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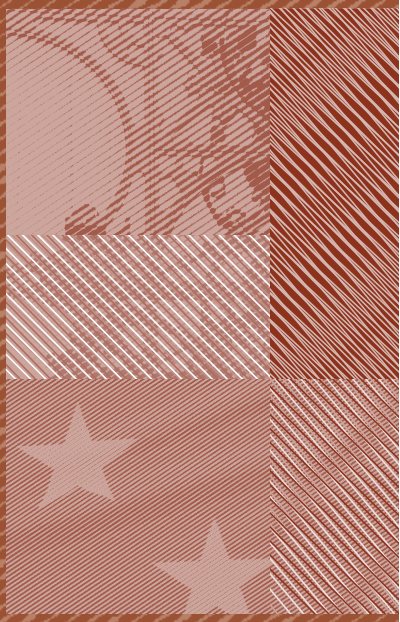

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PRIVATE SAVING. NEW CROSS-COUNTRY EVIDENCE BASED ON BAYESIAN TECHNIQUES (*)

Ignacio Hernando

BANCO DE ESPAÑA

Irene Pablos

EUROPEAN CENTRAL BANK

Daniel Santabárbara (**)

BANCO DE ESPAÑA

Javier Vallés

BANCO DE ESPAÑA

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(**) Corresponding author: Banco de España, Calle Alcalá 48, 28014 Madrid, Spain. E-mail: daniel.santabarbara@bde.es.

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Abstract

The existing literature exhibits high uncertainty over the theoretical and empirical determinants of private world saving. This paper reports new evidence on the drivers of private saving by applying Bayesian techniques, using data from the world's 35 largest economies in the period 1980-2012. After reviewing the main theories of consumption and saving decisions, and discussing the potential effects of different determinants, we specify a general model that incorporates the most commonly used factors in the literature, considering the potential endogeneity of some of the regressors. The Bayesian Model Averaging (BMA) approach summarises the information embedded in all combinations of the explanatory variables considered by averaging each specification according to its likelihood. We find that in the medium term private credit to GDP ratio, the government surplus to GDP ratio, the terms of trade, life expectancy and the old-age dependency ratio are key determinants of cross-country private saving behaviour. Lastly, we assess the long-term effect of expected demographic changes in private saving globally.

Keywords: consumption, saving, national saving, private saving, household saving, Bayesian model averaging, model uncertainty.

JEL classification: C11, C23, E21, H30.

Resumen

La literatura económica muestra una gran incertidumbre sobre los determinantes teóricos y empíricos del ahorro privado. Este trabajo aporta nueva evidencia sobre los principales determinantes del ahorro privado mediante la aplicación de técnicas bayesianas, utilizando datos de las 35 principales economías mundiales en el período 1980-2012. Después de revisar las principales teorías que explican las decisiones de consumo y ahorro, y de discutir los efectos potenciales de los diferentes determinantes, se especifica un modelo general que incorpora las principales variables explicativas consideradas en la literatura, teniendo en cuenta su posible endogenidad. El enfoque *Bayesian Model Averaging* (BMA) resume la información subyacente en los modelos resultantes de las diferentes combinaciones de las variables explicativas promediando cada especificación según su verosimilitud. Este trabajo encuentra que, a medio plazo, el crédito privado sobre el PIB, el saldo público sobre el PIB, los términos de intercambio, la esperanza de vida y el envejecimiento de la población son determinantes clave del comportamiento del ahorro privado. Por último, se evalúa el efecto a largo plazo de los cambios demográficos esperados en el ahorro privado a escala mundial.

Palabras clave: consumo, ahorro, promediado bayesiano de modelos, incertidumbre de modelo.

Códigos JEL: C11, C23, E21, H30.

1. Introduction

The existing literature exhibits high uncertainty over the theoretical and empirical determinants of private world saving. On the theoretical front, there are a number of models designed to explain household consumption and saving decisions. For a non-negligible number of determinants, their expected effects on private saving, according to different theoretical channels, have an ambiguous effect. On the empirical side, Grigoli, Herman and Schmidt-Hebbel (2014) offer a survey on studies of private saving determinants based on macroeconomic panel datasets. These studies largely differ in terms of time periods, geographical coverage, saving rate definitions, data sources and econometric techniques. These authors claim that, "unsurprisingly", the papers analysed "show large differences in empirical results that are difficult to reconcile". Trying to overcome the limitations of the empirical literature in this field, Grigoli et al. (2014) conducted an exhaustive piece of research, extending previous work on different dimensions: extending and updating the underlying data; conducting robustness analyses across estimation techniques, variable definitions and model specifications; and identifying differences in the estimated results across time periods and geographical coverage.

With the same objective of overcoming the lack of robustness of the empirical literature on the determinants of private saving, we use an alternative strategy. Starting from a set of fundamentals that the literature has catalogued as plausible determinants of private saving, a natural way to think about model uncertainly is to recognise that we do not know the 'true' model and, instead, attach probabilities to different possible models, in this case, cross-country panels. The Bayesian Model Averaging (BMA) approach averages across models according to the probability of each one (Sala-i-Martin et al. 2004). In other words, this type of approach provides estimates of the coefficients of interest that are weighted averages of the estimated coefficients in all possible models where the weights capture the plausibility of each model. Moreover, since some determinants of private saving are potentially endogenous and we are interested in exploiting the cross country panel data structure, we apply the BMA approach estimating each model by instrumental variables (IV).

This paper explores the determinants of private saving as a tool to assess its behaviour in the medium term using a cross-country panel dataset from 1980 to 2012 that includes the 35 largest economies. This paper contributes to the empirical literature on three fronts. First, it addresses the uncertainty over the determinants of private saving by applying Bayesian statistics. Second, from a methodological perspective, it is one of the first studies to apply Bayesian techniques to panel data with endogenous regressors. And third, it assesses the long-term effect of expected demographic changes on private saving globally and, hence, on real interest rates.

Our approach shows that only some of the results found in the empirical literature, in particular those reported by Grigoli et al. (2014), hold for the Bayesian techniques. The BMA methodology reduces the number of major determinants of private saving, such that financial development, fiscal policies, (transitory) income effects through terms of trade and demographic variables have a great deal of explanatory power. Contrastingly, this paper shows that the roles of permanent income, inflation and urbanisation appear to be much more limited. These results are robust to a number of changes in the specification and proxies of the determinants.

There is also an ongoing debate about how the expected demographic changes will affect private saving globally and therefore real interest rates. Where United Nations (UN) demographic projections are available for a long time span with a relatively high degree of certainty, it is possible to anticipate future pressures on private saving stemming from developments in population. Using the BMA results, we provide a quantitative long-term assessment of how life

expectancy and old-age dependency ratio changes across countries are expected to affect the saving rate. We find that in the near future, the acceleration in the weight of the old-age population, quite widespread across the world, will foreseeably put downward pressure on savings. This might be especially notable for countries such as Japan, Spain or Germany.

The rest of the paper is as follows. Section 2 discusses the private saving determinants and the main empirical findings. Section 3 presents the dataset and the estimation methodology. Section 4 provides the main econometric results and some robustness exercises. Section 5 examines the impact of expected demographic changes on private saving and Section 6 concludes.

2. Private saving determinants and empirical findings

A large number of studies have explored the potential determinants of private saving, providing comprehensive reviews of their theoretical basis and empirical evidence on their role.[1] Most of the theoretical work on the behaviour of private saving focuses on household saving, while for conceptual and practical reasons the empirical studies of private saving usually define this variable more broadly to include both household and corporate saving.[2,3] In this section, we offer an overview of the literature analysing the determinants of private saving. In particular, we discuss the channels and the expected sign effects of the determinants most commonly considered in the theoretical literature and summarise the results found in empirical papers based on the estimation of reduced-form private saving equations. The expected signs of the effects of the main determinants of private saving are summarised in Table 1.

The Keynesian consumption function linking consumption to current income was an important contribution to modern economic analysis. However, it neglected the role of interest rates and future income in the consumption decision. To address these shortcomings, the intertemporal approach to consumption and saving was developed. Under this approach, the permanent income theory (Friedman, 1957) derived from a representative infinite-lived consumer and the life cycle theory (Modigliani and Brumberg, 1954) that introduces age-related consumer heterogeneity are the two models most commonly used to analyse consumption and saving decisions. In the first of these theories, a household's consumption at a given point in time is determined not just by its current income but also by its expected income in future years—its 'permanent income'. In other words, it is changes in permanent income, rather than changes in temporary income, that drive movements in consumption. In the second model, personal saving behaviour is determined by the stage in the consumer's life cycle, as income tends to evolve systematically over the course of a person's life.

The empirical literature has not always been supportive of the implications of these theories. For instance, for liquidity-constrained households' consumption is largely driven by current income rather than permanent income, contrary to the prediction of the permanent income theory. Similarly, older individuals dissave less than the amount predicted by the life-cycle model, but instead leave much of their wealth as bequests. Thus the assumptions of such models have been

[1] See Masson et al. (1998), Loayza et al. (2000a and 2000b), Desroches and Francis (2010), Grigoli et al. (2014), and Aizenman et al. (2016) for similar reviews of the theoretical determinants of savings and the corresponding empirical findings.

[2] Aizenman et al. (2016) argue that, on the one hand, statistical data on household saving are constructed using a wide variety of methods across countries and, on the other, the line between household and corporate saving can be blurry, especially among developing economies. More generally, if firms retain more earnings, their shareholders (households) will save less by the same amount. In other words, since firms are ultimately owned by households, total private saving is basically determined by household behaviour.

[3] Despite our focus on the theoretical determinants of private saving from a household perspective, we follow the empirical literature without considering the possible change in global trends between households and corporations observed in the last few decades (Chen, Karabarbounis and Neiman, 2017).

modified by introducing features such as consumption habits, substitution effect between private and public consumption, different forms of uncertainty generating precautionary saving, consumer heterogeneity, and financial imperfections that allow the introduction of credit conditions as determinants of households' decisions. Although some of these factors also influence the behaviour of corporate saving, the empirical papers dealing with the determinants of private saving have also included other variables (e.g. measures of fluctuations in corporate profits or indexes related to the regulatory environment) that specifically condition corporate saving patterns.

In what follows, we provide an ordered review of the main determinants considered in the literature, taking into account that some variables might have different expected impacts on saving depending on the particular theory applied.

Real interest rates: Macro models assume a positive elasticity of saving with respect to real interest rates. But the magnitude and even the sign effect of interest rates on saving depends on the relative influence of the substitution and the income effects. As the household sector is usually a net creditor, the positive income effect might potentially offset the negative substitution effect, the overall interest rate effect in the economy being ambiguous (Gylfason, 1993; and Ogaki et al., 1996). The estimated effect varies widely across empirical studies and is not significant in many cases. Interestingly, Aizenman et al. (2016) find that, using a specification with interactive terms, the effect of the real interest rate on saving varies depending on the level of the interest rate as well as on different economic conditions and policies.

Income and growth: Theories based on the intertemporal approach assert that the permanent component of income must be consumed and only the transitory component will be saved. Since the observed income level makes no distinction between the proportions of the two components, the effect on the saving rate is ambiguous.

Also it is possible to analyse the effect of a rise in income growth coming, for example, from a permanent productivity gain. In a life-cycle model this is likely to affect workers more than retired people, thus increasing the aggregate saving rate. However, if these productivity gains lead to higher expectations of future income, saving rates for working individuals could fall. On the empirical front, most studies incorporate a measure of income growth (or productivity growth) and tend to find a positive and significant effect. Nevertheless, these effects might be related to other potential determinants of savings, such as demographic patterns or financial development.

When looking at the cross-country dimension, the link between saving rates and per capita income is usually explored. Here, the underlying argument is based on the Neoclassical model, which states that saving goes from rich countries (with low return on capital) to poor countries (with high return on capital) allowing for an income convergence effect. In other words, in very poor countries, the potential for saving is very low. Increases in per capita income may lead to higher saving rates, although the magnitude of this effect is likely to gradually decline as per capita income rises and may even become negative for rich economies with low investment opportunities. The income level effect is not always analysed in the empirical literature but it seems to have also a positive effect on saving, although the convergence hypothesis is not unanimously validated empirically.

Fluctuations in income: As a way of testing the permanent income hypothesis, a number of empirical papers have identified temporary income shocks, analysing whether these shocks lead to increases in the saving rate. The relative price of oil has been often used as a proxy of temporary income changes (Barro and Sala-i-Martin, 1990, and Desroches and Francis, 2010).

Terms of trade shocks: a positive shift in the relative price of export goods to that of import goods will benefit the trade balance and may be considered as an increase in net income from abroad. Again, a permanent change in that variable will feed through to consumption, whereas if the shock is perceived as transitory it will affect the saving rate. Thus, the income adjustment and its effect on the saving rate is an empirical issue. Ostry and Reinhardt (1992) were among the first in documenting a positive correlation between transitory terms-of-trade and saving. In a recent paper, Grigoli et al. (2016) find that higher terms of trade raise saving, and this effect is larger for temporary terms-of-trade shocks and when credit constraints are more binding.

Wealth: In standard macroeconomic models, the intertemporal elasticity of consumption is an increasing function of wealth. Thus, an increase in the stock of wealth leads to an increasing saving rate (Atkeson and Ogaki, 1996). However, in the buffer-stock model of Carroll (1997), savers have a target wealth-to-income ratio such that, if wealth is below the target, the precautionary saving motive will dominate, and the consumer will save, while if wealth is above the target, the consumer will dissave (Carroll, 1997). However, under the permanent income hypothesis, higher wealth leads to higher consumption and lower savings.

Demographics: According to the life-cycle models, saving rates change across different population groups with a hump-shaped pattern across the age cohorts. In general, an increase in the old-age dependency ratio reduces the amount of financial assets available to maintain the level of consumption and the saving rate will fall. In the presence of intergenerational links via bequests, the reaction of saving rate to old-age dependency weakens. An increase in life expectancy will lead to an increase in precautionary saving at all ages (Bloom et al., 2003). Finally, urbanisation may affect saving through several channels: expanding consumption opportunities, and reducing the need for precautionary saving. Although coefficients of demographic variables also display some dispersion, they are among the most robust across saving determinants. Consistent with the theory, in empirical studies an increase in the old-age dependency ratio or an increase in the urbanisation rate reduces saving, while an increase in life expectancy raises the saving rate.

Financial depth: The degree of financial development has an ambiguous effect on private saving. On the one hand, it raises the range of saving vehicles while, on the other, it lessens the need for precautionary saving by providing better insurance instruments (Edwards, 1995, and Jappelli and Pagano, 1994). The ratio of private credit to GDP is a standard proxy for financial development. In general, a negative sign is usually found for this variable, suggesting that the effect of a lower need for precautionary savings prevails.

Borrowing constraints: The presence of financial frictions generally implies a higher response of consumption to current income. Thus, a relaxation of borrowing constraints would also reduce the saving rate (Jappelli and Pagano, 1994). The empirical literature (e.g. Aron et al., 2012) has found that financial asset prices (e.g. risk premiums on interest rates) or financial quantities (e.g. credit flows) that are proxies for the existence of borrowing constraints on agents' decisions have a significant effect on consumption and saving equations. In particular, current credit flows are usually associated with a reduction in saving. An interpretation could be that larger credit flows reflect a relaxation of consumers' borrowing constraints. In spite of having an unambiguous sign in the theoretical literature, the estimated coefficients in empirical studies of the potential existence of financial constraints have a large variability.

Public sector saving: Usually under an infinitely-lived consumer model, the government budget constraint implies that the Ricardian-equivalence hypothesis holds. Thus, private agents fully offset changes in government saving with their own saving. Nevertheless, different assumptions

used in standard models lead to a partial Ricardian equivalence assumption, according to which public saving reduces private precautionary saving (López et al., 2000). Empirical results tend to corroborate the 'partial' Ricardian effect when government surplus is included in the private saving specification (De Serres and Pelgrin, 2003, or Grigoli et al., 2014). Unlike other determinants analysed, the estimated coefficient of the government-surplus effect on private saving is very similar across studies.

Government spending components: Some government spending items that characterise the welfare state, such as education, health or pensions, have an ambiguous effect on private agents' decisions. The substitution effect between public and private consumption raises private saving whereas the income effect has a negative effect on saving. The funding of a social insurance mechanism would lead to a lower need for private precautionary saving (Hubbard et al., 1995). In general, those public spending components that are viewed as less productive should generate a larger private saving response as they would require higher taxes in the future.

Uncertainty: Various sources of uncertainty (macroeconomic, financial, political) condition households' decisions. Precautionary saving models predict that the saving rate rises in response to an increase in uncertainty (Skinner, 1988, and Carroll et al., 2012). Inflation is often included in reduced-form saving equations, in an attempt to measure the precautionary saving effect coming from macroeconomic uncertainty. It usually displays a positive effect, albeit widely varying in magnitude and not always significant.

In general, the literature on the determinants of private saving is largely inconclusive.[4] On the theoretical front, the effect of a number of determinants has an ambiguous sign, reflecting the existence of different channels of influence. On the empirical front, the lack of robustness of the results isnotable, especially in the cross-country data analysis. The dispersion of the coefficient estimates is very large, and contradictory results across studies are not uncommon. The heterogeneity of results is largely due to differences in the empirical studies in terms of sample size (country and time dimensions), data sources, variables definitions, model specifications, and estimation methodologies. In particular, the selection of the variables to be included in the empirical model is a major source of uncertainty as regards the driving forces of saving patterns.

[4] See Grigoli et al. (2014) for a more detailed discussion on this issue.

Table 1. (Some) Determinants of Private Saving

Determinant	Reference	Channel	Expected sign (main effect)
Rates of return	Gylfason (1993), Ogaki, Ostry and Reinhart (1994)	Effect on intertemporal consumption	Ambiguous
Income level/growth	PIT: Friedman (1957); LCH: Modigliani and Brumberg (1964)	PIT: Higher future income - higher savings; LCH: effects depend on the most benefited cohort	PIT (+); LCH (Ambiguous)
Terms of trade / Relative prices	Ostry and Reinhardt (1992)	Positive shift in terms of trade implies an increase in net income from abroad	+
Wealth	Atkeson and Ogaki (1996), Carroll (1997)	Intertemporal elasticity of consumption is an increasing function of wealth	Ambiguous
Demographics -dependency	Modigliani and Brumberg (1964)	Life-cycle hypothesis. Hump-shaped pattern of savings.	-
Demographics - longevity	Bloom, Canning, and Graham (2003)	Increase of precautionary savings at all ages	+
Demographics - urbanisation	Loayza et al. (2000b)	More consumption opportunities and less need for precautionary savings	-
Domestic borrowing constraints	Japelli and Pagano (1994)	Relaxation of borrowing constraints reduces household savings	+
Financial depth	Edwards (1995) and Japelli and Pagano (1994)	More availability of saving vehicles versus less need for precautionary savings	Ambiguous
Fiscal policy - Public savings	López, Schmidt-Hebbel, and Servén (2000)	Under partial Ricardian equivalence, public savings reduce private precautionary savings	-
Composition of public spending	Hubbard, Skinner, and Zeldes (1995)	Presence of social insurance mechanisms leads to lower need for precautionary savings	-
Classical uncertainty (risk)	Skinner (1988), Weil (1993)	Precautionary savings. Risk-averse consumers	+

3. Methodology

3.1. Dataset and baseline specification

In our cross-country panel, the dependent variable is the private saving to GDP ratio, which better captures the behaviour of consumers, obtained either from the IMF WEO or AMECO databases, depending on the country considered (see Table A-1 for further details on definitions and sources of the dataset). In our view, private saving data are to be preferred to household saving data since they are comparable and available across advanced countries and EMEs and, from a theoretical perspective, assuming households are the ultimate owners of firms, corporate saving should also reflect households' consumption decisions.

The explanatory variables we have chosen cover the main determinants reported in the theoretical literature regardless of the ambiguity of their impact. In particular, our baseline specification includes the following 12 variables. Real interest rates, i.e. nominal term rates minus inflation expectations provided by Blanchard et al. (2014). Real income growth, proxied by GDP growth. A measure of country convergence, GDP per capita relative to the US, which measures the (relative) income level. Considering external determinants, we include the terms of trade of goods and services, signalling income effects, and real oil prices, which are common across countries. As demographic factors we include three variables: life expectancy at birth, the old-age dependency ratio, i.e. the population aged over 65 years as a proportion of the working age population ("population aged over 65 years over working age population"), and the urban population ratio. A financial sector development measure, the stock of domestic credit to the private sector as a proportion of GDP ("domestic credit to private sector over GDP"). Related to the behaviour of the public sector, we include both public health spending as a proportion of GDP ("public health spending over GDP"), in order to capture precautionary saving, and the government surplus as a proportion of GDP ("government surplus over GDP"), reflecting potential crowding out effects between private and public saving. Lastly, we also consider CPI inflation reflecting uncertainty.

The country data employed cover the world's 35 largest economies,[5] representing both advanced and emerging market economies and around 85% of global GDP. However, the sample effectively used for estimation, which requires that all variables be available for each period, includes 28 countries and 75% of world GDP.

The time period considered is 1980-2012. Since our focus is on medium-term developments in private saving, we filtered the data by constructing 5-year non-overlapping time averages. This somewhat standard procedure in country panel data allows the removal of cyclical factors and also mitigates the potential role of the dynamics as a determinant of private saving, which could be a potentially major factor. In fact, Pesaran and Smith (1995) show that filtering the short-run dynamics by using non-overlapping moving averages diminishes the bias in longer-term relationships derived from ignoring the dynamics of the dependent variable. This can be seen as an intermediate step between static and dynamic models since it filters high-frequency movements by non-overlapping moving averages and then estimates a static relationship between the filtered variables.

The empirical strategy starts by defining the following baseline specification for the private saving rate of country *c* at time t. The explanatory variable *d* is represented by $\boldsymbol{x_{d,c,t}}$, and may be exogenous or endogenous. This specification also considers fixed effects $\boldsymbol{\eta_c}$, while $\boldsymbol{\varepsilon_{c,t}}$ represents the error term. All in all, equation (1) represents a general model that allows for country heterogeneity.

$$\boldsymbol{y_{c,t}} = \boldsymbol{\eta_c} + \sum_{d=1}^{D} \boldsymbol{\beta_j x_{d,c,t}} + \boldsymbol{\varepsilon_{c,t}} \quad (1)$$

Since some of the explanatory variables are either endogenous or predetermined and fixed effects are included, we employ a panel data IV estimator to tackle the inconsistency and biases derived from this issue. Following previous empirical studies, we consider the following determinants as endogenous: real interest rates, GDP per capita relative to the US, the stock of domestic credit to private sector over GDP, GDP growth, public health spending over GDP, government surplus over GDP and CPI inflation. We instrument these variables with their first lag, assuming therefore that they are predetermined. The use of the IV type estimator instead of a GMM one, which is asymptotically efficient since it considers the covariance matrix of instruments, is required to estimate the model (pseudo) likelihood comparable across different specifications derived from the combinations of the regressors. This is key for implementing the BMA procedure described in Section 3.3.

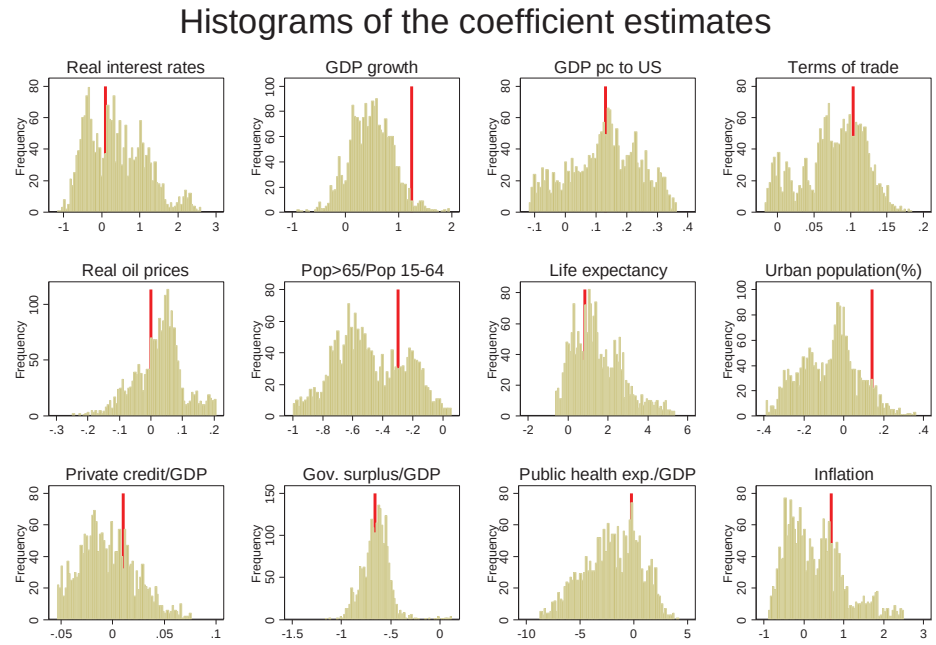
3.2. Model uncertainty

Before dealing with the BMA procedure, we show the distribution, properties and descriptive statistics of the whole range of possible models with the determinants considered in our baseline specification estimated by the aforementioned fixed effects IV estimator. In fact, to systematically address model uncertainty, we estimate all possible combinations of the 12 economic fundamentals considered (2^{12}), implying that there are 4096 different models to choose from.

[5] The countries considered are Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Italy, Japan, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Russia, Saudi Arabia, South Africa, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom and United States.

Figure 1 shows the distribution of the estimated coefficients for each variable whenever it appears in one of the regressions. These histograms give an idea of the uncertainty surrounding the contribution of each variable to explaining private savings, i.e. a measure of parameter uncertainty. In fact, we observe that the distribution of the coefficients is rather volatile and, in many cases, far away from the theoretical priors. Whereas for few variables the coefficients lie in a relatively tight range (e.g. government surplus from -0.5% to -1%), most of them have a larger range with both positive and negative values. Moreover, the distribution tends to be unimodal for most coefficients.

Figure 1

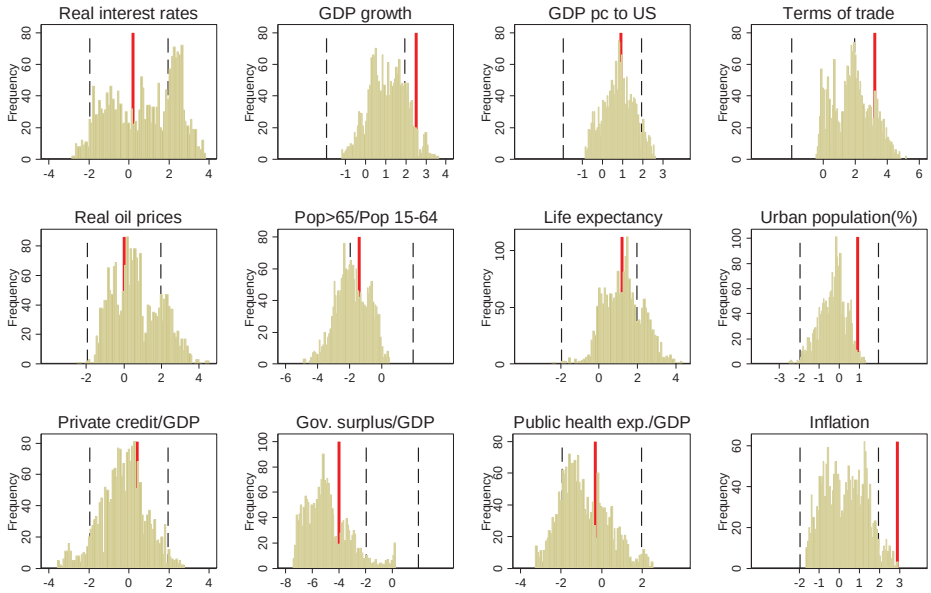


Note: Red line respresents each determinant IV estimate in the model including all determinants

Figure 2 focuses on the significance of the different determinants by plotting the histogram of the t-statistics (the coefficient divided by its standard deviation) which measures the individual significance of the coefficient estimated. The ±2 bands correspond to the 95% confidence interval. The figure reveals that most of the coefficients in most of the specifications are not significant, with the exception of government surplus over GDP, the old-age dependency ratio, the terms of trade and real interest rates. Surprisingly, in a few specifications, the real interest rate or private credit over GDP coefficients are significant, but with positive and negative signs. All in all, these figures shed some light on the reasons behind the lack of robustness of the aforementioned empirical evidence in the private saving literature.

Figure 2

Histograms of the t-statistics of the coefficients



Note: Dashed lines: 95% confidence intervals. Red line represents each determinant IV t-statistic in the model including all determinants

3.3. Bayesian Model Averaging (BMA)

The BMA approach provides a conceptually attractive solution to model uncertainty. In fact, the BMA approach allows both model and parameter uncertainty to be dealt with in a straightforward and formal way. BMA attaches probabilities to different models and averages them accordingly. It delivers coefficients on the basis of each specification's posterior probabilities and of the coefficients estimated. In other words, BMA summarises the information contained in all these 4096 models weighting each specification according to the likelihood that each one has generated the data. Our work is an extension of the BMA approach outlined by Sala-i-Martin et al. (2004), so-called Bayesian Averaging of Classical Estimates (BACE), but instead of using ordinary least squares estimates of the models, a IV panel data estimator is employed to address the potential endogeneity of some of the explanatory variables.[6] Hence, this approach combines the priors of the BACE with panel data IV estimates of such models to derive the posterior probability of each model. To our knowledge, Mirestean et al. (2016) was the first attempt to consider endogeneity in a BMA framework to revisit the growth determinants.

As outlined by Moral-Benito (2015) in his overview of the literature, BMA entails three main steps: (i) choose prior distributions on the model and parameter spaces; (ii) determine the likelihood function of the data for each model and parameter value; (iii) compute the full posterior distribution of the coefficients using Bayes' theorem.

The BACE approach developed by Sala-i-Martin et al. (2004) tackles sagaciously the determination of the prior probabilities of the models, $P(M_j)$. While the standard Bayesian approach requires the specification of a prior distribution for all parameters, BACE only needs the specification of one prior hyper-parameter: k, the expected model size. This is because it is assumed that each variable is independently included (or not) in the model, so the model size follows a binomial distribution. Sala-i-Martin et al. (2004) propose choosing a prior mean model

[6] Ca' Zorzi et al. (2012) applied the BACE approach to the determinants of current account imbalances.

size, k, with each variable having a prior probability k/K of being included, where K is the overall number of potential determinants considered (K=12, in our case).

Despite its lack of asymptotic efficiency, the panel data IV estimator with a fixed matrix of instruments allows us to compute a pseudo-likelihood function of the data under each model. As already noted, the importance of choosing a panel data IV estimator instead of a GMM type one is that the former allows the calculation of this pseudo-likelihood which is comparable across models since the instrument matrix is fixed.

Finally, if $P(M_j)$ is the prior probability that M_j is the true model, the posterior probability of the model M_j given the data y, $P(M_j|y)$, can then be derived using Bayes' rule as

$$P(M_j \mid y) = \frac{l_y(M_j)P(M_j)}{\sum_{i=1}^{2^k} l_y(M_i)P(M_i)} \tag{2}$$

where $l_y(M_j)$ is the pseudo-likelihood of model M_j given data y and k is the number of candidate regressors.

Once the model weights are obtained, Bayes' rule applies to calculate the posterior mean[7] and variance of each parameter value. Similarly, the posterior probability that a particular variable is in the regression can also be estimated.

4. Results and robustness

4.1. Baseline results

We perform our BMA estimation for the private saving equation, considering the 12 potential determinants described in Section 3.1, and taking into account the endogeneity of seven of them.[8] We considered as a starting point a prior expected model size, k=6, i.e., a prior probability of inclusion of 0.5 for each variable, motivated by the fact that most empirical studies do not include many explanatory variables. Table 2 shows the econometric results with the endogenous variables marked on italics. Column (1) reports the posterior inclusion probability of each variable, measuring the goodness-of-fit of models that include it, i.e. the sum of the posterior model probabilities for all models including that variable. Columns (2) and (3) show the posterior mean and standard deviation of the distributions, conditional on the variable being in the model regression. Column (4), the fraction of regressions with the same sign as the posterior mean, and Column (5), the fraction of regressions in which the variable is classically significant (absolute value of t-statistic greater than 2), are complementary measures of the importance of a particular determinant. Finally, Column (6) is the combination of the previous two properties.

Our BMA procedure provides reasonable results. Although the theoretical literature on saving is partly inconclusive, our results are consistent with the expected effects for which there is consensus. In fact, all the determinants' signs and magnitudes are compatible with the theoretical predictions, as the posterior mean column shows. Under our BMA procedure a particular determinant is key when the posterior probability of inclusion is larger than the prior one, which in this case is 0.5. The variables whose posterior probability of inclusion is larger than their a

[7] The posterior mean is defined as $E(\beta|y) = \sum_{j=1}^{2^k} P(M_j \mid y)\,\widehat{\beta}_j$ where $\widehat{\beta}_j$ is the IV estimate of the model j.

[8] To test the validity of the instruments chosen, we apply the Sargan-Hansen test to the panel IV estimates of the baseline specification. The joint null hypothesis is that the instruments are valid, i.e. uncorrelated with the error term. We cannot reject the null hypothesis, which supports the validity of the set of instruments chosen.

priori ones are the terms of trade, life expectancy, the old-age dependency ratio, government surplus over GDP and domestic credit to private sector over GDP. The remaining seven variables have a probability of inclusion lower than 0.5, indicating that they do not contribute appreciably to the goodness of fit of the saving regressions. In the following paragraphs we discuss the results reported in Table 2.

Table 2

	(1)	(2)	(3)	(4)	(5)	(6)
Private Savings / GDP (5 year averages) k=6	**Posterior inclusion probability** PIP	**Posterior mean** PMEAN	**Posterior st. deviation** PSTD	**Fraction of regressions with same sign as posterior mean**	**Fraction of regresions with |t-stat|>2**	**Fraction of regressions significant and with same sign as posterior mean**
Real interest rates	0.001	-0.050	0.271	0.36	0.37	0.03
GDP growth	0.032	0.354	0.321	0.88	0.19	0.17
GDP per capita relative to US	0.344	0.115	0.107	0.83	0.08	0.07
Terms of trade (goods and services)	0.993	0.080	0.035	0.93	0.45	0.43
Real oil prices	0.169	0.036	0.050	0.69	0.20	0.19
Pop>65/Pop 15-64	0.806	-0.500	0.187	0.98	0.46	0.45
Life expectancy	0.731	1.026	0.500	0.91	0.26	0.25
Urban population (%)	0.103	-0.051	0.152	0.68	0.01	0.01
Domestic credit to private sector over GDP	0.937	-0.044	0.018	0.59	0.10	0.07
Goverment surplus over GDP	1.000	-0.602	0.089	0.99	0.94	0.94
Public Health Spending/GDP	0.044	-0.772	0.817	0.75	0.19	0.16
Inflation	0.029	0.636	0.405	0.57	0.05	0.04

Variables in italics are considered as endogenous

First, the posterior mean of the real interest rate variable displays a negative sign suggesting that the income effect would prevail, but this variable has a very low posterior inclusion probability indicating that real interest rates are 'insignificantly' related to savings (in the sense used by Sala-i-Martin et al., 2004, that is, it has a lower posterior inclusion probability than the prior one). Given the potential importance of movements in investment to pin down the relationship between savings and interest rates, we also try an estimation including the total investment rate as an additional instrument, but the results barely change.

Second, as for the variables capturing income shocks, the only one displaying a 'significant' influence is the terms of trade variable. By contrast, the posterior mean of GDP per capita relative to the US and GDP growth is positive, in line with the existence of a convergence effect, but it is not 'significant', despite the posterior probability not being far from the 0.5 threshold. Higher GDP growth is also positively related to private saving, but its posterior inclusion probability is very low, which seems to be consistent with the ambiguous effect according to different theories.[9] Interestingly, a positive terms of trade shock tends to increase saving through its positive impact on income. This result is consistent with the permanent income hypothesis. Insofar as part of the increase in net income from abroad comes from temporary terms of trade shocks, we should expect a positive effect on private saving.[10] Real oil prices display a low posterior probability, as their effect might be partially captured by the terms of trade variable.

[9] Basically, the sign of the impact of higher GDP growth on saving would depend on its temporary or permanent nature.

[10] Given the difficulty in disentangling temporary from permanent shocks, we conducted the exercise including the Hodrick-Prescott cycle of the terms of trade (instead of the terms of trade) and all results hold, indicating the importance of temporary factors.

Third, demographic variables have considerable explanatory power in saving dynamics. On the one hand, an increase in life expectancy leads to a rise in private saving, and, on the other, an older population, as measured by the old-age dependency ratio, is associated with lower private saving, as the life-cycle hypothesis predicts, since the elderly consume out of accumulated saving. This result is consistent with the empirical literature based on cross-country models of savings. By contrast, empirical work based on the estimation of microeconomic models of consumption behaviour usually rejects the predictions of the life cycle hypothesis with aggregate data (Banks et al., 1998). We do not find a significant effect of the urbanisation rate on private saving. In the empirical literature, a negative sign is often found for this variable, reflecting greater consumption opportunities and lower income uncertainty for urban dwellers.

Fourth, we find a 'significant', albeit not complete, substitution between public and private saving. The variable "government surplus over GDP" has a negative posterior mean indicating that a larger government surplus (deficit) tends to reduce (increase) private saving. This result is consistent with the Ricardian equivalence hypothesis, which is a variant of the permanent income theory, whereby consumption is a function of permanent income net of the present value of government spending and taxes. The magnitude of the absolute value of the posterior mean is relatively high compared with the standard results in the literature (Grigoli et al., 2014). In any event, the economic agents are not fully Ricardian, since the absolute value of the posterior mean is lower than 1. Public health spending over GDP shows a negative posterior mean, as it tends to soften precautionary savings. However, it displays a low posterior inclusion probability.

Fifth, financial development, measured by credit to the private sector over GDP, is a major explanatory factor and tends to reduce private saving by widening consumption opportunities, or alternatively, by lowering the borrowing constraints. Since private credit over GDP is sometimes criticised for not taking into account the complex nature of financial development, a robustness test was conducted using the financial development index developed by the IMF (Svirydzenka, 2016) and the results were barely affected.

Finally, we do not find inflation to have a major role as a determinant of private saving. Inflation was included in our model as a proxy for uncertainty, since precautionary saving is likely to be higher in the presence of high uncertainty.[11]

Overall, our results, in line with those obtained in the related literature, tend to support some of the main predictions of the permanent income and life cycle theories. In particular, saving is positively related to temporary income shocks (although admittedly our determinants do not properly distinguish between temporary and permanent income shocks) and demographic factors show great explanatory power. Of the other determinants, financial development and fiscal policies are also major factors at play. These results also show that the roles of income growth, inflation and urbanisation appear to be much more limited than reported in previous empirical literature.

[11] We consider an alternative measure of the 'uncertainty' proxy: country risk from the International Country Risk Guide database. This indicator is built by averaging five indicators: socioeconomic conditions, investment profile, corruption, religious tensions, and democratic accountability. Under this specification, the effect on uncertainty continues to be not 'significant' and the rest of the results remain in place.

4.2. Robustness of results

4.2.1. Model size priors

Under the BACE approach, Ley and Steel (2009) suggest that results may be sensitive to model priors: the model size priors. Although our procedure is not a pure BACE approach, we decided to assess to what extent our results are robust to different priors. As the maximum number of determinants, K=12, is computationally manageable, we examine the robustness with respect to this hyper-parameter k by considering all model sizes, i.e. from 1 to 12 explanatory variables.

Table 3 presents this exercise in an appealing way, reporting the posterior and prior probabilities of inclusion of a variable for alternative hyper-parameters k=1,…,12. For each model size k, the table highlights the variables with a posterior probability of inclusion higher that of the prior. In general, we observe that the selection of priors does not substantially affect our conclusions. The variables that revealed major explanatory power for private saving with a prior of k=6 appear to be robust to alternative prior specifications. First, independently of the different set of priors (k), domestic credit to the private sector, government surplus and terms of trade have major explanatory power. Second, demographic factors, namely life expectancy and old age dependency ratio, are important for most prior model sizes. Again, the posterior inclusion probability for the variable "GDP per capita relative to the US" is not far from the threshold (given by the prior probability) over the whole range of values for k.

Table 3

k	1	2	3	4	5	6	7	8	9	10	11
Private Savings / GDP (5 year averages)	**Prior inclusion probability (equal, k/12)**										
	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92
	Posterior inclusion probability										
Real interest rates	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.002
GDP growth	0.007	0.012	0.015	0.019	0.025	0.032	0.040	0.049	0.058	0.067	0.074
GDP per capita relative to US	0.056	0.117	0.176	0.231	0.286	0.344	0.408	0.479	0.558	0.650	0.763
Terms of trade (goods and services)	**0.998**	**0.996**	**0.994**	**0.993**	**0.993**	**0.993**	**0.994**	**0.995**	**0.995**	**0.996**	**0.996**
Real oil prices	0.017	0.042	0.074	0.107	0.138	0.169	0.202	0.242	0.297	0.381	0.536
Pop>65/Pop 15-64	0.040	0.148	**0.329**	**0.527**	**0.690**	**0.806**	**0.882**	**0.930**	**0.961**	**0.981**	**0.993**
Life expectancy	0.027	0.123	**0.291**	**0.474**	**0.625**	**0.731**	**0.798**	**0.838**	**0.859**	**0.861**	0.829
Urban population (%)	0.016	0.030	0.044	0.060	0.079	0.103	0.135	0.177	0.236	0.328	0.495
Domestic credit to private sector over GDP	**0.254**	**0.462**	**0.646**	**0.789**	**0.882**	**0.937**	**0.968**	**0.984**	**0.993**	**0.997**	**0.999**
Goverment surplus over GDP	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
Public Health Spending/GDP	0.056	0.082	0.083	0.070	0.055	0.044	0.037	0.036	0.042	0.058	0.110
Inflation	0.003	0.007	0.011	0.016	0.022	0.029	0.039	0.052	0.073	0.110	0.202

Variables in italics are considered as endogenous

4.2.2. Time trends

Although common time trends are captured by real oil prices in the baseline specification, we also consider an alternative approach for addressing unobserved global time effects. For this purpose, we construct a transformed model where dependent and explanatory variables are time-demeaned.[12]

The new specification is $\overline{\boldsymbol{y}}_{\boldsymbol{c,t}} = \boldsymbol{\eta_c} + \sum_{\boldsymbol{d=1}}^{\boldsymbol{D}} \boldsymbol{\beta_j} \overline{\boldsymbol{x}}_{\boldsymbol{d,c,t}} + \boldsymbol{\varepsilon_{c,t}}$, where $\overline{\boldsymbol{y}}$ and $\overline{\boldsymbol{x}}$ are the time-demeaned dependent and explanatory variables. For obvious reasons, it excludes real oil prices as an explanatory variable. This approach could potentially better ensure that our posterior estimates do not capture spurious relations related to time trends.

[12] Given that including 6 additional time dummies will expand the number of models to 2^{16}=65,536, we make use of the result of the equivalence of OLS estimates with time dummies and the estimates with the time-demeaned variables.

The results of this robustness exercise are reported in Tables 4 and 5 and there are no major differences from the baseline results. The main discrepancy is that life expectancy, despite having a posterior mean of similar magnitude, becomes not 'significant' (again in the sense of displaying a posterior inclusion probability higher than the prior probability). However, for all different priors (Table 5), this is the determinant with posterior inclusion probabilities close to the corresponding prior ones. This may be related to the fact that the time trend of life expectancy across countries is rather similar. Less important is the change of sign of the posterior means of real interest rates and inflation, since they are likewise not 'significant' in both approaches, casting further doubts on the importance and magnitude of both determinants. All this means that the effect of aggregate time trends does not bear on our core results.

Table 4

Private Savings / GDP (time demeaned model, 5 year averages) k=6	**Posterior inclusion probability** PIP	**Posterior mean** PMEAN	**Posterior st. deviation** PSTD
Real interest rates	0.001	0.161	0.392
GDP growth	0.009	0.240	0.531
GDP per capita relative to US	0.177	0.059	0.112
Terms of trade (goods and services)	0.961	0.053	0.032
Pop>65/Pop 15-64	0.900	-0.559	0.200
Life expectancy	0.364	1.010	0.910
Urban population (%)	0.133	-0.054	0.159
Domestic credit to private sector over GDP	0.950	-0.038	0.018
Goverment surplus over GDP	1.000	-0.535	0.129
Public Health Spending/GDP	0.262	-1.054	1.149
Inflation	0.117	-0.028	0.089

Variables in italics are considered as endogenous

Table 5

k	1	2	3	4	5	6	7	8	9	10
Private Savings / GDP (time demeaned model, 5 year averages)	**Prior inclusion probability (equal, k/11)**									
	0.09	0.18	0.27	0.36	0.45	0.55	0.64	0.73	0.82	0.91
	Posterior inclusion probability									
Real interest rates	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
GDP growth	0.000	0.000	0.001	0.002	0.005	0.009	0.018	0.035	0.068	0.137
GDP per capita relative to US	0.025	0.050	0.076	0.103	0.136	0.177	0.229	0.298	0.393	0.532
Terms of trade (goods and services)	**0.966**	**0.950**	**0.946**	**0.949**	**0.955**	**0.961**	**0.966**	**0.970**	**0.973**	**0.973**
Pop>65/Pop 15-64	**0.124**	**0.341**	**0.561**	**0.725**	**0.833**	**0.900**	**0.941**	**0.966**	**0.983**	**0.993**
Life expectancy	0.033	0.084	0.151	0.224	0.295	0.364	0.430	0.497	0.568	0.648
Urban population (%)	0.016	0.034	0.053	0.074	0.100	0.133	0.178	0.241	0.337	0.503
Domestic credit to private sector over GDP	**0.196**	**0.453**	**0.673**	**0.819**	**0.904**	**0.950**	**0.975**	**0.989**	**0.995**	**0.999**
Goverment surplus over GDP	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
Public Health Spending/GDP	0.007	0.035	0.084	0.144	0.204	0.262	0.318	0.375	0.436	0.510
Inflation	0.012	0.026	0.042	0.061	0.085	0.117	0.159	0.219	0.309	0.452

Variables in italics are considered as endogenous

4.2.3. Estimation with yearly data

As we explained in Section 3.1, our focus is on the medium-term determinants of private saving. For this purpose, following a standard approach in the literature, our baseline model is specified in terms of 5-year non-overlapping time averages. Nevertheless, in this section we run the same model using the original yearly data. The results are reported in Table 6. Interestingly, all the variables that were 'significant' (again in the sense of displaying a posterior inclusion probability higher than the prior probability) in the results for the 5-year average panel are again 'significant' and the posterior means for this set of 'significant' variables are quite close. Four additional variables (real interest rate, GDP growth, public health spending over GDP and inflation) display

a posterior inclusion probability higher than the 0.5 threshold in the model estimated with yearly data. The signs of the posterior means for the coefficients of these variables are consistent with the theory. Higher inflation and higher GDP growth are positively correlated with private saving, while higher public health spending is negatively related to private saving. In the case of the interest rates, the posterior mean of its coefficient is positive implying that higher real interest rates raises private saving or, in other words, the substitution effect predominates over the income effect. Our interpretation is that this variable might be contributing to the short-run dynamics of private saving, while its contribution to medium-term developments in private saving appears to be more limited. Finally, the remaining three variables (GDP per capita relative to the US, percentage of urban population and real oil prices) display very low posterior inclusion probabilities.

Table 6

Private Savings / GDP (yearly data) k=6	**Posterior inclusion probability** PIP	**Posterior mean** PMEAN	**Posterior st. deviation** PSTD
Real interest rates	1.000	0.178	0.121
GDP growth	0.998	0.096	0.104
GDP per capita relative to US	0.005	-0.030	0.039
Terms of trade (goods and services)	1.000	0.073	0.015
Real oil prices	0.087	0.000	0.014
Pop>65/Pop 15-64	1.000	-0.510	0.071
Life expectancy	1.000	1.531	0.184
Urban population (%)	0.127	0.131	0.072
Domestic credit to private sector over GDP	0.998	-0.030	0.006
Goverment surplus over GDP	1.000	-0.496	0.044
Public Health Spending/GDP	0.999	-0.732	0.292
Inflation	1.000	0.472	0.088

Variables in italics are considered as endogenous

4.2.4. Non-linearities

We also conducted some robustness analyses under the BMA approach to explore non-linear relationships between private saving and some of its determinants.

Aizenman et al. (2016) studied the impact of interest rates on private saving in an attempt to identify differences in the magnitude of this effect in terms of the conditioning variables involved. They also analysed how the impact of different drivers of private saving varies depending on the level of interest rates. In particular, among other results, they found that old age dependency ratios, public healthcare expenditure, and financial development have negative impacts on private saving, but those impacts in absolute value terms tend to become smaller as the real interest rate becomes lower. Table 7 shows the results of a model which includes the interaction of the domestic credit to GDP ratio with the real interest rate. We find that the posterior inclusion probability is very low and the results for the remaining variables hardly change with respect to our baseline specification.

Grigoli et al. (2016) analysed the impact of terms of trade on private saving. They examine this relationship not only in linear form but also where the terms of trade interact with other saving determinants. They found that higher terms of trade raise private saving and that this effect is larger for temporary terms of trade shocks when the volatility of the terms of trade is higher and when credit constraints are more binding. To test for this latter possibility we include an interaction between the terms of trade and the private credit to GDP ratio (see Table 7). In our

case, we find that this interaction term has a posterior inclusion probability higher than the prior probability (7/13=0.538). However, the posterior mean is positive, indicating that the impact of terms of trade on private saving increases with increasing private credit to GDP ratio. In contrast to Grigoli et al. (2016), we consider the stock of credit, while they take the flow of credit.

Finally, we try to find some evidence in relation to the oversaving behaviour of the developing economies of Asia. The literature (e.g. Horioka and Terada-Hagiwara, 2012) reports that the determinants of these trends in the past include the age structure of the population and the rapid growth of GDP in those countries. In our model the interaction terms of those two variables with a dummy for the Asian countries[13] are positive but have a low posterior inclusion probability.

Table 7

Private Savings / GDP (5 year averages) k=7	Posterior inclusion probability PIP	Posterior mean PMEAN	Posterior st. deviation PSTD
Real interest rates	0.001	-0.077	0.291
GDP growth	0.017	0.414	0.312
GDP per capita relative to US	0.377	0.129	0.104
Terms of trade (goods and services)	0.994	0.080	0.035
Real oil prices	0.125	0.050	0.039
Pop>65/Pop 15-64	0.841	-0.478	0.185
Life expectancy	0.773	0.988	0.442
Urban population (%)	0.120	-0.050	0.152
Domestic credit to private sector over GDP	0.953	-0.045	0.017
Goverment surplus over GDP	1.000	-0.604	0.088
Public Health Spending/GDP	0.037	-0.762	0.822
Inflation	0.027	0.634	0.410
Real interest rates * Priv. Credit/GDP	**0.002**	**-0.002**	**0.002**

Private Savings / GDP (5 year averages) k=7	Posterior inclusion probability PIP	Posterior mean PMEAN	Posterior st. deviation PSTD
Real interest rates	0.001	-0.028	0.271
GDP growth	0.006	0.436	0.290
GDP per capita relative to US	0.377	0.161	0.102
Terms of trade (goods and services)	0.995	0.082	0.035
Real oil prices	0.159	0.032	0.049
Pop>65/Pop 15-64	0.851	-0.501	0.210
Life expectancy	0.801	1.151	0.484
Urban population (%)	0.094	-0.073	0.165
Domestic credit to private sector over GDP	0.952	-0.045	0.017
Goverment surplus over GDP	1.000	-0.610	0.092
Public Health Spending/GDP	0.373	-0.862	0.873
Inflation	0.072	0.515	0.386
Pop>65/Pop 15-64 * Asia dummy	**0.217**	**0.234**	**0.285**

Private Savings / GDP (5 year averages) k=7	Posterior inclusion probability PIP	Posterior mean PMEAN	Posterior st. deviation PSTD
Real interest rates	0.002	0.051	0.573
GDP growth	0.009	0.391	0.317
GDP per capita relative to US	0.270	0.161	0.103
Terms of trade (goods and services)	0.521	0.098	0.044
Real oil prices	0.226	0.041	0.045
Pop>65/Pop 15-64	0.791	-0.417	0.196
Life expectancy	0.755	1.064	0.516
Urban population (%)	0.106	-0.035	0.164
Domestic credit to private sector over GDP	0.860	-0.108	0.064
Goverment surplus over GDP	1.000	-0.608	0.089
Public Health Spending/GDP	0.179	-0.940	1.141
Inflation	0.059	0.418	0.398
Ln Terms of trade * Priv. Credit/GDP	**0.650**	**0.001**	**0.001**

Private Savings / GDP (5 year averages) k=7	Posterior inclusion probability PIP	Posterior mean PMEAN	Posterior st. deviation PSTD
Real interest rates	0.000	-0.083	0.256
GDP growth	0.008	0.335	0.327
GDP per capita relative to US	0.287	0.133	0.103
Terms of trade (goods and services)	0.994	0.074	0.035
Real oil prices	0.187	0.036	0.054
Pop>65/Pop 15-64	0.923	-0.513	0.200
Life expectancy	0.831	1.122	0.511
Urban population (%)	0.101	-0.068	0.150
Domestic credit to private sector over GDP	0.976	-0.045	0.016
Goverment surplus over GDP	1.000	-0.588	0.087
Public Health Spending/GDP	0.156	-1.184	1.101
Inflation	0.035	0.605	0.393
GDP growth * Asia dummy	**0.440**	**1.220**	**0.631**

Variables in italics are considered as endogenous.

4.2.5. Gross national saving

Although the focus of our analysis is the behaviour of private saving, as a robustness exercise in Table 8 we report the results of applying the same methodological approach to national saving. We assume that national saving might be driven by the same factors included in our model for private saving, with the exception of government surplus over GDP, as this latter variable is part of the dependent variable. In the light of the results of Table 8, there are important differences between the determinants of private saving and those of national saving. In particular, only two of the five variables that were 'significant' (again in the sense of displaying a posterior inclusion probability higher than the prior probability) in the specification of private saving (private credit over GDP and the terms of trade) are also significant in the national saving specification. Apart from the government surplus over GDP, which is omitted in this specification, the two

[13] China, Hong Kong, India, Indonesia, Japan, Korea and Thailand.

demographic variables (life expectancy and the old age dependency ratio) are not 'significant', although interestingly the posterior inclusion probabilities for both of them are close to the corresponding prior probabilities for models with a larger prior size (Table 9).

There are two variables (inflation and GDP per capita relative to the US) whose posterior inclusion probabilities are above the 0.5 threshold in the national saving specification. And, in both cases, the signs of the posterior mean of their coefficients are consistent with the theoretical hypothesis. Higher GDP per capita relative to the US raises national saving, as richer countries tend to save more, while higher inflation raises national saving, by increasing precautionary saving.

Table 8

Gross National Savings / GDP (5 year averages) k=6	**Posterior inclusion probability** PIP	**Posterior mean** PMEAN	**Posterior st. deviation** PSTD
Real interest rates	0.040	-0.709	0.206
GDP growth	0.183	0.594	0.357
GDP per capita relative to US	0.967	0.225	0.118
Terms of trade (goods and services)	1.000	0.132	0.036
Real oil prices	0.137	0.014	0.025
Pop>65/Pop 15-64	0.125	-0.291	0.288
Life expectancy	0.316	0.431	0.453
Urban population (%)	0.104	-0.041	0.173
Domestic credit to private sector over GDP	0.869	-0.039	0.019
Public Health Spending/GDP	0.091	-0.699	0.903
Inflation	0.681	1.312	0.432

Variables in italics are considered as endogenous

Table 9

k	1	2	3	4	5	6	7	8	9	10
Gross National Savings / GDP (5 year averages)	**Prior inclusion probability (equal, k/11)**									
	0.09	0.18	0.27	0.36	0.45	0.55	0.64	0.73	0.82	0.91
	Posterior inclusion probability									
Real interest rates	0.047	0.048	0.047	0.045	0.043	0.040	0.036	0.028	0.018	0.007
GDP growth	**0.103**	0.098	0.109	0.127	0.149	0.183	0.238	0.338	0.516	0.778
GDP per capita relative to US	**0.859**	**0.908**	**0.931**	**0.946**	**0.958**	**0.967**	**0.974**	**0.980**	**0.986**	**0.992**
Terms of trade (goods and services)	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
Real oil prices	0.016	0.036	0.059	0.084	0.111	0.137	0.158	0.165	0.143	0.077
Pop>65/Pop 15-64	0.008	0.017	0.029	0.048	0.077	0.125	0.205	0.341	0.559	0.836
Life expectancy	0.031	0.070	0.117	0.173	0.238	0.316	0.411	0.533	0.691	0.872
Urban population (%)	0.011	0.022	0.036	0.053	0.075	0.104	0.145	0.206	0.306	0.500
Domestic credit to private sector over GDP	**0.882**	**0.892**	**0.886**	**0.878**	**0.872**	**0.869**	**0.872**	**0.885**	**0.914**	**0.960**
Public Health Spending/GDP	0.035	0.049	0.063	0.075	0.085	0.091	0.094	0.088	0.069	0.034
Inflation	**0.148**	**0.268**	**0.382**	**0.489**	**0.589**	**0.681**	**0.765**	**0.840**	**0.904**	**0.956**

Variables in italics are considered as endogenous

5. Policy application: Demographics and private saving

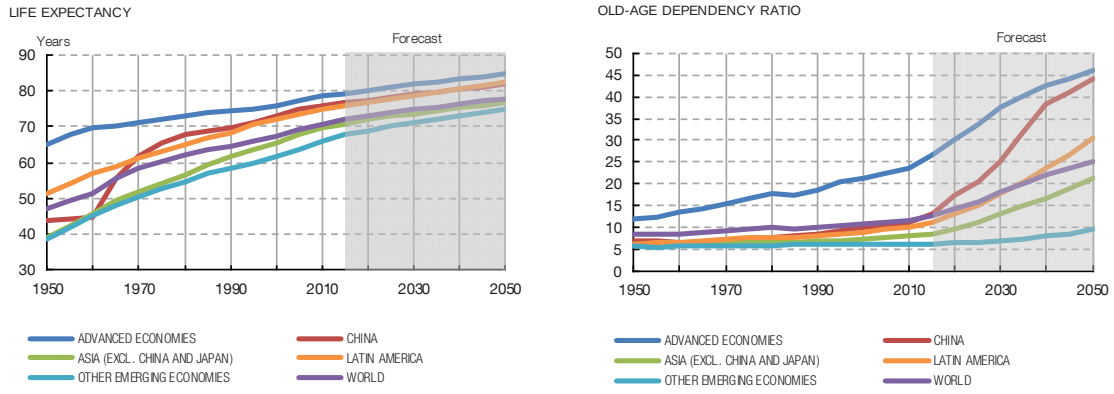
As pointed out in Section 2, the literature has emphasised the role of demographic factors in explaining the recent trends in saving across the world (Rachel and Smith, 2015). In this section we give a quantitative assessment of the expected consequences of demographic changes for the savings rate across countries. Consistently with the empirical literature, in the previous section we identified two demographic variables, namely life expectancy and old-age dependency ratio, with a 'significant' impact on the private saving ratio. To the extent that demographic projections are available for a long time span with a relatively high degree of certainty, it is possible to anticipate future pressures on private saving stemming from developments in population.

An increase in life expectancy will lead to an increase in saving in order to finance consumption over a longer period of retirement and for potentially higher health related spending. The secular

upward trend in life expectancy has continued in the last four decades both in advanced and emerging market economies. The gains in this variable have been significantly larger in the latter.[14] According to UN projections, this trend expected to continue in the coming decades at a similar rate (Figure 3, left-hand panel).

Changes in the age structure of the population also affect aggregate saving behaviour over time since the marginal propensity to save differs across age cohorts. In the initial stages of the ageing process, the aggregate propensity to save increases, as the middle-aged section of the population, which saves to finance their retirement periods, increases in weight. In later stages, as the relative weight of the eldest group increases, the propensity to save will tend to fall. While population ageing began in the developed countries in the 1980s, in many emerging economies it is beginning at the current period. These trends are clearly reflected in the path of the dependency ratio, as shown by the UN projections of population composition to 2050 by geographical area (Figure 3, right-hand panel).

Figure 3



SOURCE: United Nations (World Population Prospects 2017)

Following our baseline regression, an increase of one year in life expectancy at birth would raise the private saving rate by one percentage point (given a posterior mean of the estimated coefficient of 1.02). Therefore, other things equal, an increase in longevity generates additional incentives to save throughout the life cycle in anticipation of a longer retirement period. Eventually that would put downward pressure on real interest rates. On the contrary, an expected increase of five percentage points in the old-age dependency ratio would lead, according to our estimated model, to a reduction of 2.5 percentage points in the savings rate (given a posterior mean of the estimated coefficient of the old-age dependency ratio of -0.50). Thus, the increase in the dependency ratio would exert an upward pressure on interest rates.[15]

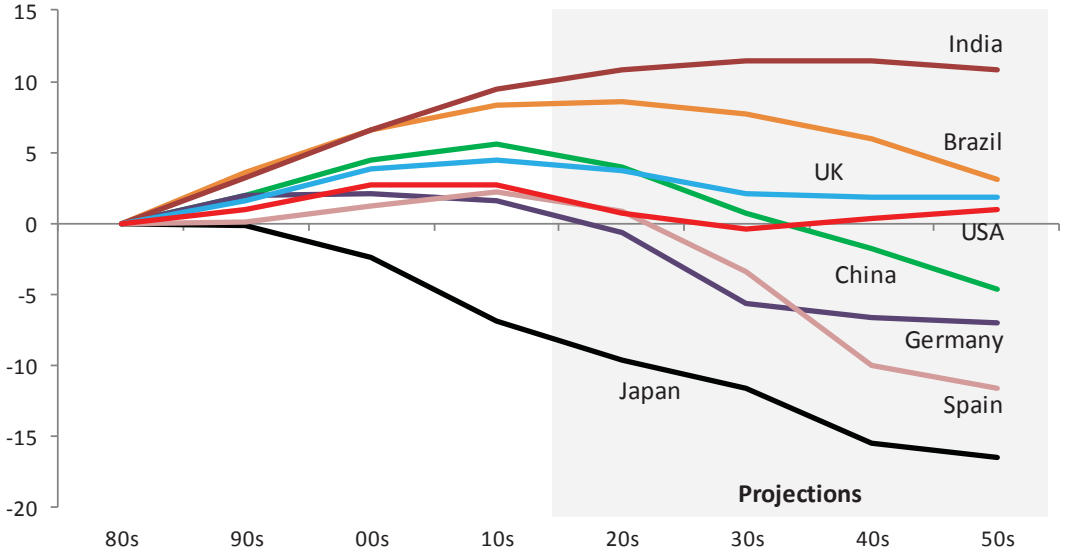
[14] Carvalho et al. (2016) show in a life cycle model that the increase in life expectancy may account for the bulk of the drop in the real interest rates of advanced economies as agents increase their saving.

[15] It is worth noting that the reduction in the working-age population inherent in this process will also have a supply effect. The decline in the labour force may generate a substitution of capital for labour, reducing the marginal product of capital. Thus, the possible upward pressure on the investment rate may have an offsetting effect on equilibrium real interest rate derived from the negative saving effect. For the euro area Ferrero et al. (2016) estimate an important negative effect of the projected dependency ratio on investment and output.

Figure 4 shows the joint effect of changes in life expectancy and the old-age dependency ratio on the private saving rate, both in the sample period and in the future, according to UN projections. Interestingly, as compared with the saving rate in the 1980s, the contribution of the changes in these variables –life expectancy and old-age dependency ratio–is positive throughout the sample period for all countries, with the exception of Japan. This results from the predominance of the effect of the increasing life expectancy, since the change in the old-age dependency ratio was moderate. However, in the near future, the widespread acceleration in the weight of the old-age population across the world will put downward pressure on savings. This may be especially notable for countries such as Japan, Spain or Germany. At the other extreme, in countries like India, where the demographic transition is less advanced, the contribution of demography to private saving will remain positive in the coming decades.

Figure 4

Change in contribution of life expectancy and dependency ratio to private saving (% GDP, 80s=0)



Source: Authors' calculations based on UN population projections

It must be considered that these expected trends in saving may also be affected by policy decisions. For example, certain European countries have been or are currently in the process of raising the age of retirement in order to boost the sustainability of their pension systems. And China has recently announced the end of the one child policy, to boost the birth rate. Thus, economic agents will endogenously change their life cycle consumption/saving path in response to these policies, potentially reversing the expected impact of these demographic trends.

6. Conclusions

The existing literature exhibits considerable uncertainty about the theoretical and empirical determinants of private saving across countries. A better understanding of private saving rates is a key element to assess medium-term macroeconomic challenges such as the pattern of real interest rates or global imbalances.

This paper reports new evidence on the drivers of private saving by applying Bayesian techniques, using data from the 35 world largest economies in the period 1980-2012. Our results are aligned with the theoretical predictions. However, our Bayesian approach confirms only a part of the results found in the empirical literature, in particular those of Grigoli et al. (2014). The BMA

methodology reduces the number of major determinants of private saving, such that financial development, fiscal policies, income effects through terms of trade and demographic variables have a great deal of explanatory power. Contrastingly, this paper shows that the roles of permanent income, inflation and urbanisation appear to be much more limited than previous literature suggests. These results are robust to a number of changes in the specification and proxies of the determinants.

In the policy arena, there is an ongoing debate on how demographics will affect private saving globally and, hence, real interest rates. Using the Bayesian estimates and the UN demographic projections, we provide a quantitative long-term assessment of how life expectancy and old-age dependency ratio changes across countries are expected to affect the saving rate. In the near future, the acceleration in the weight of the old-age population, quite widespread across the world, will put downward pressure on savings. This may be especially notable for countries such as Japan, Spain or Germany. At the other extreme, in countries like India, where the demographic transition is less advanced, the contribution of demography to private saving will still be positive in the coming decades. In any case, we must keep in mind that these expected trends on saving may be also affected by policy decisions.

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Appendix. Tables

Table A-1. Variables and sources

Variable	Description	Source
Saving	Gross national savings at current prices, local currency	IMF (WEO October 2013) and AMECO
Private saving	Gross private savings at current prices, local currency	IMF (WEO October 2013) and AMECO
Nominal gross domestic product	Gross domestic product at current prices, local currency	IMF (WEO October 2013)
Real gross domestic product	Gross domestic product at constant prices, local currency	IMF (WEO October 2013)
Real gross domestic product	Gross domestic product, volume 2005 US Dollar	OECD (Economic Outlook May 2014)
GDP per capita	Gross domestic product per capita based on PPP, current international dollar	IMF (WEO October 2013)
Terms of trade	Price of exports relative to imports	IMF (WEO October 2013)
Real interest rates	Long term goverment yield discounting expected inflation	Blanchard et al. (2014)
Domestic credit to private sector	Domestic credit to private sector	World Bank (World Development Indicators)
Pob>65/Pob 15-64	Pupulation aged 65 and over / Population aged 15 - 64	United Nations (2012 World Population Prospects)
Life expectancy	Life expectancy at birth	United Nations (2012 World Population Prospects)
Urban Population	Percentage of population living in cities	United Nations (2012 World Population Prospects)
Goverment surplus	General government net lending/borrowing	IMF (WEO October 2013)
Public Health Spending	Public Health Spending/GDP	Phillips et al. (2013)
Inflation	Annual growth rate of CPI	IMF (WEO October 2013)

Table A-2. Descriptive statistics (5-year average sample)

Variable	obs	mean	sd	min	max
Private saving over GDP	233	21.6	6.1	0.0	46.7
Real interest rates	184	3.2	2.4	-4.8	13.7
GDP growth	243	3.0	2.7	-10.2	11.4
GDP per capita relative to US	243	59.0	32.0	2.3	163.7
Terms of trade (goods and services)	236	102.0	26.9	51.1	350.9
Real oil prices	245	43.3	20.7	21.8	80.6
Pop>65/Pop 15-64	245	17.5	7.2	4.5	37.5
Life expectancy	245	73.8	6.1	52.6	82.8
Urban population (%)	245	70.2	17.6	20.8	100
Domestic credit to private sector over GDP	238	86.1	52.8	10.1	214.1
Goverment surplus over GDP	199	-2.3	4.5	-17.1	17.6
Public Health Spending/GDP	184	5.0	2.1	0.5	9.3
Inflation	241	27.0	137.2	-2.3	1690.2

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