Looking behind the facade of the Feldstein-Horioka puzzle *

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Abstract

The famous Feldstein and Horiokas finding is that despite perfect international capital mobility, domestic saving does not flow among countries to equalise yields but instead is tightly related to domestic investment. This paper critiques the limited use of theoretical foundations in existing empirical research, often confined to the saving-investment identity. We harness open economy models to demonstrate that the saving-retention coefficient informs about the relative importance of shocks with spending and foreign shocks reducing it and investment shocks increasing it. Using debt and current account surprises from IMF forecasts to proxy shocks, we empirically corroborate that the coefficient is significantly lower in IV regressions. Additionally, we find little evidence of higher investment-saving correlations in advanced economies compared to emerging markets and show this disparity vanishes completely when saving rate endogeneity is addressed. This study thus reframes the saving-retention coefficient as indicating the dominance of some shocks rather than capital mobility.

Keywords: Feldstein-Horioka puzzle; capital mobility; capital flows; open economy macroeconomics; saving and investment.

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1 Introduction

The tight relation between domestic saving and investment was famously documented more than forty years ago by Feldstein and Horioka (1980). After a careful examination of OECD countries, they observed that '[i]nternational differences in domestic savings rates among major industrial countries have corresponded to almost equal differences in domestic investment rates' (Feldstein and Horioka, 1980, p. 328). Estimates of the so-called saving-retention coefficient close to one were 'incompatible with the hypothesis of a perfectly mobile world capital stock' flowing among countries 'to equalise yields' (Feldstein and Horioka, 1980, p. 323). The literature terms their finding the Feldstein-Horioka puzzle (FH puzzle) because, in OECD countries which they focused on, 'arbitrage in similar risk-free assets comes very close to perfection' (Apergis and Tsoumas, 2009).

Three reasons motivate us to reconsider Feldstein and Horioka's puzzling finding. First, it has attracted considerable attention from international economists. Suffice it to notice that more than twenty years ago, Obstfeld and Rogoff (2000) considered the FH puzzle as one of the six major puzzles in international macroeconomics and, in another paper, termed it as the 'mother of all puzzles' (Obstfeld and Rogoff, 2001). In a recent study, Tavéra et al. (2015) examined 1,651 point estimates of the saving-retention coefficient reported in 49 papers published over three decades.

Second, there is a renewed research interest in improving our understanding of high investment-saving correlations in the most recent literature. For example, Horioka (2024) argues that the FH puzzle arises from the fallacy of composition and countries as a whole may not be able to transfer their capital abroad. Felipe et al. (2024) dismiss the puzzle, claiming that the Feldstein-Horioka-type regression is an incomplete identity, which makes the coefficient estimates biased. Yersh (2024) explores the investment-saving nexus employing panel data techniques to investigate capital mobility in Latin American countries. Martins (2024) uses an intertemporal choice framework to demonstrate that saving and investment can correlate when macro fundamentals deteriorate and illustrates this point for 12 European economies in the pre-Covid-19 period.

Third, despite the massive literature on the topic and numerous claims of the solution to the puzzle (for a literature review see, e.g., Apergis and Tsoumas, 2009), the link between empirical results and their theoretical foundations in the most recent literature rarely goes beyond the saving-investment identity. The dominance of the empirical approach coupled with advanced econometric techniques marks this line of research. Paraphrasing the title, looking behind the facade of the puzzle is limited to taking a glimpse of the theoretical framework rather than its full-fledged exploitation.

This paper provides a novel and fresh look at the FH puzzle. Our contribution to the literature is threefold. First, we demonstrate the critical importance of a theoretical framework in interpreting Feldstein-Horioka-type regressions. Our point is that rather than indicating the degree of capital mobility, the slope coefficient in the investment regression on saving informs about the source of shocks affecting the economy. In other words, contrary to its conventional interpretation, the saving-retention coefficient conveys information about the relative importance of shocks. To show this, we use both a textbook macroeconomic model and the fully microfounded open-economy RBC model. The former enables us to keep the argument as simple as possible, and the latter illustrates that our reasoning holds in a general framework. Recognising the significance of both financial frictions (see, e.g., Bai and Zhang, 2010) and the varied effects of specific shocks on saving-investment correlation (see, e.g., Chang and Smith, 2014), we utilise the RBC model with incomplete markets and multiple shocks, drawing on the framework proposed by García-Cicco et al. (2010).

Second, using simulations of the simple model and the calibrated version of the open-economy RBC model, we show that: (i) the mean saving-retention coefficients implied by both models are close to the estimates reported in the literature (see, e.g., Obstfeld and Rogoff, 2000; Tavéra et al., 2015), (ii) fiscal and foreign shocks shift the coefficient distribution towards zero, whereas (iii) investment (or productivity) shocks move the distribution rightwards.

Our third contribution is an empirical one. Since there is no ready-to-use panel data on macroeconomic shocks, we construct shock measures by employing information on forecasts published by the IMF in the World Economic Outlook databases. We use the forecast error-based approach to derive a general government debt shock and a current account shock, debt and foreign surprises for short, which are similar to measures of shocks adopted by, i.a., Furceri et al. (2022), Magud and Pienknagura (2022), and Brandao-Marques et al. (2023). Since debt and foreign surprises are unexpected disturbances, they can be considered sources of shocks to domestic and foreign savings, respectively. In a set of regressions for the large panel of 32 advanced and 50 emerging market economies, we demonstrate that (i) the conventional approach delivers the FH puzzle with the saving-retention coefficient ranging from 0.36 to 0.66, (ii) coefficient estimates are significantly lower or even negative, when changes in the saving rate are driven by debt or current account surprises, respectively, (iii) our argument holds for alternative measures of shocks, including government spending and investment shocks.

The paper is organised as follows. The next section relates our work to the existing literature on the FH puzzle. In Section 3, we develop our main argument using both a simple macroeconomic model and a more general theoretical framework. Then, in Section 4, we move on to the methodology, explaining our empirical strategy, in particular, the choice of the common correlated effect estimator and the construction of the external instruments. Section 5 first justifies empirically the use of the instrumental variable approach and then discusses the main empirical results and the robustness of our argument. Conclusions and thoughts on further research are offered in the final section.

2 Related literature

There are three dimensions of our thinking about the FH puzzle which relate it to the literature: conceptual, theoretical (analytical), and methodological. On the conceptual side, we go back to Obstfeld's (1986) point about the importance of the economic model when interpreting the Feldstein-Horioka type regression results. Obstfeld argues that it is 'hazardous' to make predictions based on FH regressions 'without knowledge of the economic model underlying the measured correlation' and warns that 'regression results, taken by themselves, are an insufficient basis for policy formulation' (Obstfeld, 1986, p. 71-72). To demonstrate this point, he builds a life-cycle model in which a population growth rate is a common factor driving both saving and investment rates. The resultant high correlation between them does not imply, however, that any shift in the saving rate, e.g., a policy-induced one, will be followed by a change in the investment rate. Obstfeld emphasises that his results should not be considered an explanation of the FH puzzle but taken as showing that explanations other than low international capital mobility are quite possible. Conceptually, our work is rooted in Obstfeld's point about the prominence of a theoretical model for valid interpretation of saving-investment correlations. In the following sections, we reiterate this argument within both simple and modern fully microfounded models and then support it with novel and robust empirical evidence.

The theoretical framework underlying our thinking about the FH puzzle draws on works of Feldstein (1983), Mendoza (1991), Schmitt-Grohé and Uribe (2003), García-Cicco et al. (2010), Bai and Zhang (2010), and Chang and Smith (2014). Recognising the problem of endogeneity of saving, Feldstein (1983) argues that it is not serious when estimates are based on cross-country data averaged over long spans of time. His argument has two parts. The first is a simple theoretical model explaining a relation between the estimated saving-retention coefficient and properties of exogenous components of saving and investment. The second is a set of assumptions that boil down to making shocks to saving the dominant source of shocks and then considering these assumptions as 'a reasonable approximation of cross-country data' (Feldstein, 1983, p. 144). Feldstein's line of reasoning is neat and elegant but seems to suffer from two problems. First, the conclusion, i.e. the interpretation of the β coefficient as a response of investment to changes in saving, is not proven but imposed in the assumptions. No evidence is offered to lend support to critical assumptions about the prevalence (and independence) of saving shocks. In this sense, the conclusion is self-mapping. The second problem is related to conceptual incoherence between the intended interpretation of the β coefficient and the emphasis on using cross-sectional averages over long periods. Such data are relevant to evaluating the saving-investment norms that are used to explain normal or equilibrium current account positions (see, e.g., Faruqee, 1998) rather than assessing international capital mobility. The latter is related to the ability of capital flows to cross borders in reaction to disturbances. What matters for the degree of mobility is the short-term response and not the average over five to ten years, which, given the stochastic nature of disturbances, is likely to be close to nil.[1] Moreover, since long-term investment and saving rates are likely to have some common determinants, e.g. relative fiscal, demographic, and stage-of-development factors, a single-equation regression of investment on saving is bound to be subjected to endogeneity bias. For these reasons we do not consider the main argument put forward by Feldstein (1983) as convincing but, at the same time, find his model-based approach worth following.

Mendoza (1991), Schmitt-Grohé and Uribe (2003), García-Cicco et al. (2010), and Bai and Zhang (2010) develop the dynamic stochastic models of an open economy, in which domestic physical capital and foreign financial assets are vehicles for saving and there exist some capital adjustment costs. Mendoza (1991) demonstrates that a high positive correlation between saving and investment under perfect capital mobility is driven by the strong persistence of productivity shocks.[2] Accordingly, he concludes that such a correlation furnishes no clear indication of the degree of capital mobility. Schmitt-Grohé and Uribe (2003) and García-Cicco et al. (2010) do not discuss the FH puzzle but provide important insights into the open-economy models. Schmitt-Grohé and Uribe (2003) explain how to close the open-economy model, making its steady-state independent of initial conditions (or, in other words, removing the random walk component from the equilibrium dynamics). They discuss alternative models inducing stationarity, including one in which a domestic interest rate is increasing in the country's foreign debt. García-Cicco et al. (2010) argue that the RBC models, even those with both permanent and transitory productivity shocks, poorly explain features of business cycles in emerging market economies. They introduce a simple form of financial friction to the baseline model and augment it with shocks to domestic absorption and country risk premium. The importance of financial frictions is also emphasized by Bai and Zhang (2010). They extend the model with incomplete markets, in which the spanning of assets is limited to a noncontingent bond, by introducing the limited enforcement friction that serves to endogenise the debt limits. Using a calibrated model with these two frictions, they demonstrate that the implied saving-investment correlation and the volume of capital flows are close to the data. Following this line of research, in the next section, we harness the RBC model with incomplete markets and multiple shocks to illustrate the contributions of specific shocks to shaping the saving-retention coefficient.

Chang and Smith (2014) observe that the FH puzzle has an additional dimension, i.e. saving-investment

[1] See, also, Krol (1996). Obstfeld (1995) argues that both long-run and short-run relationships are pertinent to capital mobility evaluation. Ford and Horioka (2017) emphasise that the FH puzzle is related to net transfers of capital between countries and claim frictions in global *goods* markets to be behind high saving-investment correlations. Moosa (1996) points out that different concepts and measurements of capital, for example, net vs gross, short-term vs long-term, contribute to the confusion in the literature on international capital mobility.

[2] His extended model features the disturbances to the world's real interest rate. They, however, have only minimal effects on the results.

correlations in emerging market economies tend to be significantly lower than in advanced economies (see also Coakley et al., 1998; Kasuga, 2004). To explain it, they develop a DSGE model with cross-correlations between domestic and global productivity shocks but without any real or financial frictions. In a series of experiments, they show that the saving-retention coefficient can be significantly positive in a model with domestic transitory and permanent shocks only and even higher in a model with a strong cross-correlation between domestic and global shocks. In light of their results, the explanation of both dimensions of the FH does not require the cross-correlations between domestic and global shocks. Since such an extension does not seem critical to explain the saving-investment correlation, we do not use it in our explanation.

On the methodological side, our study follows the strand of the empirical literature employing panel data approaches. It diverges from the cross-sectional regressions because of reasons aptly summarised, among others, by Ho (2002) and Krol (1996). First, in light of a country's intertemporal budget constraint, the long-term average difference between investment and saving must equal zero. This introduces the correlation between variables.[3] When averages are not taken over long enough periods, the cross-sectional coherence can be amplified by common shocks or global business and financial cycles, which make saving and investment move together. Second, the high correlation may be driven by the country size effect: the change in saving or investment in a large economy can affect the world interest rates, causing the co-movement of saving and investment. Third, period averaging over long periods may result in misspecification of the cross-sectional approach, consisting of estimating the identity. This point, albeit in a country-by-country regression framework, has recently been forcefully made by Felipe et al. (2024). They argue that the saving-retention coefficient in the Feldstein-Horioka-type regressions is a biased estimate of the coefficient entering the accounting identity, and the bias is due to the omission of foreign saving in the specification.

Panel data methodologies employing annual data rather than long-term averages mitigate these problems. Cross-country heterogeneity, e.g. stemming from the economy's size, and common factors like the global financial cycle can be captured by country and time fixed effects. We take advantage of these strengths of the panel data approach, noting that, unlike the cross-sectional regression on long-term averages, it does not turn the estimated regression into the identity. The reason is that country fixed effects cannot encompass the time-varying component of foreign saving. At the same time, we do not go as far as Felipe et al. (2024), who question the validity of regressing investment rate on saving rate, because we think that the regression does not have to be interpreted as a faulty or misspecified identity. Instead, we offer an alternative interpretation of the saving-retention coefficient linking the estimate to the composition and evolution of underlying economic shocks, as explained in the next section.

[3]For an early formulation of this point, see Roubini (1988) and Sinn (1992).

Designing our econometric methodology, we considered two additional issues, i.e. saving endogeneity and cross-sectional dependence. In the literature, it is uncontroversial that the saving rate is endogenous. In their seminal paper, Feldstein and Horioka not only discuss this possibility but also address the problem using social security and demographic variables as instruments and showing that the two-stage least squares estimates are in line with the baseline results (Feldstein and Horioka, 1980). Leaving aside the endogeneity issue in the cross-sectional framework (see, e.g. Dooley et al., 1987; Kasuga, 2004), one has little doubt that notwithstanding all the advantages of using the annual panel data, it is subject to the presence of simultaneity bias (Ho, 2002; Brueckner et al., 2020). Therefore, we adopt the instrumental variable approach and construct debt and current account surprises to measure exogenous and unanticipated shocks to domestic saving. In doing this, we draw on the point raised by Brueckner et al. (2020), who proxy unanticipated shocks with (the variation in) rainfall and employ it as an instrument in their investigation of the relationship between domestic saving and the current account in developing economies.

Building on this general point, we construct several measures of shocks, including debt surprises (Brandao-Marques et al., 2023; Furceri et al., 2022; Abiad et al., 2016), current account shocks, government spending shocks (Magud and Pienknagura, 2022), and investment shocks. It is worthwhile noting that some fiscal variables have already been employed in the Feldsten-Horioka-type regressions. For example, Tavéra et al. (2015, p. 94) observe that the β coefficient in cross-sectional analyses 'seems to be systematically underestimated with models including indicators of the public deficit' and Roubini (1988) shows that disregarding the role of budget deficits biases the estimates of capital mobility downwards in time-series regressions. Our approach, however, is different: we use panel data, and, more importantly, our fiscal variable, rather than being an additional explanatory variable, incorporates the unanticipated changes in public saving, which are employed to instrument the saving ratio.

In panel data setups in economics, some form of cross-sectional correlation of errors 'is likely to be the rule rather than the exception' Chudik and Pesaran (2015). The importance of this problem is recognised in the literature, albeit to a limited extent. There are a few studies employing the estimators accounting for cross-sectional dependence. Using common correlated effects mean group (CCEMG) and augmented mean group estimators, Pata (2018) shows that the long-term saving-retention coefficients in a panel of seven fast-growing countries are close to 0.8. Employing a similar approach and estimators, Eyuboglu and Uzar (2020) find mixed results for a panel of 'lucky seven' countries: saving-retention coefficients are high and significant in three countries but not for the whole panel. Several other studies also employ the CCEMG estimator for larger sets of countries. Murthy and Ketenci (2020) and Yersh (2024) examine Latin American and Caribbean countries using the dynamic CCEMG estimator and find that capital mobility is relatively high. Working on a set of 25 OECD member countries Holmes and Otero (2014) find that the saving-retention coefficient in the baseline specification is around 0.3, lending support to the greater, albeit not perfect, capital mobility than found in other studies. Bibi and Jalil (2016) extend the sample to a panel of 88 countries and augment the specification with interactive terms. They provide evidence supporting the FH puzzle.

These studies account for the endogeneity that arises from the common factors affecting both investment and saving rates (Holmes and Otero, 2014), but neglect the endogeneity stemming from country-specific shocks. Recognising that fact, our empirical strategy goes a step further and accommodates both sources of endogeneity by employing the instrumental variable approach.

The following two sections build on these insights from the literature, first inferring the interpretation of the saving-retention coefficient from a theoretical framework and then expounding our empirical strategy.

3 Saving-retention coefficient in a theoretical framework

This section discusses the critical importance of a theoretical framework in interpreting the results of regressing investment rate on saving rate. Our point is that the slope coefficient in the famous FH regression does not indicate the degree of capital mobility but rather informs about the source of shocks affecting the economy.

We demonstrate the validity of this point in four steps. First, using a textbook macroeconomic model augmented with stochastic components, we lay down the essence of our argument. Second, we add more structure to the model by endogenizing investment and then run a series of simple simulations showing how the distribution of the slope coefficient changes with the structure of shocks. Finally, to demonstrate that our argument holds in a general equilibrium setting, in the last two steps, we decompose the saving-retention coefficient into shock-specific coefficients and employ the full-fledged open economy RBC model to illustrate the decomposition.

3.1 The basic argument

The FH puzzle arose because when regressing investment on domestic saving, the slope coefficient β was found to be close to unity (Feldstein and Horioka, 1980). Using the definition of the OLS estimator, the estimate of β can be written as

$$\hat{\beta} = \frac{\text{cov}(I, S)}{\text{var}(S)} = 1 + \frac{\text{cov}(F, S)}{\text{var}(S)}, \tag{1}$$

where the second equality follows from the identity between investment, I, and domestic and foreign saving, S and F, respectively. In the seminal Feldstein and Horioka's paper, one reads that '[...] the value of β, implied by perfect world capital mobility would be zero' and 'estimates of β close to one would indicate that most of the incremental saving in each country has remained there' (Feldstein and Horioka, 1980, p. 318-319). That is why the β coefficient is interpreted as the 'saving-retention coefficient' (Horioka, 2024; Felipe et al., 2024).

We can rationalise the original interpretation of β using the textbook model with a set of shocks. For the sake of brevity, the details of this simple model and its solution are moved to Appendix A. Following equation (1), the model implies that the β estimate is

$$\hat{\beta} = \frac{(1+b)\text{var}(\epsilon^i)}{b^2\left[\text{var}(\epsilon^c) + \text{var}(\epsilon^g)\right] + \text{var}(\epsilon^i) + \text{var}(\epsilon^n)}, \tag{2}$$

where ϵ^j's for $j = \{c, n, i, g\}$ are shocks to consumption, net exports, investment, and government spending, whereas b proxies for the degree of openness of an economy. If an economy is closed with no foreign trade and capital flows, then $\hat{\beta}$ is indeed one. It is because there are no foreign shocks, i.e. $\text{var}(\epsilon^n) = 0$, and $b = 0$. In an open economy, both $\text{var}(\epsilon^n)$ and b are strictly positive, and capital can flow into and out of the domestic economy. The saving-retention coefficient can equal zero only when investment shocks are non-existent, i.e. $\text{var}(\epsilon^i) = 0$.[4] In this case, any change in domestic saving induced by consumption or government spending shocks is offset by the opposite adjustment in foreign saving. At the same time, disturbances in foreign saving (shocks to net exports) are compensated for by changes in domestic saving.

Let us look closer at these two cases. It is uncontroversial that the closed economy case implies the estimate of β equal to 1. Our point, however, is that the reasoning in the opposite direction is fallible. Using the same framework, one can show that unitary β can also be obtained in the open economy case. Suffice it to assume that consumption and government spending shocks are negligible, i.e. $\text{var}(\epsilon^c)$ and $\text{var}(\epsilon^g)$ are equal (or close) to 0, two other shocks have equal variances and $b = 1$. In such a setting, investment is still financed by both domestic and foreign savings, in a way characteristic of an open economy. Thus, the estimate of β close to 1 does not necessarily indicate that the economy is closed.

The second case is that of an open economy and perfect capital mobility. However, the link between openness and the value of β is not as straightforward as suggested by the conventional interpretation. As explained above, an open economy can have β equal to 0, but the requirement that investment shocks are negligible lies behind this result rather than openness. When this requirement is relaxed, the β coefficient can take positive values. Depending on the relative importance of the shocks, the estimate of β not only can range from 0 to 1, but it can also be greater than 1. The latter case can be observed when investment shocks dominate the other shocks, i.e. $\text{var}(\epsilon^c), \text{var}(\epsilon^g)$, and $\text{var}(\epsilon^n)$ are equal (or close) to 0. Then β

[4]More precisely, the coefficient estimate can also be indistinguishable from zero when the variance of one of the other shocks is much larger than that of investment shocks. What follows is relevant for this case as well.

(approximately) equals $1+b$ where b is strictly positive. Its conventional interpretation breaks down because instead of indicating saving-retention, β informs about the potential of investment to induce domestic and foreign savings: the greater the positive deviation of β from unity, the larger the share of investment financed with *foreign* saving, and the higher the capital mobility. It is at odds with the original interpretation that links capital mobility with small values of β.[5] It turns out that the case of the open economy and perfect capital mobility is consistent with the whole range of β values, not necessarily close to 0.

Let us reiterate our point. The textbook model demonstrates that the interpretation of the β coefficient in terms of retaining saving and (limited) international capital mobility is flawed. The valid interpretation is that the coefficient conveys information about the relative importance of shocks. When investment shocks are overshadowed by other shocks, β is close to 0, whereas the dominance of investment shocks results in values close to or even above 1. The relative importance of shocks on the one hand, and openness and capital mobility on the other hand, are different things.

3.2 Simulated distribution of the saving-retention coefficient

Our argument so far can beg two important questions or doubts. First, investment and saving enter the textbook model differently: the former is an exogenous process, whereas the latter, both domestic and foreign, is endogenous. Consequently, saving is driven by all shocks, while investment is isolated from any impact other than investment shocks. Therefore, the doubt could be whether the interpretation of β we offer will remain similar after endogenising investment.

Second, in their seminal paper, Feldstein and Horioka investigated the relationship between saving and investment *rates*, expressed as percentages of nominal GDP rather than *levels*. Other researchers examining the FH puzzle followed the same approach. Investment and saving rates are driven by all shocks, so the question may arise whether the source of shock actually matters for the value of β.

In order to make our point more general, we first extend the textbook model and then run a set of simulations that demonstrate the robustness of our argument. The extensions are twofold. First, following one of Paul Samuelson's celebrated papers, in which he investigated the acceleration principle, arguing that the national income should include induced investment 'proportional to the time increase in consumption' (Samuelson, 1939), we make investment dependent on the lagged change in consumption. Second, in line with Sims (2012), we model government spending as an autoregressive process. The details of both extensions are discussed in Appendix A.

Next, we use the extended model to run a series of simulations or Monte Carlo experiments. The objective

[5] This inconsistency is signalled by Obstfeld (1986, footnote 13).

is to obtain the distribution of the estimate of β. The technical details of these simulations are moved to Appendix A. Figure 1 depicts the distribution of β estimate in five cases. In the baseline case, illustrated with the blue histogram, all shocks are equally important. The mean of β estimate equal to 0.452 is below the saving-retention coefficient reported in the seminal paper on the FH puzzle (0.887) but close to estimates reported in more recent literature (for example, 0.46 in Bai and Zhang, 2010). It is in line with the observation that the coefficient has fallen over time (see, e.g., Obstfeld and Rogoff, 2000). Nevertheless, the distribution is above zero, so one could be tempted to repeat after Feldstein and Horioka (1980, p. 321) that our baseline result 'contradicts the hypothesis of perfect world capital mobility' because a disproportionately large part of 'incremental saving tends to remain in the country in which the saving is done'.

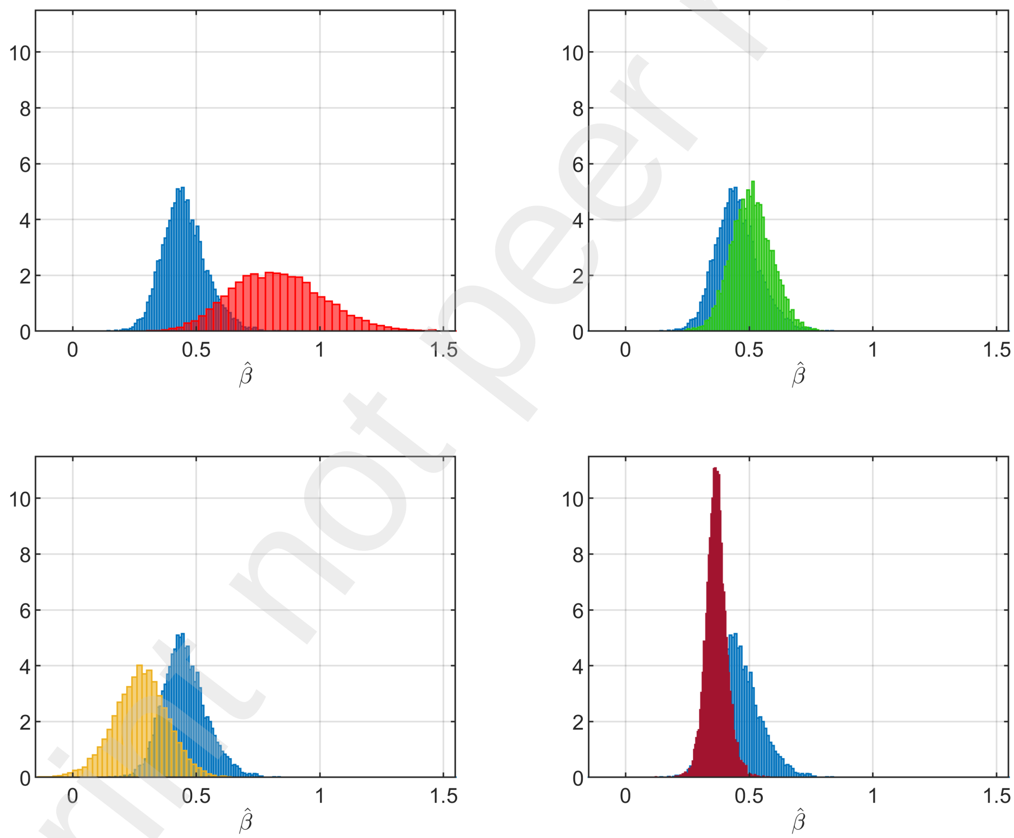

Figure 1: Distribution of $\hat{\beta}$ in the regression of investment rate on (domestic) saving rate under alternative scenarios

Notes: The histogram in blue: all shocks have unitary variances. The histogram in red: shocks other than investment shocks are relatively less important, with variances equal to 0.16. The histogram in green: shocks other than consumption shocks are relatively less important, with variances equal to 0.16. The histogram in orange: shocks other than net exports shocks are relatively less important, with variances equal to 0.16. The histogram in brown: shocks other than government spending shocks are relatively less important, with variances equal to 0.16.

To illustrate the importance of shocks, we consider four cases in which one shock dominates the others. Thus, the histogram in red shows the distribution of the β coefficient when investment shocks prevail over the other shocks (whose variances are reduced from one to 0.16). In this case, the distribution shifts to the right in line with the simple macroeconomic model discussed above, and it is more likely to obtain a large estimate of β, including values greater than one.

The other histograms illustrate cases in which consumption, net exports, and government spending shocks, respectively, overshadow the other shocks. The dominance of consumption shocks (histogram in green) does not change the distribution much. When foreign shocks prevail (histogram in orange), the estimates of β are more likely to be small, sometimes even negative. Government spending shocks (histogram in brown) also shift the distribution leftward, albeit to a smaller extent, and make it more leptokurtic.

Despite corroborating the intuition arising from the macroeconomic model with simulation results, one may remain sceptical about the relevance of our argument in a more general framework. Thus, in the following two subsections, we turn to a microfounded setting.

3.3 Deriving the saving-retention coefficient in a general framework

Let us consider the following structural, dynamic model for investment and saving

$$I_t = \psi_I + \boldsymbol{\Psi}_I \boldsymbol{X}_t \tag{3}$$

$$S_t = \psi_S + \boldsymbol{\Psi}_S \boldsymbol{X}_t, \tag{4}$$

where $\boldsymbol{X}_t$ represents a vector of state variables of a model

$$\boldsymbol{X}_t = \boldsymbol{\Phi} \boldsymbol{X}_{t-1} + \boldsymbol{\Phi}_{\boldsymbol{\epsilon}} \boldsymbol{\epsilon}_t, \tag{5}$$

with n mutually independent shocks

$$\boldsymbol{\epsilon}_t = \begin{bmatrix} \epsilon_{1,t} & \dots & \epsilon_{n,t} \end{bmatrix}', \quad \mathrm{E}(\boldsymbol{\epsilon}_t) = \mathbf{0}, \quad \mathrm{E}(\boldsymbol{\epsilon}_t \boldsymbol{\epsilon}_t') \equiv \boldsymbol{\Omega} = \mathrm{diag}\left(\begin{bmatrix} \sigma_1^2 & \dots & \sigma_n^2 \end{bmatrix}\right). \tag{6}$$

The specification (3)-(6) encompasses linearized versions of DSGE models with independent shocks and SVAR models.

Then, the saving-retention coefficient can be expressed as

$$\beta = \frac{\mathrm{cov}(S_t, I_t)}{\mathrm{var}(S_t)} = \frac{\mathrm{E}[(S_t - \bar{S})(I_t - \bar{I})]}{\mathrm{E}(S_t - \bar{S})^2} = \frac{\mathrm{E}[(\boldsymbol{\Psi}_S \boldsymbol{X}_t)(\boldsymbol{\Psi}_I \boldsymbol{X}_t)']}{\mathrm{E}([\boldsymbol{\Psi}_S \boldsymbol{X}_t)(\boldsymbol{\Psi}_S \boldsymbol{X}_t)']} = \frac{\boldsymbol{\Psi}_S \mathrm{E}(\boldsymbol{X}_t \boldsymbol{X}_t') \boldsymbol{\Psi}_I'}{\boldsymbol{\Psi}_S \mathrm{E}(\boldsymbol{X}_t \boldsymbol{X}_t') \boldsymbol{\Psi}_S'} = \frac{\boldsymbol{\Psi}_S \boldsymbol{\Gamma}_0 \boldsymbol{\Psi}_I'}{\boldsymbol{\Psi}_S \boldsymbol{\Gamma}_0 \boldsymbol{\Psi}_S'}, \tag{7}$$

where $\mathbf{\Gamma}_0 = \mathrm{E}(\boldsymbol{X}_t \boldsymbol{X}_t')$ is the covariance matrix of the state variables that is given by the Lyapunov equation (see Fernández-Villaverde et al. 2016, p. 635, or Lütkepohl 2005, p. 27)

$$\mathbf{\Gamma}_0 = \mathbf{\Phi}\mathbf{\Gamma}_0\mathbf{\Phi}' + \mathbf{\Phi}_\epsilon \mathbf{\Omega} \mathbf{\Phi}_\epsilon'. \tag{8}$$

The covariance matrix of shocks $\mathbf{\Omega}$ can be decomposed into shock-specific components, i.e. $\mathbf{\Omega} = \sum_{j=1}^n \sigma_j^2 \boldsymbol{I}_j$, where $\boldsymbol{I}_j$ is a zero square matrix with j-th diagonal element equal to one (so $\sum_{j=1}^n \boldsymbol{I}_j = \boldsymbol{I}$). Therefore, the same holds for $\mathbf{\Gamma}_0$:

$$\mathbf{\Gamma}_0 = \sigma_1^2 \mathbf{\Gamma}_1 + \cdots + \sigma_n^2 \mathbf{\Gamma}_n, \tag{9}$$

where $\sigma_j^2 \mathbf{\Gamma}_j$ represents the covariance matrix for the state variables induced by shock j that solves the Lyapunov equation

$$\sigma_j^2 \mathbf{\Gamma}_j = \sigma_j^2 \mathbf{\Phi}\mathbf{\Gamma}_j\mathbf{\Phi}' + \sigma_j^2 \mathbf{\Phi}_\epsilon \boldsymbol{I}_j \mathbf{\Phi}_\epsilon'. \tag{10}$$

Denote the share of unconditional variation in saving due to shock j by κ_j

$$\kappa_j \equiv FEVD_{S,j} = \frac{\sigma_j^2 \mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_S'}{\mathbf{\Psi}_S \mathbf{\Gamma}_0 \mathbf{\Psi}_S'}. \tag{11}$$

Then, the saving-retention coefficient can be expressed as a linear function of κ_j's

$$\beta = \beta_1 \kappa_1 + \cdots + \beta_n \kappa_n, \tag{12}$$

where β_j denotes the shock-j-specific saving-retention coefficient

$$\beta_j = \frac{\mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_I'}{\mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_S'} \tag{13}$$

that is when all shocks but j are muted. This is because

$$\sum_{j=1}^n \beta_j \kappa_j = \sum_{j=1}^n \frac{\mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_I'}{\mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_S'} \cdot \frac{\sigma_j^2 \mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_S'}{\mathbf{\Psi}_S \mathbf{\Gamma}_0 \mathbf{\Psi}_S'} = \frac{\sum_{j=1}^n \sigma_j^2 \mathbf{\Psi}_S \mathbf{\Gamma}_j \mathbf{\Psi}_I'}{\mathbf{\Psi}_S \mathbf{\Gamma}_0 \mathbf{\Psi}_S'} = \frac{\mathbf{\Psi}_S \mathbf{\Gamma}_0 \mathbf{\Psi}_I'}{\mathbf{\Psi}_S \mathbf{\Gamma}_0 \mathbf{\Psi}_S'} = \beta. \tag{14}$$

From (12), it immediately turns out that

$$\min_j \beta_j \leq \beta \leq \max_j \beta_j. \tag{15}$$

Thus, the saving-retention coefficient ranges between the smallest and the largest shock-specific coefficients for any combination of the shock variances.

3.4 Results for an open-economy RBC model

Here, we apply the decomposition from the previous subsection to a typical open-economy RBC model. We utilize the loglinearized financial frictions version of the model proposed by García-Cicco et al. (2010). The authors augment the basic open-economy RBC model of Schmitt-Grohé and Uribe (2003) that has just single transitory productivity shock (a_t) with four additional shocks: the permanent productivity shock (X_t) as in Aguiar and Gopinath (2007), the domestic preference shock (ν_t), the domestic spending shock (SP_t), and the country risk-premium shock (μ_t). All but the permanent productivity shocks follow the standard first-order autoregressive processes in logs, and the growth rate of the permanent productivity shock $g_t = \frac{X_t}{X_{t-1}}$ is given by

$$\ln\left(\frac{g_t}{g}\right) = \rho_g \ln\left(\frac{g_{t-1}}{g}\right) + \epsilon_t^g, \tag{16}$$

where g is the deterministic productivity growth rate and $\epsilon_t^g \sim N(0, \sigma_g^2)$.

The production process is characterised by the standard two-factor production function

$$Y_t = a_t K_t^{\alpha} (X_t h_t)^{1-\alpha}, \tag{17}$$

where Y_t is output, K_t denotes the capital stock, h_t represents hours worked, and α is the capital share of income.

A representative household maximizes the expected lifetime utility function of the following form

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \nu_t \tilde{\beta}^t \frac{\left[C_t - \frac{\theta X_{t-1} h_t^{\omega}}{\omega}\right]^{1-\gamma} - 1}{1-\gamma}, \tag{18}$$

subject to the sequential budget constraint

$$\frac{D_{t+1}}{1+r_t} = D_t - Y_t + C_t + SP_t + I_t + \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - g\right)^2 K_t, \tag{19}$$

and the no-Ponzi scheme constraint

$$\lim_{j \to \infty} \mathbb{E}_t \left[\frac{D_{t+j}}{\prod_{s=0}^{j}(1+r_{t+s})}\right] \leq 0, \tag{20}$$

where C_t denotes consumption, I_t is gross investment, D_{t+1} represents the stock of debt acquired in period t, and r_t denotes the domestic interest rate. Moreover, $\tilde{\beta}$ is the discount rate, γ drives the curvature of the utility function, θ represents the disutility of labour, ω governs the elasticity of labour supply, and ϕ is the capital adjustment cost. The stock of capital evolves in the standard way

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{21}$$

where δ is the capital depreciation rate.

The country faces the debt-elastic interest rate premium, so the domestic interest rate depends on the fixed world interest rate r^* and a country premium that is an increasing function of debt:

$$r_t = r^* + \Psi\left(e^{\frac{D_{t+1}}{X_t}-\bar{d}} - 1\right) + e^{\mu_t - 1} - 1, \tag{22}$$

where $\bar{d}$ is the steady-state level of the debt to GDP ratio, Ψ governs the sensitivity of the domestic interest rate to the debt level, and μ_t is the risk-premium shock.

García-Cicco et al. (2010) calibrated the parameters to match the equilibrium characteristics of the Argentinian economy. Values of the parameters governing the shock processes together with g, Φ, and Ψ were estimated using annual growth rates of GDP, consumption, and investment as well as the trade-balance-to-GDP ratio for Argentina covering the period 1900-2005. In calculations, we use the original parameter values from García-Cicco et al. (2010) with medians of posterior distributions for the estimated parameters.

The results of the decomposition derived in (12) are shown in Table 1. We consider two versions of the saving-retention coefficient: where both saving and investment are expressed in relation to GDP and for the variables in levels. Depending on the shock composition, the saving-retention coefficient can range from -0.631 to 1.018 for the ratio variables and from -0.203 to 1.031 for the variables in levels.

Table 1: Decomposition of the saving-retention coefficients for the open-economy RBC model

	Stat. tech. (a_t)	Nonstat. tech. (g_t)	Preference (ν_t)	Dom. spend. (SP_t)	Risk-premium (μ_t)
	Results for investment and saving rates ($\beta = 0.587$)				
β_i	1.018	0.030	0.882	0.324	-0.631
κ_i	0.024	0.001	0.778	0.000	0.196
	Results for investment and saving levels ($\beta = 0.895$)				
β_i	1.031	0.778	1.029	0.246	-0.203
κ_i	0.272	0.002	0.618	0.000	0.108

The wide range of values of the saving-retention coefficient implied by a general setup aligns with simulation results obtained for a simple macroeconomic model. The β coefficient of 0.587 is fairly close to the mean of 0.452 in the baseline case in the textbook model and lies in the lower part of the range of estimates reported in Tavéra et al. (2015) (from 0.56 to 0.67). Moreover, when all but preference shocks are shut off, the saving-retention coefficient is above its mean level. It is similar to the case of consumption shocks in the textbook model that can be roughly thought of as a counterpart of preference shocks. Analogous correspondence can be observed for both domestic spending and risk-premium shocks. Like their counterparts in the textbook model, i.e. government spending and net export shocks, they reduce the β coefficient.

The crude character of such comparisons notwithstanding, we believe they lend support to our point. At the same time, we realize it is necessary to go beyond them and the Argentine case and test our argument empirically for a larger set of countries.

4 Methodology and data

4.1 Methodology

The Feldstein-Horioka puzzle was established within a cross-sectional regression framework. Since the 1980s, the literature has shifted more towards the panel data techniques (Apergis and Tsoumas, 2009). For reasons discussed in Section 2, we follow that approach.

Panel data models allow one to exploit both time and cross-sectional dimensions. There are, however, two important issues we should deal with when applying these models. First, it is likely that there is a correlation across countries (cross-sectional dependence) driven by unobserved common factor(s). Neglecting that dependence can result in inconsistent estimation and misleading inference (Chudik and Pesaran, 2015). In order to deal with this issue, we employ the common correlated effect (CCE) estimator. Second, our theoretical framework implies that both saving and investment are subject to shocks and, as such, are endogenous. In order to obtain the unbiased saving-retention coefficient β, we use an instrumental variable approach.

Assume that the scalar variable y_{it} is observed for the i-th country at time t, and it is generated by the conventional panel data model

$$y_{it} = \alpha_i + \boldsymbol{\delta}'\boldsymbol{x}_{it} + u_{it}, \tag{23}$$

where α_i is a country fixed effect, $\boldsymbol{\delta}$ is a vector of coefficients, $\boldsymbol{x}_{it}$ includes country-specific regressors, $i = 1, \dots, N$, and $t = 1, \dots, T$. The errors have the factor structure

$$u_{it} = \boldsymbol{\gamma}_i'\boldsymbol{f}_t + \epsilon_{it}, \tag{24}$$

where $\boldsymbol{f}_t$ and $\boldsymbol{\gamma}_i$ are vectors of unobserved factors and factor loadings, respectively, and the idiosyncratic errors ϵ_{it} are independent and identically distributed (see, e.g., Ditzen, 2018).

The framework consisting of equations (23) and (24) gives rise to three specifications we employ in the empirical part. The first one, in which $\boldsymbol{\gamma}_i = \mathbf{0}$, is the standard country fixed effect model. In the second specification, all $\boldsymbol{\gamma}_i$'s are set equal to $\boldsymbol{\gamma}$, so the $\boldsymbol{\gamma}_i' \boldsymbol{f}_t$ term boils down to γ_t, and the model becomes the familiar time and country fixed effects setup. The third specification employs the cross-section averages to proxy for unobserved factors (see, e.g., Eberhardt, 2012). Pesaran (2006) demonstrates that such a model can be consistently estimated by the OLS or pooled regression and calls the estimation method the CCE estimator.

There are three advantages of the CCE estimator that justify its use in our empirical context. Firstly, the last specification is more flexible than the one with time fixed effects. It is because each cross section can react differently to the factors, i.e. the $\boldsymbol{\gamma}_i$ coefficient vector is country-specific. Secondly, the CCE estimator was designed for panels in which both cross-sectional and time-series dimensions are large. Given that our sample includes more than 80 countries but spans only 13 years, we cannot assume that both dimensions are large. Westerlund et al. (2019) investigate statistical properties of the CCE estimator in the fixed T case. They show that the CCE estimator is consistent when T is fixed. Importantly, it outperforms the GMM estimator in terms of a bias, a root mean squared error and a size accuracy of the t test except for the cases with the smallest T considered in their experiments, i.e. four observations per cross-section. Finally, even though the unobserved factors can alternatively be estimated with principal component analysis as demonstrated by Bai (2009), it remains unclear whether such an approach should be used when N is large and T is small. Westerlund et al. (2019, p. 747) argue that the principal component approach 'is not valid when only N is large'. Both estimators are compared by Westerlund and Urbain (2015). These three reasons induce us to apply the CCE estimator.

The second issue, saving endogeneity, calls for the instrumental variable that enables us to isolate the impact of saving on investment. To capture the importance of shocks in shaping the β coefficient, we use the debt shock (surprise) as an instrument for the saving rate. Our reasoning is that debt shocks result in unexpected changes in public saving, a component of domestic saving. This setup, therefore, makes it possible to disentangle linkages between saving and investment and capture the one running from the former to the latter in line with the interpretation of β as a saving-retention coefficient. Given the affinity of debt surprises to government spending shocks in the textbook model and domestic spending shocks in the open-economy RBC model, we expect the estimated saving-retention coefficient to be smaller than in the regressions without instruments.

The debt shock is a difference between actual and forecast debt-to-GDP ratios. In other words, it is a debt-to-GDP ratio forecast error

$$d_{it}^{FE} = d_{it} - d_{it}^{F}, \tag{25}$$

where d_{it} denotes the general government debt in per cent of GDP in country i and at year t, whereas superscripts F and FE denote forecast and forecast error, respectively.

It is worth emphasising that some other studies also use forecast errors to construct fiscal shocks. For example, Brandao-Marques et al. (2023) construct debt surprises and Magud and Pienknagura (2022) derive government expenditure shocks using a similar forecast error-based approach. There are two important advantages of this approach: (i) the unanticipated change in the fiscal variable mitigates the so-called anticipation effect, and (ii) it is unlikely to be endogenous. When policy changes are anticipated, agents can adjust their investment and saving decisions in advance. Using unanticipated changes makes the approach robust to such adjustments because, by definition, they are impossible. Turning to the second advantage, we note that the forecast debt-to-GDP ratios are retrieved from the October editions of the IMF's World Economic Outlook databases. Given the short period between the time of forecast and the end of the year, the forecast error is exogenous rather than the outcome of the fiscal authority's response to the state of the economy. In order to be endogenous, the fiscal policy would need to change in the same quarter the news arrived, which, due to various policy lags, is highly unlikely (Abiad et al., 2016). These advantages make the debt shock a good measure of saving shocks.

In order to provide more in-depth insights into the link between the saving-retention coefficient and shocks, we construct an alternative instrument which proxies for foreign shocks. As demonstrated in the theoretical framework, these shocks push the distribution of the saving-retention coefficient leftwards in both the simple and RBC models. Accordingly, we expect that the coefficient estimates obtained in regressions with instrumented saving ratio will be smaller than in the simple regressions without instruments. Analogously to equation (25), the current account surprise is constructed as the difference between the actual and forecast current account-to-GDP ratios. We admit, however, that this instrument is inferior to debt surprises because lags in current account responses to the state of the economy are likely to be shorter than those of fiscal policy.

4.2 Data

Likewise Feldstein and Horioka (1980), we employ data on gross domestic saving and gross domestic investment, both expressed in per cent of GDP. The annual saving and investment rates are collected for a set of 82 countries spanning the period between 2010 and 2022. The choice of the sample period is related to the fact that the IMF's forecasts are publicly available only for the period starting in 2010. The panel is slightly unbalanced because there are 16 missing data points in the total of 1,066. It includes 32 advanced economies and 50 emerging market economies whose complete list is detailed in Table B1 in Appendix B.

All data are collected from the online IMF's World Economic Outlook databases. The actual levels of saving and investment rates, as well as the debt-to-GDP and current account-to-GDP ratios, are from the WEO edition published in the following year, whereas forecasts are retrieved from the current year's edition. For example, the actual saving rate in 2022 is obtained from the WEO October 2023 edition, and the forecast debt-to-GDP ratio for 2022 is from the WEO October 2022 vintage data. The detailed description of the data and sources is in Table B2 and the descriptive statistics are reported in Table B3 in Appendix B.

5 Empirical results

We start with the preliminary analysis that reports the results obtained with conventional panel data techniques, including fixed effect estimation. We demonstrate why the lagged variables are not pertinent instruments and make a case for using the debt and current account shocks. Then, we move on to the main results obtained with the CCE estimator and show how the results change when the saving rate is instrumented with debt and current account surprises. The potential differences between country groups are examined by splitting the sample into advanced economies and emerging market economies following the IMF's classification. Finally, we report the results of robustness checks.

5.1 Justifying the IV approach

The natural starting point is a replication of Feldstein and Horioka's cross-sectional regressions. To this end, we apply the between estimator that exploits the cross-countries variation and leaves aside information about the evolution of variables within the country. Table 2 reports the results of the baseline regressions. The between estimation corroborates the FH puzzle, albeit the β coefficient of 0.5 is more in line with our simulations than the originally found 0.9. It is well-known that the between or groups mean estimator can be misleading when the unobserved individual (country) effect α_i is important and correlated with regressors (Greene, 2018, pp. 388-389). Thus, column (2) summarises the estimation results of the country fixed effect model. The saving-retention coefficient changes little and remains highly statistically significant. The problem, however, is that the CD test's null of weak cross-sectional dependence is rejected at all conventional levels of statistical significance. The issue can be, at least to a certain extent, mitigated by time fixed effects (column (3)). The point estimate of the β coefficient is slightly lower than in the two previous models but continues to be significantly positive.

In the following two columns, we instrument the saving ratio with its lagged level and debt shocks,

Table 2: Baseline regressions: The whole sample

	Between estimator	Country FE	Country & time FE	IV: lagged saving	IV: debt shocks	IV: CA shocks
	(1)	(2)	(3)	(4)	(5)	(6)
saving ratio	0.5340***	0.5027***	0.4857***	0.5716***	-0.1125	-1.9767
	(0.0550)	(0.0782)	(0.0817)	(0.0728)	(0.4004)	(1.3961)
Observations	1,050	1,050	1,050	971	1,050	1,050
Countries	82	82	82	82	82	82
Country FE	No	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes	Yes	Yes
CD*		-2.1481**	0.7631	0.1775	-0.5212	-0.6956
K-P rk LM				20.0495***	3.1965*	5.2302**

Notes: The results obtained with the Stata commands xtreg and xtivreg2. The robust standard errors in parentheses. The CD* is the bias corrected CD statistic from Pesaran and Xie (2021). The K-P rk LM statistic from the Kleibergen-Paap underidentification test (the null is that instruments are not correlated with the endogenous regressors). ***, **, and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

respectively. When we use the former, the saving-retention coefficient moves up in the positive territory, making the puzzle more pronounced. Even though the lagged saving ratio is a sound instrument from an econometric point of view, it is not satisfactory from an economic standpoint. It safeguards against simultaneity bias because the lagged saving cannot correlate with a contemporaneous shock. Moreover, the null of no correlation between the instrument and the endogenous regressor in the Kleibergen-Paap test is strongly rejected. At the same time, however, the saving shocks are wiped out of the picture, so β loses its original interpretation as a saving-retention coefficient. From an economic perspective, it is preferable to have an instrumental variable embodying the saving shocks. As explained in the previous section, debt shocks incorporate unanticipated changes in the general government debt. Such changes, in turn, correlate with shifts in public saving, which are a component of domestic saving. Column (5) reveals that in the instrumental-variable regression with debt surprises, the saving-retention coefficient ceases to be significant. This finding is important because it foreshadows the results we obtain with the more refined estimator.

In column (6), we obtain a similar picture employing current account surprises instead of debt shocks. This time, our economic argument is that the surprises proxy for foreign shocks and, in line with the theoretical framework, we should expect the saving-retention coefficient to be substantially smaller than in the simple regressions. Indeed, the estimated coefficient is again insignificant and fits our expectations.

At this stage, however, we must admit that the confidence intervals in the IV regressions are relatively wide. Consequently, one can argue that the lack of significance of β stems from the problems with the precision of estimation rather than unriddling the puzzle.

To build more confidence in these preliminary results, we split the sample into advanced and emerging market economies and rerun the same regressions. The results are reported in Tables B4 and B5 in Appendix

B for both country groups, respectively. We observe the same pattern, i.e. the instrumentation with the lagged saving ratio changes the results marginally. Instead, using surprises, both debt and current account shocks, drives the saving-retention coefficient down. Country group regressions, however, are less robust statistically. On top of wide confidence intervals, debt and current account surprises seem to be weak instruments in both country groups and advanced economies, respectively.

5.2 Main results

In order to obtain more refined and robust results, we employ the CCE estimator. As discussed in the section on methodology, it has good statistical properties, including its direct focus on cross-sectional dependencies and compatibility with the panel data when the number of countries is large and the time dimension is small.

The main results are reported in Table 3. All the regressions are augmented with the cross-section averages of the saving and investment ratios which, following the logic of the CCE estimator, approximate the unobserved common factors. The table has three blocks corresponding to the results for the whole sample and two country groups.

Table 3: Regressions with saving ratio instrumented by either debt or current account shocks, CCE estimator

	All countries			Advanced economies			Emerging market economies		
	No instruments	IV: debt shocks	IV: CA shocks	No instruments	IV: debt shocks	IV: CA shocks	No instruments	IV: debt shocks	IV: CA shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
saving ratio	0.4842***	0.1236	-1.3185***	0.3685***	0.0670	-2.9725***	0.4110***	0.0952	-0.4349***
	(0.0701)	(0.0869)	(0.2547)	(0.1329)	(0.1336)	(0.5589)	(0.0733)	(0.0794)	(0.1363)
Observations	1,050	1,050	1,050	411	411	411	639	639	639
Countries	82	82	82	32	32	32	50	50	50
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CD*	3.9983***	0.2948	-2.1279**	0.6456	0.6148	-2.1587**	-1.7604*	-1.6019	-1.0870
K-P rk LM		5.0439**	14.7125***		3.3895*	6.4300**		4.3989**	11.5892***

Notes: The results obtained with the Stata command xtdcce2. The robust standard errors in parentheses. The CD* is the bias corrected CD statistic from Pesaran and Xie (2021). The K-P rk LM statistic from the Kleibergen-Paap underidentification test (the null is that instruments are not correlated with the endogenous regressors). ***, **, and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Let us start with the estimates obtained for the whole sample of countries. As documented in column (1), the saving-retention coefficient is significantly positive in the specification without instruments and only marginally smaller than the estimate in the two-way fixed effects model reported in Table 2. Therefore, the use of the CCE estimator does not change that point estimate much.

When we instrument the saving ratio with the debt surprise in column (2), the estimated coefficient decreases and becomes statistically indistinguishable from zero. Two points are noteworthy. First, the confidence interval is reasonably narrow, unlike in the baseline instrumental variable regression with time and country fixed effects (see column (5) in Table 2). In other words, the CCE estimator enables us to obtain more precise estimates when the debt shocks are employed as an instrument. Second and more importantly, the key finding is not that the β coefficient is insignificant but that its estimate is significantly *smaller* in the IV regression than the one obtained without instruments. The focus on the single type of shocks, debt surprises, shifts the saving-retention coefficient downwards, which is the direction implied by the predominance of government spending (or domestic spending) shocks in our theoretical framework.

Moving to the regression instrumenting the saving ratio with current account surprises, we observe that the coefficient in column (3) is significantly negative, implying divergent changes in saving and investment rates. Similarly to the case with debt surprises, the estimate is more precise, and the coefficient value fits the theoretical framework well. In both textbook and general models, foreign shocks trigger the adjustments driving saving and investment in opposite directions. What lends support to our argument is not that the coefficient estimate is negative or significant but the finding that it is substantially below the one in the regression with no instruments.

It is worth observing that the IV regressions are statistically sound. None of them show symptoms of underidentification, indicating that the debt and current account surprises are relevant instruments. Moreover, the null of weak cross-sectional dependence is not rejected for debt surprises. This, however, is not the case when we employ current account shocks, as some cross-sectional correlations remain in the residuals. Nevertheless, the estimates of the saving-retention coefficient are robust, and the cross-sectional dependence can be removed by adding more lags of cross-section averages, as documented in the following subsection.

At this stage, the question may arise whether our results hold when countries are divided into advanced and emerging market economies. The question is well-rooted in the empirical literature. Suffice is to note that Chang and Smith (2014) coin the term 'FH2 puzzle', arguing that the puzzle has an additional layer because contrary to the general belief that capital mobility is lower in emerging market economies than in advanced economies, saving-investment correlations are significantly lower in the former country group.[6] In line with this claim is the literature survey by Apergis and Tsoumas (2009), who link the higher degree of capital mobility in emerging market economies with foreign aid, the non-traded sector size, the degree of openness and the economy's financial structure. Therefore, we split the sample into advanced and emerging market economies and rerun regressions for each country group separately. The results are reported in columns (4)-(9) in Table 3.

The general observation is that regression results for both country groups are qualitatively similar to

[6] In their meta-analysis, Tavéra et al. (2015) find that the saving-retention coefficient in advanced economies is larger by between 0.10 to 0.15 than in the mixed samples including both advanced and emerging market economies.

those for the whole sample. The saving-retention coefficient is positive and significant in regressions with no instruments, supporting the FH puzzle. When we employ the debt shock, the coefficient estimate decreases to 0.067 and 0.095 for advanced and emerging market economies, respectively, and becomes insignificant. Moreover, its confidence interval is much narrower than in the baseline regressions reported in Tables B4 and B5 in Appendix B, indicating the more precise estimates.

Moving on to the regressions with the current account surprises, we also find a similar pattern to the one in the whole sample. The point estimates are significantly negative, in line with a shift implied by the theoretical framework. Country group regressions enable us to recognize that a cross-sectional dependence is present in the advanced economies sample but not in the emerging market economies sample. To tackle the problem identified in the former sample, in the following subsection, we run the sensitivity check employing more lags of cross-section averages.

Overall, these results do not lend support to the FH2 puzzle: saving retention coefficients are similar across country groups and in line with the theoretical framework. Figure 2 summarises the main results. The upper part shows that regressions neglecting the endogeneity of the saving ratio deliver the FH puzzle across all country groups. The instrumentation with debt or current account surprises removes the simultaneity bias by isolating the effects of specific shocks. In this way, we can obtain sound estimates of the shock-specific saving-retention coefficients. The estimates shift to the neighbourhood of zero when we employ debt surprises (the middle part) and become negative when we use current account surprises (the lower part). The pattern is observed for the whole sample and both country groups. For the reasons discussed above, we consider the estimates obtained with the former instrument superior to those from regressions with the latter instrument.

5.3 Robustness checks

We run three types of robustness checks. First, we check whether our results are robust to outliers and show that the saving-retention coefficient estimates are not distorted by a few abnormal observations. Second, we augment the list of cross-sectional averages with their first lags. Such an extension can provide further insights into the validity of the results in those cases in which the null of weak cross-sectional dependence is either rejected or not rejected only marginally. Third, we employ alternative instruments and check whether the results are in line with the theoretical implications.

The outlying observations can disproportionately influence the regression coefficients, undermining their economic interpretation. To check the robustness of our results, we use winsorized data. First, we trim and replace the extreme observations at 2.5 and 97.5 percentiles and then estimate the saving-retention coefficient. Table 4 reports the results. The main findings do not change: even though the IV regressions with

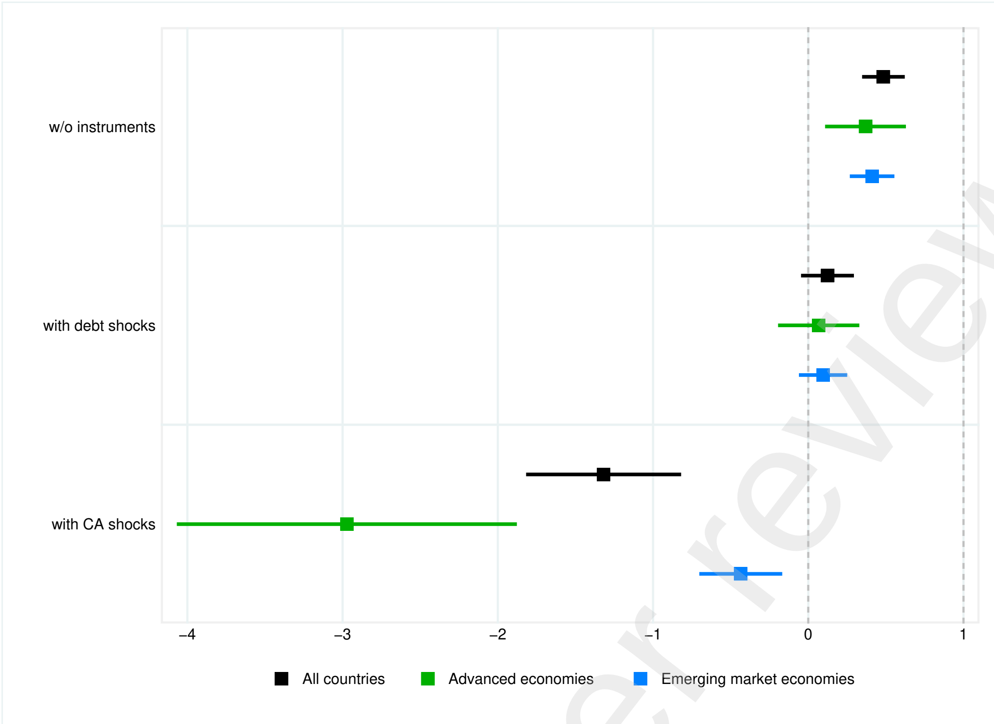

Figure 2: Estimates of saving-retention coefficients under alternative specifications across country groups

debt surprises indicate that the saving-retention coefficient is positive in all country groups and significant in the whole and emerging market economies samples (columns (2) and (8)), it is lower than in the regressions without instruments. In specifications with current account surprises (columns (3), (6), and (9)), the coefficient is negative, which also corroborates the main results.

We follow an alternative approach by identifying outliers in each regression reported in Table 3 and excluding them from the sample. The outlier is the country-year data point whose standardized error is greater (less) than 3 (-3). Table B6 in Appendix B documents that after removing outlying observations, the estimation results are very much in line with the main results. Under the instrumentation with debt or current account surprises, the saving-retention coefficients are smaller than in the uninstrumented regression. When the debt surprises are employed, the coefficient decreases below zero (columns (2) and (8)), making the difference to the specification without instruments even more pronounced than in the main results.

Adding the first lag can be motivated by the fact that cross-sectional dependence has not been completely removed from the IV regressions with current account surprises. For the sake of completeness, Table 5 reports regression results with both types of surprises and across all country groups. The general observation is that estimates of saving-retention coefficients do not differ much from those in the more parsimonious specifications. The instrumentation with any surprise drives the estimates downwards, in the case of current

Table 4: Regressions with with saving ratio instrumented by either debt or current account shocks on winsorized data at 2.5 and 97.5 percentiles, CCE estimator

	All countries			Advanced economies			Emerging market economies		
	No instru-ments	IV: debt shocks	IV: CA shocks	No instru-ments	IV: debt shocks	IV: CA shocks	No instru-ments	IV: debt shocks	IV: CA shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
saving ratio	0.4612***	0.2224***	-0.9679***	0.3644***	0.1011	-1.5068***	0.4211***	0.1712**	-0.5174***
	(0.0693)	(0.0767)	(0.2048)	(0.1234)	(0.1277)	(0.3439)	(0.0775)	(0.0817)	(0.1567)
Observations	1,081	1,081	1,081	416	416	416	665	665	665
Countries	84	84	84	32	32	32	52	52	52
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CD*	2.3605**	0.0643	-2.1776**	-0.4498	0.5342	-0.6481	0.0567	-0.6177	-0.6909
K-P rk LM		6.9903***	15.2573***		4.4453**	6.9595***		7.0974***	9.8395***

Notes: See Table 3. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

account shocks to a negative range.[7]

Table 5: Regressions augmented with the first lag of cross-sectional averages, CCE estimator

	All countries			Advanced economies			Emerging market economies		
	No instru-ments	IV: debt shocks	IV: CA shocks	No instru-ments	IV: debt shocks	IV: CA shocks	No instru-ments	IV: debt shocks	IV: CA shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
saving ratio	0.4745***	0.3606***	-1.1227***	0.2610*	-0.2645*	-4.1182***	0.4264***	0.8497***	-0.2188*
	(0.0819)	(0.0840)	(0.2494)	(0.1552)	(0.1385)	(0.7614)	(0.0723)	(0.1012)	(0.1158)
Observations	967	967	967	379	379	379	588	588	588
Countries	82	82	82	32	32	32	50	50	50
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CD*	-0.7602	-0.2047	0.0330	-0.6442	1.8921*	-2.3808**	-1.2128	-2.2770**	1.0029
K-P rk LM		5.4474**	12.3601***		3.1597*	4.7749**		2.7190*	12.9826***

Notes: See Table 3. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Focusing on the regressions with current account surprises in columns (3), (6), and (9), we note that coefficient estimates are similar to those reported as main results in Table 3. This time, however, the null of weak cross-sectional dependence is not rejected for the whole sample case, making the results more robust from a statistical point of view. The same, however, cannot be said about the advanced economies sample: the cross-sectional dependence is still present there, albeit the saving-retention coefficient is negative. Thus, for this sample and current account shocks, the results are not as robust as for instrumentation with debt surprises and leave the floor open to future regressions on samples with a longer time dimension.

The third type of robustness check involves the employment of alternative instruments. Exploiting further

[7]In passing, we note that in the emerging market economies group, the coefficient in column (8) is greater than in column (7). This case, however, is plagued by cross-sectional dependence and is statistically inferior to the estimate obtained in the regression without the lag of cross-sectional averages (see column (8) in Table 3).

the WEO datasets, we construct two more external instruments that proxy government spending shocks and investment shocks. Both are designed analogously to debt surprises as the difference between the actual and forecast ratios to GDP.

Government spending (fiscal) shocks can be treated as an alternative to debt surprises because they also measure changes in domestic saving triggered by public saving. These shocks, however, do not account for the possibly accompanying changes in taxes and, as such, seem to be slightly inferior to debt surprises from an economic point of view. Nevertheless, government spending surprises can be considered empirical counterparts of such shocks in the simple macroeconomic model and domestic spending shocks in the open-economy RBC model discussed in Section 3. Both models imply that the distribution of the saving-retention coefficient shifts leftwards in the face of government spending shocks. Thus, we expect the IV estimates to be lower than in the uninstrumented regressions.

Investment shocks proxy for the variation unrelated to exogenous changes in either domestic or foreign savings. On the one hand, given that the investment process is usually extended over time, the lags in investment responses to the state of the economy can be long enough to insulate against endogeneity. On the other hand, due to the heterogeneity of investment, a certain portion of investment shock can be endogenous. With this caution in mind, we observe that investment shocks form an empirical counterpart of such shocks in the simple model and, most likely, transitory productivity shocks in the RBC model expounded in Section 3. In line with these models, we expect the distribution of the saving-retention coefficient to move rightwards, so the IV estimates should be greater than those in regressions without instruments.

Table 6: Regressions with saving ratio instrumented by either government spending or investment shocks, CCE estimator

	All countries			Advanced economies			Emerging market economies		
	No instruments	IV: gov't spend. shocks	IV: invest. shocks	No instruments	IV: gov't spend. shocks	IV: invest. shocks	No instruments	IV: gov't spend. shocks	IV: invest. shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
saving ratio	0.4842***	0.1617*	1.8161***	0.3685***	-0.1333	9.9685***	0.4110***	0.8859***	0.8882***
	(0.0701)	(0.0840)	(0.1883)	(0.1329)	(0.1444)	(1.5417)	(0.0733)	(0.1138)	(0.1263)
Observations	1,050	1,050	967	411	411	381	639	639	586
Countries	82	82	82	32	32	32	50	50	50
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CD*	3.9983***	0.4599	-0.4731	0.6456	0.7691	-1.7029*	-1.7604*	-1.0566	-2.1201**
K-P rk LM		0.2475	8.2094***		3.4350*	1.0718		0.0305	18.6280***

Notes: See Table 3. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table 6 reports the empirical results of these robustness checks. Estimates align with theoretical frameworks: in the regressions on the full sample, fiscal and investment shocks shift the estimates in opposite directions, the former makes the saving-retention coefficient smaller (0.162) and the latter makes it greater (1.816) than in the regression without instruments (0.484). We need to admit, however, that, in light of the Kleibergen-Paap test, the government spending shock is an irrelevant instrument (see column (2))[8].

The regressions on country-group samples reveal the same pattern of importance of shocks for the estimated coefficient. Nonetheless, these results are not that convincing because either the instrument turns out to be irrelevant (columns (6) and (8)) or there remains cross-sectional dependence in residuals (columns (6) and (9)). This scepticism should not override the finding that the coefficient estimates fit our theoretical framework well, and the better the statistical properties of the regression, the stronger the corroboration.

6 Conclusions

This paper reconsiders the interpretation of the saving-retention coefficient rather than attempts to provide one more solution to the FH puzzle. To that end, it recognises the critical importance of a full-fledged theoretical framework and the need to go beyond the ascetic empirical modelling of saving-investment identity. Using a rudimentary macroeconomic model, we demonstrate that investment regressions on saving do not inform about the degree of saving-retention and international capital mobility but, at best, provide some insights into the relative importance of shocks. The Monte Carlo experiments of the simple open economy macroeconomic model augmented with the acceleration principle confirm that the simulated distribution of the regression coefficient moves towards zero when fiscal and foreign shocks overshadow investment shocks and towards unity in the opposite scenario. We demonstrate that our point holds in a more general framework by reiterating our reasoning in a fully microfounded open-economy RBC model with an even larger set of shocks. In the model calibrated to the Argentine economy, the saving-retention coefficient ranges from -0.631 to 1.018, depending on the shock composition.

Our theoretical argument gets robust support from the empirical evidence. First, employing annual data for more than 80 countries in the period 2010-2022, we demonstrate that the FH puzzle holds in both cross-section and simple panel regressions with the saving-retention coefficient close to 0.5, the average estimate reported in the meta-analysis carried out by Tavéra et al. (2015). Next, we retrieve the IMF's forecasts and, following i.a. Brandao-Marques et al. (2023), construct debt and current account surprises, consider them proxies of shocks to domestic and foreign savings, respectively, and use them to instrument the saving rate. This brings us to the second main finding: In line with the theoretical framework, the saving-retention coefficient is significantly lower in the instrumental variable regressions than in the regressions without in-

[8] This is also the case in the baseline IV regressions with government spending shocks as instruments. See Table B7 in Appendix B.

struments. Third, unlike Chang and Smith (2014), we find little support for the so-called FH2 puzzle that investment-saving correlations are higher in advanced economies than in emerging market economies. It is present only in a few regressions without instrumentation. When we use the debt or current account surprises to instrument saving ratios, the between-country group differences disappear, and the FH2 puzzle fades. Fourth, the linkages between the saving-retention coefficient and shocks are not limited to debt and current account surprises. We corroborate the coherence of coefficient estimates with the theoretical framework employing alternative sets of fiscal and investment shocks.

Despite the encouraging and robust results, we realise our approach has some limitations. First, we employ a relatively simple empirical strategy that employs external instruments. The alternative would be to develop the approach put forth by Chang and Smith (2014), estimate the open-economy RBC models on a country-by-country basis, and, going beyond their approach, examine the contribution of specific shocks to the saving-retention coefficients. This is the line of research we follow in a companion paper. Second, the timespan of our study is limited to the 2010s and early 2020s due to data availability. The backward extension of the sample would require access to the IMF's forecasts, currently available only to IMF researchers (see, e.g., Brandao-Marques et al., 2023). Third, the empirical part uses alternative instruments to measure several shocks. In principle, our analysis can be replicated with other proxies and other shocks. The challenge, however, lies in identifying shocks using macroeconomic data (Brueckner et al., 2020). We consider these limitations as possible lines of further research in this area.

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Appendix A:

Notes on the textbook macroeconomic model

A1. A baseline macroeconomic model

The textbook macroeconomic model consists of the national income identity, two behavioural equations for consumption and net exports, and two exogenous processes driving investment and government spending (taxes are assumed to be nil for simplicity):

$$Y_t = C_t + I_t + G_t + NX_t \tag{A1}$$

$$C_t = c_0 + c_1 Y_t + \epsilon_t^c \tag{A2}$$

$$NX_t = n_0 - n_1 Y_t + \epsilon_t^n \tag{A3}$$

$$I_t = i_0 + \epsilon_t^i \tag{A4}$$

$$G_t = g_0 + \epsilon_t^g, \tag{A5}$$

where ϵ_t^j, $j = \{c, n, i, g\}$, are shocks to consumption, net exports, investment, and government spending, the parameters are denoted with lower case letters and $0 \leq n_1 < c_1 < 1$.

The equilibrium output can be obtained in a straightforward way and equals the product of a spending multiplier m and autonomous spending

$$Y_t = m\left(a_0 + \epsilon_t\right), \tag{A6}$$

where $m = (1 - c_1 + n_1)^{-1}$ and $a_0 = c_0 + g_0 + i_0 + n_0$ and $\epsilon_t = \epsilon_t^c + \epsilon_t^i + \epsilon_t^g + \epsilon_t^n$ capture deterministic and stochastic components of aggregate demand, respectively. It is convenient to express output in terms of a deviation from its deterministic steady-state level, i.e. the level that would be observed when all shocks are nil, $\bar{Y} = ma_0$,

$$\widetilde{Y}_t = m\epsilon_t, \tag{A7}$$

where a tilde denotes deviation, $\widetilde{Y}_t = Y_t - \bar{Y}$.

Domestic saving, both private and public, equals income (output) less consumption and government spending, whereas foreign saving is the additive inverse of net exports. Investment is an exogenous process. Investment and domestic and foreign savings can also be expressed in terms of their deviations from the deterministic steady-state levels as

$$\widetilde{I}_t = \epsilon_t^i \tag{A8}$$

$$\widetilde{S}_t = m\left[-n_1(\epsilon_t^c + \epsilon_t^g) + (1-c_1)(\epsilon_t^i + \epsilon_t^n)\right] \tag{A9}$$

$$\widetilde{F}_t = m\left[n_1(\epsilon_t^c + \epsilon_t^g + \epsilon_t^i) - (1-c_1)\epsilon_t^n\right], \tag{A10}$$

where $\widetilde{F}_t \equiv -\widetilde{NX}_t$.

Using equations (A8)-(A10) in the definition of the OLS estimator (equation (1) in the main text), one can show that the estimate of the saving-retention coefficient is a function of relative importance of shocks as indicated by equation (2) in the main text, i.e.

$$\hat{\beta} = \frac{(1+b)\text{var}(\epsilon^i)}{b^2\left[\text{var}(\epsilon^c) + \text{var}(\epsilon^g)\right] + \text{var}(\epsilon^i) + \text{var}(\epsilon^n)}. \tag{A11}$$

A2. The extended textbook macroeconomic model

The extended textbook model includes the same equations as the baseline model except for equations (A4) and (A5), which are replaced by

$$I_t = i_0 + i_1 \Delta C_{t-1} + \epsilon_t^i \tag{A12}$$

$$G_t = g_0 + g_1 G_{t-1} + \epsilon_t^g, \tag{A13}$$

where ΔC_{t-1} is the lagged change in consumption, and i_1 is the 'factor of proportionality or relation' (Samuelson, 1939) and g_1 is the autoregressive coefficient of government spending. These extensions make our theoretical framework similar to the one employed by Sims (2012) and Haavelmo (1943), albeit they focus on the closed economy case.[9]

Introducing the acceleration principle to the model makes it dynamic. Output depends on its lagged levels and current and lagged shocks and can be written as

$$Y_t = \bar{Y} + \widetilde{Y}_t, \tag{A14}$$

[9] In passing, it is noteworthy that, following these authors, we do not introduce the so-called Robertson lag in the consumption function. The consumption function is left unchanged.

where $\bar{Y}$ is a deterministic steady-state level

$$\bar{Y} = m\left(a_0 + \bar{G}\right), \tag{A15}$$

and $\widetilde{Y}_t$ a deviation from that level

$$\widetilde{Y}_t = m\left(\epsilon_t + i_1 \Delta \epsilon^c_{t-1} + g_1 \widetilde{G}_{t-1} + c_1 i_1 \Delta \widetilde{Y}_{t-1}\right). \tag{A16}$$

The autonomous spending encompasses $a_0 = c_0 + i_0 + n_0$ and $\bar{G} = \frac{g_0}{1-g_1}$. Following equation (A13), the government spending can be decomposed as $G_t = \bar{G} + \widetilde{G}_t$, where $\widetilde{G}_t = g_1 \widetilde{G}_{t-1} + \epsilon^g_t$ is the deviation from the steady-state level. We assume that the model is stable. The stability condition, i.e., the modulus of each root less than one, is checked in simulations.

A3. Details of simulations

The extended model is used to run a series of simulations or Monte Carlo experiments. The objective is to obtain the distribution of the estimate of coefficient β. We adopt the following approach. First, the structural parameters of the model are set in such a way that the equilibrium level of output in a deterministic scenario is 100. Second, we assume shocks are normal, independent, and identically distributed random variables with zero means and unitary variances. Third, in each iteration, we construct time series of output, investment, and saving, calculate investment and saving rates, and then estimate β using 1,050 draws of shocks. The effective sample size in each iteration is 50 because the initial 1,000 draws are treated as burn-in draws. Finally, we estimate β in each iteration and use estimates to construct the histogram. The number of iterations is 10,000.

Appendix B:

Additional empirical results

The Appendix contains additional tables and figures, referenced to in the main text.

Table B1: List of countries

Advanced economies		Emerging market economies	
Australia	Slovenia	Albania	Kazakhstan
Austria	Spain	Argentina	Malaysia
Belgium	Sweden	Armenia	Mexico
Canada	Switzerland	Azerbaijan	Moldova
Cyprus	Taiwan	Bangladesh	Mozambique
Czechia	United Kingdom	Belarus	Nicaragua
Denmark	United States	Bolivia	Nigeria
Estonia		Bosnia and Herzegovina	Pakistan
Finland		Brazil	Panama
France		Bulgaria	Paraguay
Germany		Chile	Peru
Greece		China	Philippines
Hong Kong, China		Colombia	Poland
Ireland		Costa Rica	Romania
Israel		Croatia	Russia
Italy		Dominican Republic	Saudi Arabia
Japan		Ecuador	Serbia
Korea		Egypt	South Africa
Latvia		El Salvador	Sri Lanka
Lithuania		Georgia	Thailand
Netherlands		Guatemala	Turkey
New Zealand		Honduras	Ukraine
Norway		Hungary	Uruguay
Portugal		India	Uzbekistan
Slovakia		Indonesia	Vietnam

Table B2: Data description and sources

Variable	Description	Source
investment ratio	A ratio of total investment to GDP in year t obtained from the WEO edition published in the autumn of the following year	The IMF's WEO, various editions, 2009-2023; WEO series code: NID_NGDP
saving ratio	A ratio of gross national saving to GDP n year t obtained from the WEO edition published in the autumn of the following year	The IMF's WEO, various editions, 2009-2023; WEO series code: NGSD_NGDP
debt shock	A debt-to-GDP ratio forecast error constructed as a difference between the actual general government debt (in per cent of GDP) in year t obtained from the WEO edition published in the autumn of the following year, and the forecast for year t retrieved from the WEO edition published in the autumn of the current year	Own construction based on the data from the IMF's WEO, various editions, 2009-2023; WEO series code: GGXWDG_NGDP
current account shock	A current-to-GDP ratio forecast error constructed as a difference between the actual current account (in per cent of GDP) in year t obtained from the WEO edition published in the autumn of the following year, and the forecast for year t retrieved from the WEO edition published in the autumn of the current year	Own construction based on the data from the IMF's WEO, various editions, 2009-2023; WEO series code: BCA_NGDPD
government spending shock	A government spending-to-GDP ratio forecast error constructed as a difference between the actual government spending (in per cent of GDP) in year t obtained from the WEO edition published in the autumn of the following year, and the forecast for year t retrieved from the WEO edition published in the autumn of the current year	Own construction based on the data from the IMF's WEO, various editions, 2009-2023; WEO series code: GGX_NGDP
investment shock	An investment-to-GDP ratio forecast error constructed as a difference between the actual investment (in per cent of GDP) in year t obtained from the WEO edition published in the autumn of the following year, and the forecast for year t retrieved from the WEO edition published in the autumn of the current year	Own construction based on the data from the IMF's WEO, various editions, 2009-2023; WEO series code: NID_NGDP

Table B3: Descriptive statistics, full sample

Variable	Observations	Mean	Std. deviation	Minimum	Maximum	Skewness	Kurtosis
investment ratio	1,050	23.044	5.975	9.832	48.854	1.072	5.359
saving ratio	1,050	22.733	7.855	4.103	53.359	0.614	3.718
debt shock	1,050	-0.456	4.031	-29.596	33.945	-0.069	16.557
current account shock	1,050	0.191	2.025	-22.149	10.752	-0.947	19.549
government spending shock	1,050	-0.343	1.875	-12.952	12.924	-0.155	11.484
investment shock	967	0.024	4.377	-63.904	24.346	-3.905	63.092

Notes: All statistics in per cent of GDP (except for the number of observations).

Table B4: Baseline regressions: Advanced economies sample

	Between estimator (1)	Country FE (2)	Country & time FE (3)	IV: lagged saving (4)	IV: debt shocks (5)	IV: CA shocks (6)
saving ratio	0.3635***	0.5679***	0.4643***	0.7038***	-0.0912	-7.0523
	(0.0639)	(0.0938)	(0.1583)	(0.1151)	(0.4471)	(15.2217)
Observations	411	411	411	380	411	411
Countries	32	32	32	32	32	32
Country FE	No	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes	Yes	Yes
CD*		3.9146***	0.9497	0.0903	1.1911	-2.0406**
K-P rk LM				4.3622**	0.8068	0.3329

Notes: See Table 2 in the main text. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table B5: Baseline regressions: Emerging market economies sample

	Between estimator (1)	Country FE (2)	Country & time FE (3)	IV: lagged saving (4)	IV: debt shocks (5)	IV: CA shocks (6)
saving ratio	0.6574***	0.4781***	0.4755***	0.5214***	-0.1963	-0.9115**
	(0.0675)	(0.0996)	(0.1006)	(0.0854)	(0.6379)	(0.3919)
Observations	639	639	639	591	639	639
Countries	50	50	50	50	50	50
Country FE	No	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	Yes	Yes	Yes
CD*		0.4020	-2.0282**	-0.5821	-0.3391	-0.6790
K-P rk LM				15.1248***	1.4847	8.9132***

Notes: See Table 2 in the main text. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table B6: Regressions with with saving ratio instrumented by either debt or current account shocks on samples without outliers, CCE estimator

	All countries			Advanced economies			Emerging market economies		
	No instruments (1)	IV: debt shocks (2)	IV: CA shocks (3)	No instruments (4)	IV: debt shocks (5)	IV: CA shocks (6)	No instruments (7)	IV: debt shocks (8)	IV: CA shocks (9)
saving ratio	0.5801***	-0.1786**	-0.7491***	0.3081***	0.1001	-0.8388***	0.4247***	-0.2022**	-0.6093***
	(0.0434)	(0.0710)	(0.0983)	(0.0675)	(0.0660)	(0.1555)	(0.0633)	(0.0784)	(0.1175)
Observations	1,036	1,029	1,022	404	406	405	630	629	625
Countries	82	82	82	32	32	32	50	50	50
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CD*	1.8487*	1.3781	-1.6180	-1.6686*	-1.9411*	-0.1037	-1.9325*	-0.4099	-0.0500
K-P rk LM		4.8944**	27.4240***		6.3079**	21.4127***		2.7682*	9.4244***

Notes: See Table 3 in the main text. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table B7: Baseline regressions with government spending and investment shocks as instruments

	All countries		Advanced economies		Emerging market economies	
	IV: gov't spend. shocks	IV: invest. shocks	IV: gov't spend. shocks	IV: invest. shocks	IV: gov't spend. shocks	IV: invest. shocks
	(1)	(2)	(3)	(4)	(5)	(6)
saving ratio	0.3589	1.5177***	0.3242	5.4112**	1.7435	1.0104***
	(0.4376)	(0.4165)	(0.3777)	(2.7414)	(10.5767)	(0.2111)
Observations	1,050	967	411	381	639	586
Countries	82	82	32	32	50	50
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
CD*	0.9077	0.3886	0.7268	-1.9235*	-1.9823**	0.6503
K-P rk LM	1.5316	11.7633***	2.3020	4.3818**	0.0142	10.3309***

Notes: See Table 2 in the main text. ***, ** and * denote statistical significance at the 1, 5 and 10 percent level, respectively.