference, suggesting a stationary cointegrating relation among the variables.

[Table 5 about here.]

### 3.2. Empirical Strategy

I estimate a saving function which is consistent with both the permanent income hypothesis (PIH) and the life-cycle hypothesis (LCH). Since the goal of this study is to test the hypothesis of which of the interest rate effect, income or substitution, is likely to dominate in the short- or long-run, or both periods, I apply the PMG method proposed by Pesaran and others to distinguish short-term effects from long-run effect. The PMG estimator is an intermediate estimator between the Dynamic Fixed Effect (DFE) estimator and the Mean Group (MG) estimators since it involves a mixture of pooling and averaging which allows the intercepts, short-run coefficients, and error variances to be different across groups, but imposes homogeneity on the long-run coefficients across groups. One major of PMG over traditional dynamic fixed effect model is that it is possible to allow the short-run dynamic specification to differ from country to country. The underlying assumptions of the PMG estimator are as follows: first, the error terms are serially uncorrelated and are distributed independently of the regressors, that is, the explanatory variables can be treated as exogenous; second, there is a long-run relationship between the dependent and explanatory variables; and third, the long-run parameters are the same across countries.<sup>7</sup> I assume the long-run savings function is given by:

$$s_{it}^{rg} = \theta_{0i} + \theta_{1i}i_{it}^{sn} + \theta_{2i}\pi_{it}^e + \theta_{3i}hpr_{it} + u_{it}, i = 1, 2, \dots, N, t = 1, 2, \dots, T \quad (1)$$

where  $s^{rg}$  is the real gross saving rate,  $i^{sn}$  is the short-term nominal interest rate,  $\pi^e$  is one-year expected inflation rate, and  $hpr$  is real housing prices as a proxy for wealth.

For simplicity, I assume a common maximum lag of one for both the dependent and independent variable, which leads to an autoregressive distributed lag model (ARDL (1,1,1,1)) that can be written as:

$$s_{it}^{rg} = \mu_i + \delta_{10i}i_{it}^{sn} + \delta_{11i}i_{it-1}^{sn} + \delta_{20i}\pi_{it}^e + \delta_{21i}\pi_{it-1}^e + \delta_{30i}hpr_{it} + \delta_{31i}hpr_{it-1} + \lambda_i s_{it-1}^{rg} + \varepsilon_{it} \quad (2)$$

The error correction equation is derived as:

$$\Delta s_{it}^{rg} = \phi_i (s_{i,t-1}^{rg} - \theta_{0i} - \theta_{1i}i_{it}^{sn} - \theta_{2i}\pi_{it}^e - \theta_{3i}hpr_{it}) - \delta_{10i}\Delta i_{it}^{sn} - \delta_{20i}\Delta \pi_{it}^e - \delta_{30i}\Delta hpr_{it} + \varepsilon_{it} \quad (3)$$

where

$$\theta_{0i} = \frac{\mu_i}{1 - \lambda_i}, \theta_{1i} = \frac{\delta_{10i} + \delta_{11i}}{1 - \lambda_i}, \theta_{2i} = \frac{\delta_{20i} + \delta_{21i}}{1 - \lambda_i}, \theta_{3i} = \frac{\delta_{30i} + \delta_{31i}}{1 - \lambda_i}, \phi_i = \lambda_i - 1 \quad (4)$$

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<sup>7</sup>See Pesaran and others (1999) for an elaborative discussion of the PMG estimation method.

Equation (3) is estimated using the maximum likelihood estimation procedure described by Pesaran and others. The estimated coefficients are obtained using the Newton-Raphson algorithm, which uses both first and second derivatives of the log-likelihood function. The mean group estimates are used as initial estimates for the long-run parameters of the pooled maximum likelihood estimation. For long-run equilibrium to exist and convergence to take place, the estimated error correction adjustment term in equation (3),  $\phi_i$  is required to be negative and significant. Although this estimation procedure allows one to choose lag structures based on the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC), I restrict the model to a maximum lag of one, and the results are presented in the next section that follows. Given the fact that  $T$  is relatively small ( $T=24$ ), I do not report MG estimates as they may suffer from small  $T$  bias stemming from the lagged dependent variable problem.

## 4. Estimation Results

### 4.1. Baseline Results

The first regression results are given in Table B.6. The first column reports the results of a basic estimation where real gross saving rate,  $s^{rg}$ , is exclusively explained by the short-term nominal interest rate,  $i^{sn}$ .<sup>8</sup> The result indicate the existence of income effect (negative) in the short run and a substitution effect (positive) in the long-run period.<sup>9</sup> The error correction coefficient is around -0.31 and is highly significant. In the second column, I add the one-year expected rate of inflation, as a measure of uncertainty, to the basic specification. The result in terms of the expected signs in both periods remain the same, with the negative value of the error correction term increasing to -0.34, and the coefficient of the short-term nominal interest rate increasing from previous estimate of 0.39 to 0.43. In the third column, I add real housing prices to capture wealth effects. I use this model as a benchmark model and refer to it throughout the rest of the analysis. Again, as in the previous two models, I detect the existence of income and substitution effect in the short- and long-run period, respectively. The average error correction coefficient is now -0.36 and is highly significant. This implies that any deviation of the real gross saving rate from the value predicted by the long-run relationship with the short-term nominal interest rate, expected rate of inflation and real housing prices triggers a change in the opposite direction in the real gross saving rate. The long-run coefficients of the interest rate, expected rate of inflation and real housing prices are now 0.35, -0.22 and -0.013, respectively, and are all significant. However, the coefficient of the expected rate of inflation is marginally significant in the short-run, while that of real housing prices is not to significant.

[Table 6 about here.]

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<sup>8</sup>The approach is to start with a trivial regression and observe the results of subsequent addition of other variables. However, for some cases I present the baseline result directly.

<sup>9</sup>Caution must be taken in comparing these results with other panel studies which uses the real interest in its estimation.

The estimations of the short-run country-specific coefficients are reported in Table B.7. All countries have the expected sign of the error correction coefficients except Sweden. The fastest adjustments are Norway  $\hat{\phi} = -0.77$  while Belgium is the slowest with  $\hat{\phi} = -0.09$ . The country-specific short-run estimates also show that for 14 countries out of a total of 19, there is a significant relationship between the short-term nominal interest rates and household saving. Significant short-run substitution effect can only be found for Sweden. Moreover, the magnitude, sign and the significance of the one-year expected inflation rate, as well as wealth effects through real housing prices vary across countries. These variations in results reflect different institutional frameworks across countries.

[Table 7 about here.]

## 4.2. Further Results

In this section, I present further empirical evidence by testing whether the results presented in the previous section are sensitive to the choice of variables (real gross saving rate versus real net saving rate; expected versus the actual rate of inflation; short-term nominal interest rate versus long-term nominal interest rate).

### 4.2.1. Real Gross Saving Rate versus Real Net Saving Rate

Columns 4, 5 and 6 of Table B.6 reports estimation result when the real net saving rate of households ( $s^n$ ) was used as the dependent variable. These results are quite similar to the previously reported ones, with the error correction coefficient of -0.34 and is highly significant. The long-run coefficients of interest rate, rate of one-year expected inflation and real housing prices are now 0.39, -0.19 and -0.01, respectively. The short-run estimates are now -0.36, 0.10 and 0.02 respectively. These coefficients are significant in both short- and long-run period except real housing prices, which is not significant. Again, this result indicates that the hypothesis that the income effect outweighs the substitution effect in the short run and vice versa, in the long run, is by so far robust to an alternative definition of the dependent variable.

### 4.2.2. Expected versus Actual Rate of Inflation

When the one-year expected rate of inflation is made equal to the actual rate (i.e.  $\lambda = 1$ ), the actual rate of inflation replaces the expected rate in the estimating equation. The equations are then re-estimated and the results reported in columns 1, 2, 3 and 4 of Table B.8. The error correction term is now -0.45 and is highly significant. For the baseline results (column 2, with real gross saving rate as the dependent variable), the estimated long-run coefficients of the interest rate, inflation rate and real housing prices are significantly now 0.831, -0.378 and -0.027, respectively, compared with 0.35, -0.22 and -0.01 of previous estimates. The short-run coefficients are now -0.46, 0.06 and 0.03, respectively (real housing prices was found not). Column 4 of Table B.8 reports the results when real net saving is used as the dependent variable. Similarly, as in the previous model, all long-run coefficients are highly significant and have the expected signs. However, the result differs in terms of

magnitude. The coefficients of the interest rate, inflation rate and real housing prices are now 1.037, -0.20 and -0.04, respectively. Likewise, the short-run coefficients differ and are now -0.63, 0.04 and 0.01, respectively. Only the coefficient of the interest rate variable is robust in terms of short-run significance. The error correction term remains the same and is highly significant.<sup>10</sup> Overall, these results again indicate that the income effect outweighs the substitution effect in the short run and vice versa in the long run.

[Table 8 about here.]

#### 4.2.3. *Short-term versus Long-term Nominal Interest Rate*

When the models were re-estimated with the long-term nominal interest rate instead of the short-term nominal interest, significant long-run results similar in terms of expected signs were obtained.<sup>11</sup> The results are reported in columns 1, 2, and 3 of Table B.9 for the case where the real gross saving rate is used as the dependent variable, and in columns 4, 5, and 6 when the real net saving rate is used. The error correction coefficient is now -0.38 as compared to -0.36 obtained from the equation with the short-term nominal interest rate while the long-run coefficients of the long-term nominal interest rate, the expected inflation and real housing prices are now 0.36, -0.13 and -0.01, respectively, compared with 0.35, -0.22 and -0.01. In terms of the short-run coefficients, the estimates were consistent in terms of the expected sign but were not statistically significant across all specifications. Results within close ranges were obtained when the real net saving rate was used as the dependent variable. These results confirm the existence of substitution effects in the long-run, but the income effect cannot be confirmed in the short run, although expected signs were obtained.

[Table 9 about here.]

#### 4.3. *Sensitivity to other Determinants of Household Saving*

The purpose of this section is to conduct further investigations by introducing into the baseline specification other macroeconomic variables that determine household saving, first, to check if their inclusion in the model changes the results previously obtained, thus, if income effect will still dominate the substitution effect in the short run, and second, to observe the impact each variable has on the real gross saving rate. The variables are first added separately into the baseline specification, results are reported in columns 1, 2, 3 and 4 of Table B.10 and later altogether, as reported in columns 5 and 6.<sup>12 13</sup>

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<sup>10</sup>The standard errors of the parameter estimates are a bit higher which suggest this equation might not fit the data quite well, as compared with model estimated with expected rate of inflation.

<sup>11</sup>The use of long-term nominal interest rates here is merely a distinct empirical exercise and should not be viewed as a substitute for the short-term nominal interest rate in the hypothesis testing. Monetary policy is generally presumed to have a limited impact on the long-term rates.

<sup>12</sup>I do not simultaneously add more than three policy variables to the benchmark model in order to ensure sufficient number of degrees of freedom.

<sup>13</sup>See Loayza, Schmidt-Hebbel, and Servén, for a tabulated long list of variables with their expected sign as well as the results of 16 panel studies of private saving

#### 4.3.1. *Current Taxes on Income and Wealth*

Taxes, particularly on income and wealth distort households economic decisions, as it depresses income and wealth, hence, saving.<sup>14</sup> The question of which forms of taxes are more or less distortionary, although an empirical one, have not received much attention in the empirical literature as compare to theoretical simulations. When current taxes on income and wealth is added to the baseline specification, again, I find that the income effect dominates the substitution effect in the short run, and vice versa in the long-run. The results are reported in column 1 of Table B.10. However, I observe a substantial increase in the long-run interest rate coefficient. The long-run coefficients of the other variables, as well as the error correction coefficient, are of the expected sign and are highly significant, except real housing prices which the sign changes from negative in previous estimates to positive. I find a statistically significant and strong negative relationship between current taxes on income and wealth and household saving rates in both the short- and long-run periods. The estimated coefficients are -0.96 and -0.84 in the long- and short-run period, respectively. This result is consistent with previous studies (see, for example Tanzi and Zee) that focused solely on the impact of taxes on household saving and found estimated coefficients to be high and negative.

#### 4.3.2. *Unemployment Rate*

In order to capture the effect of uncertainty about labour income prospects, unemployment rates in levels were included. Unemployment rates together with the rate of inflation (which represents the effect of diminished actual resources) create an unusual degree of uncertainty for households. These two variables are used as proxies for general measures of uncertainty.<sup>15</sup> Column 2 of Table B.10 reports the result when the unemployment rate is added to the baseline specification.<sup>16</sup> The long-run coefficients for the interest rate and real housing prices are now 0.4 and -0.02, respectively and are all significant. The error correction coefficient, in comparison with previously obtained results, is also within the expected range (-0.3 to -0.4 approximately). Both measures of uncertainty, namely, the rate of inflation and unemployment rate negatively impact household saving in the long run, with coefficients of -0.22 and -0.16, respectively. These negative long-run coefficients of the general measures of uncertainty suggest that the "income effect" dominates the "substitution effect". Thus, an increase in unemployment reduces household saving, through a reduction in income, while inflation diminishes actual resources. I find no evidence of any significant short-run impact of these variables on real gross saving. The significance of the short-run coefficients is affected by the introduction of the unemployment rate variable.

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<sup>14</sup>Consumption tax if it is linear, does not distort household's intertemporal decision. Wage and capital income taxes do influence household's intertemporal saving and consumption decisions.

<sup>15</sup>See, for example, Howard; Howrey and Hymens; and Mason and others for a detailed discussion on the ambiguous effects of these variables.)

<sup>16</sup>Note that the one-year expected rate of inflation is already part of the baseline specification.

#### *4.3.3. Domestic Credit to the Private Sector (as a percentage of GDP)*

The expected sign of financial development is ambiguous. On the one hand, financial development could raise saving through the development of deep and well regulated financial systems. On the other hand, financial investments are part of household wealth, and a more developed financial and capital markets boost household demand for instruments and lessen the need for precautionary saving, which could lower household saving. Column 3 of Table B.10 reports the result after the inclusion of the financial development variable. I find that, upon inclusion of a financial development measure, the income effect dominates the substitution effect in the short run, and vice versa in the long run. The short-run interest rate coefficient is now -0.53, highly significant and higher than previously estimated ones. The error correction coefficient is highly significant and negative, as expected. I also find that the financial development measure is a positive contributor to household saving in the long run. This indicates that financial development may be associated with more efficient capital markets or financial system leading to higher expected returns and an inducement of saving. The coefficient of the one-year expected inflation rate is significant in both periods, negative in the long run, but positive in the short run. Real housing prices is not statistically significant in both periods.

#### *4.3.4. General Government Debt (as a percentage of GDP)*

In the absence of a full Ricardian offset, government debt should have an impact on the level of interest rates, and should ordinarily drive households concern about the possibility of future higher taxes. The baseline specification is extended by general government gross debt as a share of GDP to capture Ricardian equivalence effects (REH). Column 4 of Table B.10 reports the estimation result. Income effect still dominates the substitution effect in the short run, and vice versa in the long run. The long- and short-run coefficients of interest rate are now 0.57 and -0.50, respectively, and are all highly significant. The error correction coefficient is now -0.47 and also highly significant. The general government debt variable is highly significant and negatively related to the household saving rate in the long run, but the short-run coefficient is negative and marginally significant. The coefficients of the one-year expected inflation rate and real housing prices are negative and highly significant in the long run, but not statistically significant in the short run.

Columns 5 of Table B.10 reports the results of a simultaneous introduction of two variables, namely, current taxes on income and wealth, and unemployment rate into the baseline specification. The income effect still dominates the substitution effect in the short-run, and vice versa in the long run. The error correction term is now -0.53 and is highly significant as expected. Current taxes on income and wealth strongly and negatively impact household saving in both periods. The one-year expected rate of inflation, real housing prices, unemployment rate and general government gross debt all significantly impact household saving in the long run but not in the short-run period.

Column 6 of Table B.10 reports the result of the simultaneous addition of three policy variables, namely, current taxes on income and wealth, unemployment rate and the general government debt into the baseline model. Again, the income effect rules over the substitution effect in the short run, and vice versa in the long run. The long- and short-run coefficients

are now 0.69 and -0.52, respectively. The error correction coefficient increased from the previous range (between -0.3 and -0.5) to -0.60, the highest so far. The long-run results of the one-year expected rate of inflation, real housing prices, unemployment rate and general government gross debt are as expected, except that the coefficient of the unemployment rate is now positive. Just like the previously obtained short-run results presented in column 5, only the coefficients of current taxes on income and wealth, and the interest rate remains significant.

[Table 10 about here.]

#### 4.4. Diagnostics

This section discusses some econometric test applied to individual country equations before proceeding to assess the robustness of the benchmark model. The test results for Godfrey's test of residual serial correlation, Ramsey's RESET test of functional form, Jarque-Bera's test of normality of regression residuals and Breusch-Pagan test for heteroskedasticity are reported in Table B.11. Two countries, Austria and France, suffer from serial correlation. Austria also shows evidence of misspecification of the functional form. Austria and Sweden show evidence of non-normal errors. There is also evidence of heteroskedasticity in 12 out of the 19 countries. Heterogeneous panels, in general, tend to show some signs of heteroskedasticity in the errors. Because the analysis is conducted on panel data, the overall fit is good for the country-specific regressions.

[Table 11 about here.]

For a graphical representation of the model fit for individual countries, see graphs (a) to (d) of Figures B.2, B.3, and B.4. The graphs shows the actual household saving rate with the fitted values generated by the full model as well as the fitted values based on the long-run equation. The graphs show that the PMG model describes the saving rate very well for almost all the countries in this study, except for Luxembourg.

[Figure 2 about here.]

[Figure 3 about here.]

[Figure 4 about here.]

The equation for each country was estimated, allowing the lag order to be chosen by the Akaike Information Criterion (AIC) in each country, with a maximum common lag of 1.<sup>17</sup> The long-run estimated coefficients for each country are reported in Table B. 12.

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<sup>17</sup>AIC is more reliable than a fixed lag, thus, ARDL (1,1,1,1) since  $T$  is small in this study. Moreover, estimations with a common ARDL (1,1,1,1) showed more evidence of misspecification than when the lag was chosen by AIC.



The results indicate that ARDL (1,1,00) was chosen for 6 countries , ARDL (1,1,0,1) for 4 countries, ARDL (1,0,0,0) for 4 countries, ARDL (1,0,0,1) for 2 countries, ARDL (1,1,1,1) for 1 country, ARDL (1,0,1,0) for one country, and ARDL (1,1,1,0) for 1 country. The estimated  $\phi_i$  is less than -0.2 in all countries. Austria and Luxembourg have the fastest adjustment, whereas Portugal, United Kingdom and Finland have the slowest adjustment. These country-specific long-run slope coefficients differ considerably in terms of the sign, magnitude and statistical significance. Due to the paucity of time-series observations for each country, these country-specific long-run estimates are not that informative and should be interpreted with caution. However, meaningful conclusions can be drawn from the error correction terms, which ranges from -0.3 to -1, are significant.

[Table 12 about here.]

## 5. Conclusion

Recent years trends in household saving rates seem dramatic, especially when one considers the adoption of near-zero, zero and negative interest-rate policies by some central banks. This has left policy-makers and some economists in doubt regarding the effectiveness of such policy approaches. The question of to what extent do households change their saving or consumption in response to a change in the interest rate has often been the central topic of policy debates. This paper test the hypothesis of which of the short-term nominal interest rate effects, namely, income (negative) or substitution (positive), is likely to dominate in the short run, long run, or both periods. For this reason, I applied the Pooled Mean Group estimator (PMG) to a dynamic heterogeneous panel data model in order to test this hypothesis. From the baseline estimations, I find that the income effect outweighs the substitution effect in the short run, and vice versa in the long run. Several model specifications, primarily through the inclusion of other determinants of household saving as explanatory variables, and through the alternative definition of the dependent variable generally did not alter the result. Country-specific short-term estimates affirmed this finding.

I also find that inflation (both expected and actual), household wealth through real housing prices, current taxes on income and wealth, unemployment rate and general government gross debt all have a significant negative impact on household saving in the long run. The results also suggest that financial development proxied with domestic credit to the private sector have a positive impact on household saving in the long-run period. I find that current taxes on income and wealth have a significant negative effect on household saving in the short-run. However, I do not find evidence of any significant impact of real housing prices, unemployment rate, financial development and general government debt on household saving in the short-run period.

We could draw some few lessons from these findings. First, the results lessen the burden of monetary policy-makers considering moving rates into zero or negative territories since these results provide evidence that there is a significant link between the short-term nominal interest rate and household saving rate in both the short run and the long run. Second, the

evidence that the income effect prevails over the substitution effect in the short run seems to suggest that a large proportion of households are liquidity constrained.

The sign and magnitude of interest rate effect on saving in the short and long run depend on the offsetting influences of the substitution and income effects. The strength of this effect depends on both the elasticity of inter-temporal substitution and the proportion of households who face liquidity constraint. Consider a fall in interest rate, for example, which lowers the cost of current consumption relative to future consumption, thereby providing an incentive to increase consumption and lower saving (substitution effect). The fall in interest rate also means that household's future labour income is worth more in the present time, hence, should lead to lower household saving (human wealth effect, which is also a particular type of income effect). In such a case, if the household is a net creditor, then it now receives less interest income for the same amount of saving, which makes it consume less in the present as well as in all future periods, thereby raising current saving. From this analysis, one would expect that the relationship between saving and interest rate should be negative.

If the household is a net debtor ( young households, in particular, are expected to be substantial net debtors for many years), then the lower interest rate should result in a low saving. Moreover, it is often argued that low interest rate environment, like in recent times, generates a feeling of uncertainty of future economic (monetary or financial ) conditions which tends to encourage people to engage in precautionary saving. In such cases, we will expect a positive relationship between the interest rate and saving unless households are liquidity constrained in some form. The long-run results from this study support these propositions. However, the short-run estimates indicate that the income effect dominates the substitution effect in the short run. This seems to suggest that a significant proportion of households face liquidity constraint in the short-run period.

Therefore, from a policy standpoint, this finding is crucial as any policy geared towards influencing the real side of the economy might not generate the desired outcomes that it seeks if a significant portion of households are liquidity constrained. Even for the best-case scenario of assuming perfect capital markets, households could still face other forms of liquidity constraint that results from institutional frameworks that theoretical models may fail to capture. Empirical studies have neglected short-run effects and focused on long-run estimations and conclusions. This study highlights the point that short-run income effects are not of low order of importance and should be taken into consideration in policy discussions.

## **Appendix A. Sample Country Lists and ID's**

Austria (AUT)

Belgium (BEL)

Denmark (DEN)

Finland (FIN)

France (FRA)

Germany (GER)

Greece (GRE)

Ireland (IRE)

Italy (ITA)

Japan (JAP)

Luxembourg (LUX)

Netherlands (NED)

Norway (NOR)

Portugal (POR)

Spain (ESP)

Sweden (SWE)

Switzerland (SWI)

United Kingdom (GBR)

United States (USA)

## Appendix B. Data Descriptions and Sources

**Real Gross Saving Rate (in percent of gross disposable income) -  $s_{it}^{rg}$**  : Saving of households and non-profit institutions serving households (NPISH) without deducting consumption of fixed capital and deflated by the price deflator private final consumption expenditure. Source: AMECO database.

**Real Net Saving Rate (in percent of gross disposable income) -  $s_{it}^{rn}$**  : Saving of households and non-profit institutions serving households (NPISH) after deducting consumption of fixed capital and deflated by the private final consumption expenditure. Source: AMECO database.

**Short-term Nominal Interest Rate -  $i_{it}^{sn}$**  : Mainly policy interest rates or 3-months money market rates. Source: AMECO database.

**Long-term Nominal Interest Rate -  $i_{it}^{ln}$**  : Mainly Central Government bonds of over 10 years. Source: AMECO database.

**Long-term Real Interest Rate -  $i_{it}^{lr}$**  : Long-term nominal interest rate (iln) adjusted for price deflator private final consumption expenditure. Source: AMECO database.

**Unemployment Rate -  $u_{it}$**  : Share of the total active population (labour force). Source: AMECO database.

**Current Taxes on Income and Wealth -  $t_{it}$**  : Comprise taxes on income from employment, property, entrepreneurship, pensions, etc., including taxes deducted by employers (PAYE taxes) and other current taxes on capital, poll taxes, levied per adult or per household, independently of income or wealth, expenditure taxes, payable on the total expenditures of persons or households. Source: AMECO database.

**General Government Gross Debt-  $gd_{it}$**  : General government net financial liabilities as percent of GDP. Source: AMECO database. Given the lack of general public debt data for some countries such as Switzerland, central government debt data is used as an alternative.

**Domestic credit to private sector (as a percentage of GDP -  $dcr_{it}$ )** : Financial resources provided to the private sector by financial corporations, such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable, that establish a claim for repayment. Source: IMF, IFS, and World Bank and OECD GDP estimates.

**Real Housing Price Index -  $hpr_{it}$**  : Nominal house price indices deflated by the consumer price index. Source: OECD Analytical database.

**Expected Inflation -  $\pi_{it}^e$**  : Computed (on the assumption of adaptive expectations of price expectations) from the annual rate of change ( $\Delta pcdef$ ) of the price deflator private final consumption expenditure (pcdef) in per cent per annum with adjustment weights ( $\lambda$ ) varying from 0.1 to 1. Series with the best prediction of dpcd was used as expected rate of inflation:

$$\pi_{it}^e = \lambda \Delta pcdef_{it} + (1 - \lambda) \pi_{it-1}^e \quad (\text{B.1})$$

**Rate of Inflation -  $\pi_{it}$**  : Computed as annual rate of change of the price deflator private final consumption expenditure (pcd) in percent per annum:

$$\pi_{it} = 100.0 * ((pcd_{it} / pcd_{it-1}) - 1)$$

Similar results could be obtained with:

$$\pi_{it} = 100.0 * (\log(pcd_{it}) - \log(pcd_{it-1}))$$

Source: Author's computation.

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Table (B.1) Some Central Banks with Negative Interest Rate Policy

Central Bank	Date of Policy Adoption
1. Danmarks Nationalbank	July 2012
2. European Central Bank (ECB)	June 2014
3. Swiss National Bank (SNB)	January 2015
4. Sveriges Riksbank (Swedish)	February 2015
5. Bank of Japan	January 2016
6. National Bank of Hungary (NBH) <sup>a</sup>	March 2016

Notes:

a) NBH introduced negative rate on overnight deposits.



Table (B.2) Summary of Some Panel Studies on Saving Behaviour

Study	Data Type	Real Interest rate	Inflation	Unemployment	Taxes	Credit to GDP	Wealth	Government Debt
1. Corsetti et al (1992)	HS	NS	NEG	-	-	-	NEG	-
2. Edwards (1996)	PS	NS	NS	-	-	POS	NEG	NS
3. Callenn and Thimann (1997)	HSD	POS	POS	NEG	NEG	NEG	-	-
4. Masson et al. (1998)	PSD	POS	POS	-	-	-	POS	-
5. Haque et al. (1999)	PSD	N.S	N.S	-	-	-	N.S	-
6. Bandiera et al. (2000)	PSD	POS	POS	-	-	-	-	-
7. Loayza et al. (2000)	PSD	NEG	POS	-	-	NEG	-	-
8. De Serres and Pelgrin(2003)	PSD	NEG	N.S	-	-	-	-	-
9. De Mello et al. (2004)	PSD	NEG	N.S	-	-	-	NEG	NEG
10. Horioka and Wan (2007)	HSD	POS	POS	-	-	-	-	-
11. Ferrucci and Miralles (2007)	PSD	POS	-	-	NEG	-	-	-
12. Salotti (2010)	HSD	-	-	-	-	-	NEG	-
13. Nabar (2011)	HSD	NEG	POS	-	-	-	NEG	-
14. Mody et al. (2012)	HSD	POS	-	POS	-	NEG	NEG	-
15. Aizenman et al. (2019)	PSD	POS	-	-	-	NEG	-	-

Notes:

a) HSD = Household Saving Data, PSD = Private Saving Data and the sign of the estimated coefficients are given by: POS = Positive, NEG = Negative, N.S = Non-Significance.

b) Explanatory variables differs across studies; hence, the variables used for the table have been generally categorized to provide some useful insights.

Table (B.3) Descriptive Statistics

Variable	Mean	Maximum	Minimum	Standard Deviation
$s^{rg}$	12.23	32.23	-11.96	6.18
$s^{rn}$	6.11	27.49	-18.26	6.67
$i^{sn}$	3.07	27.59	-0.50	3.48
$i^{ln}$	4.24	22.50	-0.05	2.58
$u$	7.59	27.50	1.90	4.32
$t$	10.41	29.99	3.88	4.73
$gd$	70.55	236.71	6.94	41.93
$dcr$	112.09	312.02	12.89	46.90
$hp^r$	94.77	175.15	32.38	25.40
$\pi^e$	1.87	20.47	-26.86	4.33
$\pi$	1.75	20.82	-30.31	4.71

Note:

See appendix B for a description and sources of the variables.

Table (B.4) Rankings of Household Saving Rates (Averages)

Country	1995-2018
1. SWIS	21.3
2. LUX	19.3
3. GER	17.1
4. BEL	16.5
5. AUT	15.9
6. ITA	15.4
7. FRA	14.9
8. NED	13.7
9. JAP	12.5
10. SWE	12.5
11. NOR	12.2
12. ESP	11.5
13. USA	11.2
14. POR	10.1
15. FIN	8.9
16. IRE	8.8
17. UK	8.3
18. DEN	7.2
19. GRE	5.1
EU	11.3

Note:

The horizontal lines in the middle of the table split the table into categories of countries with average household real gross saving rates (in percent of real gross disposable) above and below European Union (EU) average for the full sample period 1995-2018.

Table (B.5) Unit Root Test

Variable	Test	Constant		Constant and Linear trend	
		Level	1st Difference	Level	1st Difference
$s^{rg}$	Levin, Lin and Chu (2002)	-3.331***	-9.238***	-2.910**	-6.988***
	Im, Pesaran, Shin (2003)	-1.910*	-10.390***	-3.276***	-7.664***
$s^{rn}$	Levin, Lin and Chu (2002)	-2.723**	-7.831***	-1.931*	-5.315***
	Im, Pesaran, Shin (2003)	-1.298	-9.504***	-2.819**	-6.667***
$i^{sn}$	Levin, Lin and Chu (2002)	-3.584***	-13.791***	-5.069***	-11.992***
	Im, Pesaran, Shin (2003)	-1.112	-9.598***	-5.746***	-12.218***
$i^{ln}$	Levin, Lin and Chu (2002)	-2.726**	-8.649***	-2.680**	-6.814**
	Im, Pesaran, Shin (2003)	-0.743	-9.213***	-4.685***	-5.934***
$u$	Levin, Lin and Chu (2002)	-4.158***	-6.885***	-2.891***	-5.108***
	Im, Pesaran, Shin (2003)	-4.652***	-6.786***	-3.928***	-3.752***
$t$	Levin, Lin and Chu (2002)	-1.830*	-8.896***	-2.059*	-7.238***
	Im, Pesaran, Shin (2003)	-1.957*	-8.662***	-1.534	-6.641***
$gd$	Levin, Lin and Chu (2002)	-2.499**	-3.860***	-3.004**	-1.440
	Im, Pesaran, Shin (2003)	0.063	-4.144***	-0.707**	-1.211**
$dcr$	Levin, Lin and Chu (2002)	-5.002***	-4.446***	-2.387**	-4.446***
	Im, Pesaran, Shin (2003)	-1.469	-4.243***	1.813	-4.243***
$hpr$	Levin, Lin and Chu (2002)	-4.196***	-4.053***	-3.843***	-2.976**
	Im, Pesaran, Shin (2003)	-1.080	-3.639***	-0.911	-2.416**
$\pi^e$	Levin, Lin and Chu (2002)	-13.639***	-21.649***	-13.907***	-17.461***
	Im, Pesaran, Shin (2003)	-11.983***	-20.448***	-12.030***	-16.917***
$\pi$	Levin, Lin and Chu (2002)	-7.746***	-11.484***	-4.860***	-7.662***
	Im, Pesaran, Shin (2003)	-9.725***	-18.285***	-8.054***	-15.301***

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01 denote rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% significance level.

Table (B.6) PMG Estimation Result 1: Use of Short-term Nominal Interest Rate ( $i^{sn}$ ) and Expected Inflation Rate ( $\pi^e$ )

	<i>Dependent variable:</i>					
		$s^{rg}$			$s^{rn}$	
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Error-correction (coefficient):</b>						
$\phi_i$	−0.313*** (0.043)	−0.340*** (0.048)	−0.360*** (0.053)	−0.306*** (0.044)	−0.309*** (0.044)	−0.343*** (0.058)
<b>Long-run effect (coefficients):</b>						
$i^{sn}$	0.387*** (0.043)	0.427*** (0.070)	0.346*** (0.054)	0.468*** (0.087)	0.483*** (0.084)	0.388*** (0.071)
$\pi^e$		−0.285*** (0.064)	−0.224*** (0.056)		−0.231** (0.077)	−0.190** (0.073)
$hpr$			−0.013* (0.006)			−0.008 (0.008)
<b>Short-run effect (coefficients):</b>						
$\Delta i^{sn}$	−0.263* (0.119)	−0.326** (0.122)	−0.329** (0.107)	−0.324** (0.111)	−0.364** (0.130)	−0.364** (0.111)
$\Delta \pi^e$		0.053 (0.033)	0.063* (0.032)		0.069 (0.046)	0.101* (0.045)
$\Delta hpr$			−0.004 (0.021)			0.020 (0.042)
Observations	435	435	406	427	427	398

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Although the constant term was estimated, it is omitted from presentation. Standard errors in parentheses.

Table (B.7) Country Specific Short-run Estimation Results

Country	$\phi$	$i^{sn}$	$\pi^e$	$hpr$
Austria	-0.102** (0.016)	0.019 (0.056)	0.035 (0.091)	-0.044* (0.012)
Belgium	-0.088*** (0.004)	-0.262* (0.047)	0.165** (0.018)	0.031 (0.013)
Denmark	-0.420** (0.033)	-0.527 (0.334)	0.526 (0.258)	0.011 (0.006)
Finland	-0.512*** (0.016)	-0.579** (0.052)	-0.068* (0.017)	0.070** (0.008)
France	-0.558*** (0.041)	-0.343** (0.029)	0.028 (0.011)	0.027*** (0.001)
Germany	-0.586*** (0.020)	-0.121*** (0.004)	0.028*** (0.002)	0.045*** (0.000)
Greece	-0.103** (0.007)	-0.168 (0.105)	0.095 (0.044)	0.075*** (0.003)
Ireland	-0.652*** (0.041)	-1.092** (0.171)	0.153** (0.020)	-0.044*** (0.001)
Italy	-0.233*** (0.009)	-0.155* (0.047)	0.043*** (0.003)	0.093*** (0.002)
Japan	-0.160*** (0.007)	-0.304 (2.157)	0.002 (0.001)	-0.007** (0.012)
Luxembourg	-0.674** (0.081)	-0.514** (0.078)	-0.086 (0.049)	-0.202 (0.023)
Netherlands	-0.279*** (0.007)	-0.673** (0.059)	-0.034 (0.018)	-0.061*** (0.002)
Norway	-0.769*** (0.059)	-0.447 (0.206)	-0.006 (0.011)	-0.237* (0.049)
Portugal	-0.154*** (0.003)	-0.761*** (0.038)	-0.021 (0.019)	0.010** (0.001)
Spain	-0.326*** (0.010)	-1.011** (0.114)	0.218** (0.034)	-0.003 (0.001)
Sweden	0.003 (0.006)	0.813** (0.088)	-0.047** (0.004)	-0.078** (0.0122)
Switzerland	-0.584** (0.050)	-0.265* (0.008)	0.112*** (0.006)	-0.090** (0.010)
United Kingdom	-0.389*** (0.006)	-0.745*** (0.050)	0.071*** (0.002)	-0.015** (0.002)
United States	-0.249*** (0.001)	-0.268** (0.036)	-0.014*** (0.001)	-0.070*** (0.002)

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Although the constant term was estimated, it is omitted from presentation. Standard errors in parentheses.

Table (B.8) PMG Estimation Results 2: Use of Short-term Nominal Interest Rate ( $i^{sr}$ ) and Actual Inflation Rate ( $\pi$ )

	<i>Dependent variable:</i>			
	$s^{rg}$		$s^{rn}$	
	(1)	(2)	(3)	(4)
<b>Error-correction (coefficient):</b>				
$\phi_i$	-0.302*** (0.050)	-0.449*** (0.050)	-0.288*** (0.039)	-0.450*** (0.058)
<b>Long-run effect (coefficients):</b>				
$i^{sn}$	0.338*** (0.074)	0.831*** (0.122)	0.456*** (0.093)	1.037*** (0.131)
$\pi$	-0.515*** (0.092)	-0.378*** (0.76)	-0.205* (0.092)	-0.200** (0.073)
$hpr$		-0.026** (0.006)		-0.037*** (0.010)
<b>Short-run effect (coefficients):</b>				
$\Delta i^{sn}$	-0.219* (0.100)	-0.459*** (0.098)	-0.292** (0.117)	-0.625** (0.135)
$\Delta \pi$	0.028 (0.048)	0.063* (0.032)	0.017 (0.047)	0.041 (0.087)
$\Delta hpr$		0.034 (0.023)		0.012 (0.030)
Observations	435	406	427	398

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Although the constant term was estimated, it is omitted from presentation. Standard errors in parentheses.

Table (B.9) PMG Estimation Result 3: Use of Long-term Nominal Interest Rate ( $i^{ln}$ ) and Expected Inflation Rate ( $\pi^e$ )

	<i>Dependent variable:</i>					
		$s^{rg}$			$s^{rn}$	
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Error-correction (coefficient):</b>						
$\phi_i$	−0.337*** (0.057)	−0.350*** (0.057)	−0.381*** (0.065)	−0.313*** (0.049)	−0.314*** (0.051)	−0.301*** (0.085)
<b>Long-run effect (coefficients):</b>						
$i^{ln}$	0.306*** (0.076)	0.336*** (0.065)	0.358*** (0.070)	0.468*** (0.087)	0.477*** (0.070)	0.614** (0.205)
$\pi^e$		−0.187*** (0.056)	−0.127*** (0.050)		−0.169* (0.071)	−0.058 (0.073)
$hpr$			−0.010 (0.009)			−0.007 (0.021)
<b>Short-run effect (coefficients):</b>						
$\Delta i^{ln}$	−0.164 (0.272)	−0.225 (0.275)	−0.295 (0.203)	−0.124 (0.111)	−0.172 (0.282)	−0.098 (0.203)
$\Delta \pi^e$		0.035 (0.038)	0.049 (0.037)		0.053 (0.055)	0.039 (0.053)
$\Delta hpr$			−0.010 (0.021)			−0.064 (0.025)
Observations	432	432	402	424	424	394

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Although the constant term was estimated, it is omitted from presentation. Standard errors in parentheses.



Table (B.10) PMG Estimation Result 4:Further Results

	<i>Dependent variable:</i>					
	<i>s<sup>rg</sup></i>					
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Error-correction (coefficient):</b>						
$\phi_i$	−0.275*** (0.055)	−0.340*** (0.055)	−0.343*** (0.077)	−0.466*** (0.064)	−0.533*** (0.057)	−0.603*** (0.099)
<b>Long-run effect (coefficients):</b>						
$i^{sn}$	0.825*** (0.096)	0.455*** (0.059)	0.764*** (0.064)	0.570*** (0.073)	0.845*** (0.093)	0.685*** (0.056)
$\pi^e$	−0.235*** (0.046)	−0.220*** (0.061)	−0.216*** (0.060)	−0.138*** (0.045)	−0.168*** (0.040)	−0.112** (0.037)
$hpr$	0.066*** (0.017)	−0.019** (0.006)	0.016 (0.011)	−0.126*** (0.011)	−0.066*** (0.010)	−0.107*** (0.009)
$t$	−0.963* (0.391)				−0.772*** (0.164)	−0.719*** (0.114)
$u$		−0.156** (0.059)			−0.203** (0.070)	0.222** (0.073)
$dcr$			0.045** (0.014)			
$gd$				−0.138*** (0.014)		−0.079*** (0.011)
<b>Short-run effect (coefficients):</b>						
$\Delta i^{sn}$	−0.299* (0.142)	−0.231 (0.118)	−0.528*** (0.154)	−0.499*** (0.107)	−0.361** (0.130)	−0.524** (0.185)
$\Delta \pi^e$	0.061 (0.024)	0.060 (0.032)	0.120** (0.036)	0.055 (0.088)	0.006 (0.032)	0.039 (0.039)
$\Delta hpr$	−0.029 (0.025)	0.009 (0.021)	0.034 (0.037)	0.022 (0.039)	0.030 (0.020)	0.084 (0.050)
$\Delta t$	−0.841** (0.303)				−0.766** (0.290)	−1.104** (0.403)
$\Delta u$		0.224 (0.139)			0.292 (0.171)	0.101 (0.201)
$\Delta dcr$			−0.037 (0.028)			
$\Delta gd$				0.071* (0.033)		0.043 (0.037)
Observations	406	406	329	396	406	396

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Although the constant term was estimated, it is omitted from the presentation. Standard errors in parentheses. I added not more than three policy variables at the same time to the benchmark model in order to ensure that there is a sufficient number of degrees of freedom and also to maintain the stability of the model.

Table (B.11) Country-Specific Diagnostic Test

Country	$\hat{\sigma}$	$\chi^2_{SC}$	$\chi^2_{FF}$	$\chi^2_{NO}$	$\chi^2_{HE}$	$\bar{R}^2$
Austria	0.761	8.608	5.279	0.674	5.478	0.953
Belgium	0.577	2.690	0.738	0.807	2.550	0.985
Denmark	2.410	2.542	0.898	0.414	2.861	0.369
Finland	0.953	0.004	0.263	0.842	2.687	0.828
France	0.680	5.305	3.362	0.317	9.956	0.763
Germany	0.223	0.014	0.916	0.436	5.593	0.953
Greece	2.192	1.881	0.927	0.498	7.601	0.926
Ireland	1.716	0.552	0.060	1.312	1.980	0.563
Italy	0.966	1.725	2.982	2.843	7.039	0.976
Japan	1.203	0.781	1.132	0.684	8.700	0.898
Luxembourg	0.961	0.093	0.930	0.166	9.909	0.264
Netherlands	1.005	1.324	0.399	2.793	4.276	0.853
Norway	2.635	0.440	0.786	0.774	2.740	0.308
Portugal	0.978	0.549	2.050	0.491	6.178	0.956
Spain	1.436	2.800	1.546	0.614	0.998	0.907
Sweden	1.501	2.076	1.782	5.784	1.428	0.891
Switzerland	0.948	2.252	2.243	1.591	6.403	0.706
United Kingdom	1.044	1.058	0.319	0.520	6.836	0.865
United States	0.837	0.793	0.509	0.040	7.763	0.795

Note:

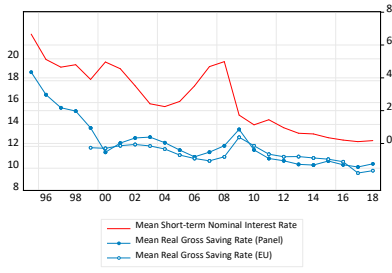
$\hat{\sigma}$  is the standard error of the country specific regression,  $\chi^2_{SC}$ ,  $\chi^2_{FF}$ ,  $\chi^2_{NO}$ , and  $\chi^2_{HE}$  are Chi-squared statistics for tests of residual serial correlation, functional form mis-specification, non-normal errors, and hetroskedasticity .  $\bar{R}^2$  is the adjusted multiple correlation coefficient.

Table (B.12) Country-Specific Long-run Estimates

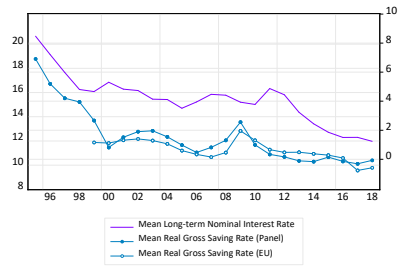
Country	$\phi_i$	AIC Lag Selection	$i^{sn}$	$\pi^e$	$hpr$
Austria	-1** (0.246)	1,1,0,1	0.865** (0.230)	-0.302 (0.350)	-0.131*** (0.028)
Belgium	-0.659*** (0.084)	1,1,0,0	1.586*** (0.206)	-0.170 (0.173)	-0.102*** (0.020)
Denmark	-0.759** (0.202)	1,0,0,0	-0.849 (0.414)	0.953 (0.789)	0.032 (0.045)
Finland	-0.376*** (0.060)	1,1,0,0	1.059 (0.581)	-1.499 (0.905)	-0.018 (0.064)
France	-0.509** (0.158)	1,1,0,0	0.441 (0.283)	0.104 (0.427)	-0.015 (0.021)
Germany	-0.625*** (0.154)	1,1,0,1	0.282** (0.070)	-0.159 (0.130)	-0.023* (0.010)
Greece	-0.422* (0.155 )	1,1,0,1	0.773 (0.496)	0.814 (0.968)	0.093 (0.067)
Ireland	-0.561*** (0.112)	1,1,0,1	-0.404 (0.467)	0.444 (0.513)	0.019 (0.033)
Italy	-0.471*** (0.074)	1,1,1,1	1.464*** (0.258)	-0.505 (0.306)	-0.016 (0.030)
Japan	-0.606*** (0.138)	1,0,1,0	5.498** (1.828)	-0.128 (0.065)	0.170*** (0.032)
Luxembourg	-1** (0.257)	1,0,0,0	-0.294 (0.220)	-0.197 (0.286)	-0.030 (0.034)
Netherlands	-0.891*** (0.184)	1,1,0,0	-0.394* (0.168)	-0.095 (0.208)	-0.100*** (0.018)
Norway	-0.948** (0.270)	1,0,0,1	-0.463 (0.450)	-0.060 (0.192)	-0.058 (0.047)
Portugal	-0.301** (0.078)	1,1,0,0	5.42 (0.619)	-0.253 (0.730)	0.142 (0.63)
Spain	-0.491*** (0.099)	1,1,0,0	0.913* (0.384)	0.634 (0.633)	-0.033 (0.026)
Sweden	-0.527*** (0.118)	1,0,0,0	1.117 (0.735)	0.002 (0.148)	0.244*** (0.060)
Switzerland	-0.698** (0.178)	1,0,0,0	1.107* (0.402)	-0.132 (0.106)	0.011 (0.056)
United Kingdom	-0.334*** (0.066)	1,1,1,0	0.453 (0.448)	-0.305 (0.147)	0.010 (0.067)
United States	-0.557*** (0.104)	1,0,0,1	-0.226 (0.156)	-0.099* (0.044)	-0.045 (0.031)

Note:

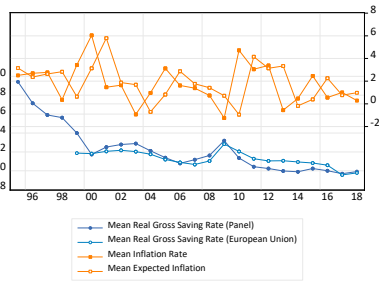
\*p<0.1; \*\*p<0.05; \*\*\*p<0.01. Although the constant term was estimated, it is omitted from the presentation. Standard errors in parentheses.



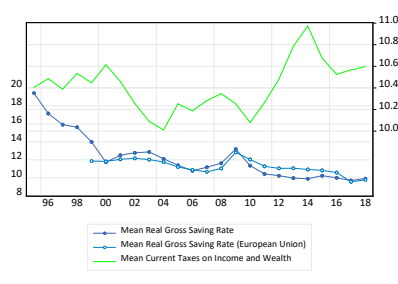
(a)



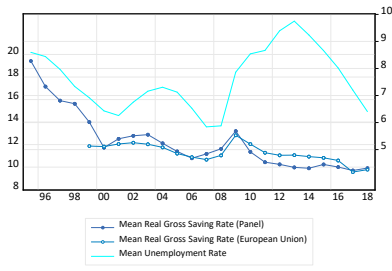
(b)



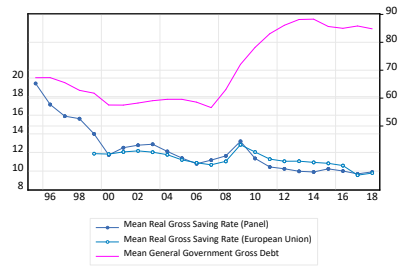
(c)



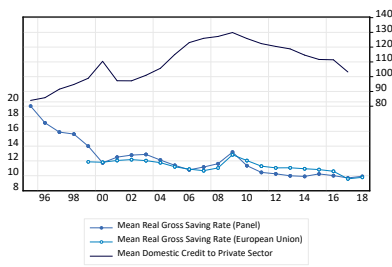
(d)



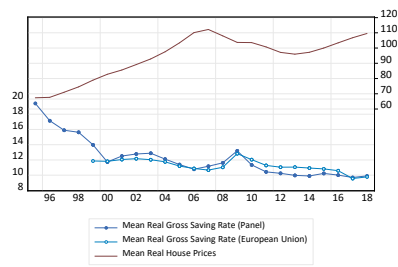
(e)



(f)

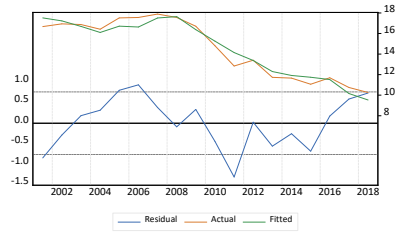


(g)

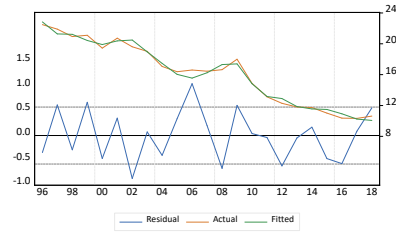


(h)

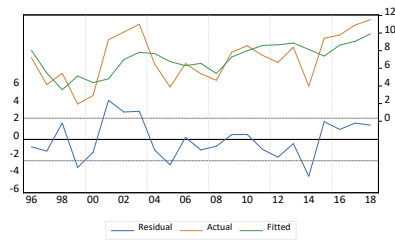
Figure (B.1) The time trends in mean of the variables (Panel): 1995-2018



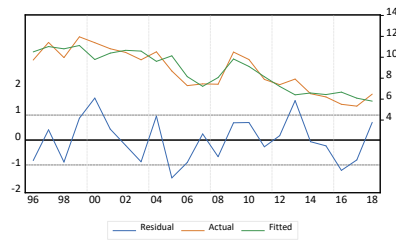
(a) PMG Model - Austria



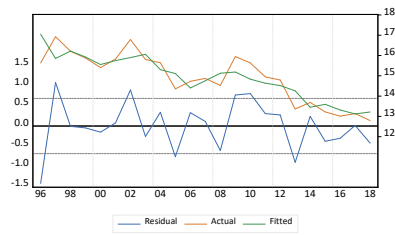
(b) PMG Model - Belgium



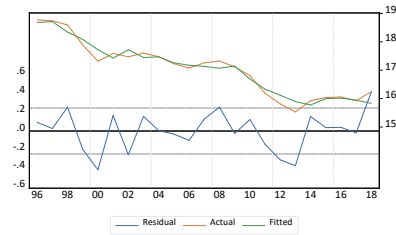
(c) PMG Model - Denmark



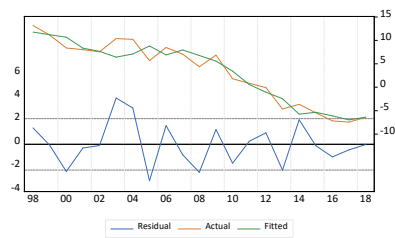
(d) PMG Model - Finland



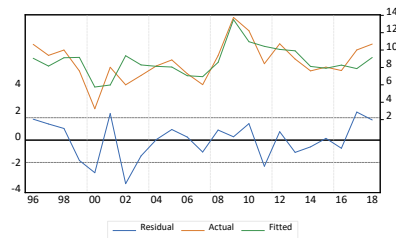
(e) PMG Model - France



(f) PMG Model - Germany

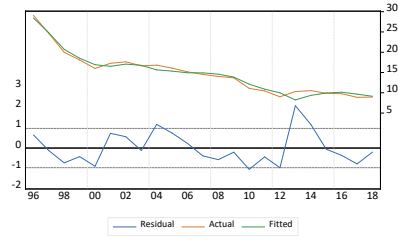


(g) PMG Model - Greece

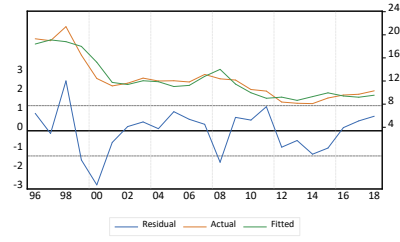


(h) PMG Model - Ireland

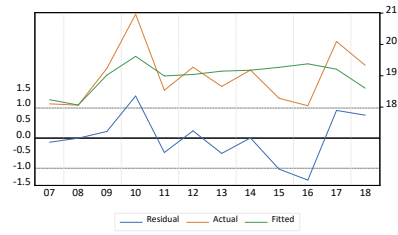
Figure (B.2) Country Specific Results, Actual vs Fitted Values, and Residual Plot



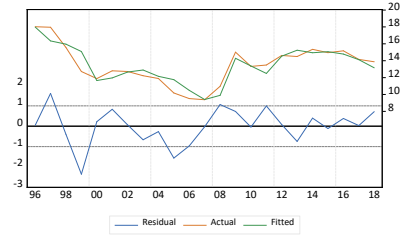
(a) PMG Model - Italy



(b) PMG Model - Japan



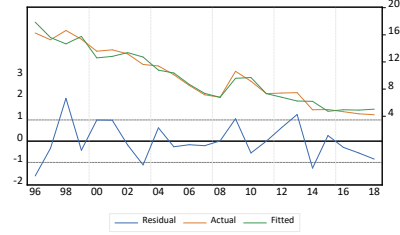
(c) PMG Model - Luxembourg



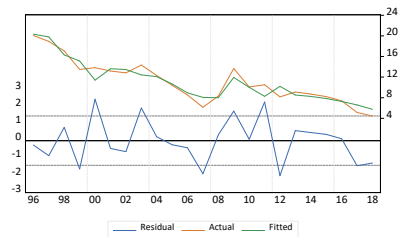
(d) PMG Model - Netherlands



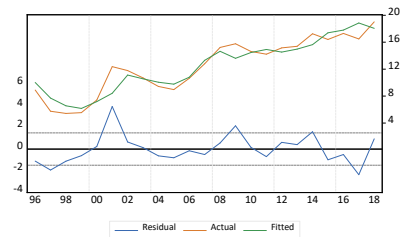
(e) PMG Model - Norway



(f) PMG Model - Portugal

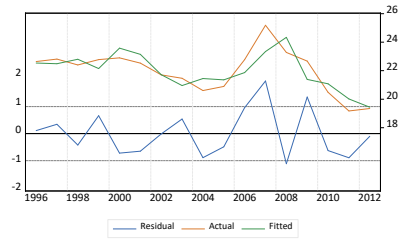


(g) PMG Model - Spain

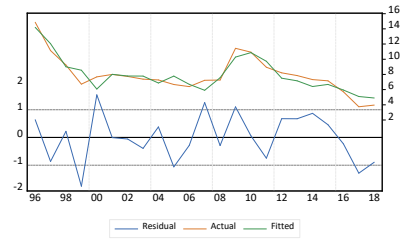


(h) PMG Model - Sweden

Figure (B.3) Country Specific Results, Actual vs Fitted Values, and Residual Plot (Continuation)



(a) PMG Model - Switzerland



(b) PMG Model - United Kingdom



(c) PMG Model - United States

Figure (B.4) Country Specific Results, Actual vs Fitted Values, and Residual Plot (Continuation)