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## The “Mother of All Puzzles” at Thirty:

### A Meta-Analysis

Christophe Tavera<sup>1,3</sup>, Jean-Christophe Poutineau<sup>1</sup>, Jean-Sébastien Pentecôte<sup>1</sup>, Isabelle Cadoret<sup>1</sup>, Arthur Charpentier<sup>1</sup>, Chantal Gueguen<sup>1</sup>, Maryline Huchet<sup>2</sup>, Julien Licheron<sup>1</sup>, Guillaume Loeillet<sup>1</sup>, Nathalie Payelle<sup>1</sup>, Sébastien Pommier<sup>1</sup>.

Revised version, November 18, 2014

#### Summary

This paper provides a meta-analysis of 1651 point estimates of Feldstein and Horioka saving retention coefficient from 49 peer-reviewed papers published over three decades. We get two main results. First, correcting for publication bias, we find a consistent underlying coefficient lying between 0.56 and 0.67 for studies using the original paper. Second, heterogeneity reported in the estimates of the Feldstein and Horioka can be explained by a few main factors. In particular, we find evidence that the saving retention coefficient is systematically underestimated with models written in first difference, models using the saving ratio or the current account ratio as the dependent variable instead of the investment ratio, and models including indicators of the public deficit or indicators of the country size as additional explanatory variables.

Keywords: Feldstein-Horioka coefficient; capital mobility; saving-investment correlation; meta-analysis

JEL Classification: F32, F40, C83

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# The “Mother of All Puzzles” at Thirty: A Meta-Analysis

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## Summary

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## 1. Introduction

In a pioneering paper, Feldstein and Horioka (1980) investigated the consequences of international financial integration on the correlation between domestic saving and investment. They argued that a low value of the saving retention coefficient should be observed in the case of perfect capital mobility. Testing this assumption over a cross section sample for 16 OECD countries, they found a value of the saving retention coefficient equal to 0.85 and failed to reject the null hypothesis of a one-to-one saving-investment association. They concluded that zero capital mobility was supported by the data, which appeared to be at odds with most theoretical models assuming perfect capital mobility and with the observed increasing financial integration. The Feldstein and Horioka puzzle was thus born.

More than thirty years after the publication of the original paper, the basic finding that national saving and investment are closely related has generated a huge theoretical and empirical literature. As an example, searching on EconLit for keywords related to the seminal publication of Feldstein and Horioka, we find that 994 articles have been published by December 2008, so that the literature on this topic has averaged 3 monthly papers since 1980. The Feldstein and Horioka result still remains more or less a stylized fact of international macroeconomics. It has even been crowned as “the mother of all puzzles” in international finance (Obstfeld and Rogoff, 2001).

This impressive literature that spans over thirty years is heterogeneous on several aspects: the saving investment link has been measured extensively for advanced and developing countries, for nations and regions, through various regression specifications, various estimation methods, and with alternative data frequencies. As a consequence, reported results are hardly comparable with one another on a direct basis. The quantitative evaluation of an underlying

consistent value of the saving investment relationship thus requires a more rigorous treatment such as the one provided by meta-analysis techniques.

Meta-analysis provides a set of quantitative methods to evaluate empirical results from different studies with similar characteristics or, alternatively, with different characteristics that can be controlled for. This method is helpful for clarifying controversial issues and has been used in various fields of economics such as international economics, public economics, transport economics... Regarding the field of international macroeconomics, this approach has already been applied to study different questions such as the trade effect of monetary union (Rose and Stanley, 2005), the impact of exchange rate volatility on trade (Ćrorić and Pugh, 2010), the correlation of business cycle between countries (Fidrmuc and Korhonen, 2006) or the analysis of capital controls (Magud et al., 2011).

The aim of this paper is to use the statistical tools of meta-analysis to determine the underlying consistent value of the saving-investment coefficient that can be extracted from this literature. This statistical approach is well suited for the question at hand since most papers have an empirical content and report at least one main estimated value. We do not provide a broad survey on the subject and we refer to Apergis and Tsoumas (2009) for a recent overview of this literature. Rather, we concentrate on a quantitative analysis of the underlying value of the saving retention coefficient that emerges from a selection of the published articles. Then we evaluate the factors that may explain discrepancies across estimates.

The conduct of our meta-analysis of the Feldstein and Horioka relationship is in line with the common practices of the field (Stanley et al., 2013, Havranek and Irsova, 2011). In a first step we build a representative sample of the literature - called the meta-sample - that has been published in peer-reviewed journals or working paper series, and we evaluate whether the selected studies are subject to publication biases. In a second step we proceed to a meta-

regression analysis (MRA) to determine whether the sample delivers a underlying true value for the saving retention coefficient, and to detect the possible factors that could explain the estimate heterogeneities.

In a previous study, Bineau (2010) provides a meta-analysis of the Feldstein and Horioka coefficient. We depart from this study on various aspects. First, we use a different meta sample to provide a complementary analysis of this question. We use a larger data set containing 1651 point estimates (instead of 1349) which proves worthwhile given the great number of papers published on this topic over the last 30 years. Second, his analysis mainly concentrates on the original way of measuring the puzzle that links the ratio of investment over output to the ratio of savings over output. In our paper we enlarge the analysis to alternative approaches provided in the literature (such as the current account as the dependent variable, the relation in variations rather than in levels...). Third, and mainly, Bineau (2010) finds evidence of a publication bias, but he leaves the correction for publication bias for future research, while the present study explicitly deals with the correction for publication bias.

To build a suitable meta-sample we have selected and codified 49 empirical studies drawn from Econlit with regard to their structure, keywords, statistical reports... This sample provides a total number of 1651 point estimates of the Feldstein and Horioka saving retention parameter. The whole sample mean of this parameter is 0.498, while reported values range from -1.70 to 2.09. Since the selected studies give 1 to 211 point estimates, we complete the OLS meta-regression with a mixed-effect multilevel estimation to correct for a potential dependence of results coming from the same paper or the same author(s). Our meta-sample is not subject to a Type I publication bias (which occurs when editors, referees, and/or researchers have a preference for a particular direction of results). However as it includes mainly peer reviewed articles we find a Type II bias (which arises when editors, referees, and/or researchers have a preference for results that are statistically significant).

To understand the heterogeneity in the saving retention coefficient, we codify each of the 1651 point estimates of the meta-sample with regard to 19 main characteristics related to the data, the specification of the estimated equation, the estimation method, and the publication features. Our contribution to the literature is twofold. First, we get a underlying true Feldstein and Horioka coefficient lying between 0.562 and 0.677 for the sub-sample sharing the main characteristics of the original Feldstein and Horioka (1980) paper. Second, heterogeneity in the estimates comes mainly from features related to the origin of variables or from the specification of the regression model. In particular, studies taking into account only developed countries in the sample or adopting econometric methods different from ordinary least squares (OLS), instrumental variables (IV), generalized method of moments (GMM), panel with either fixed or random effects (FE or RE respectively), overestimate the Feldstein and Horioka coefficient. In contrast studies adopting the saving rate or the current account as dependent variables, taking into account the public deficit or the country size as exogenous variables or estimating the Feldstein and Horioka relation in first difference tend to get lower estimates of the saving retention coefficient.

Thus despite the deepening of financial integration, the domestic saving-investment correlation that emerges from the literature, once corrected for alternative biases in the publication process, is high since it lies between one half and two thirds. There could be two ways of interpreting this main finding. On the one hand, since this abnormally strong figure is clearly at odds with financial integration, it questions the relevance of the Feldstein and Horioka regression as a way to measure capital mobility. On the other hand, one may be interested in identifying the external factors behind such a high correlation in a world of high capital mobility. In this alternative view, our reported value can be used as a benchmark for model calibration to assess the relative importance of the various sources of correlation between domestic savings and investment in a situation of perfect capital mobility.

The rest of the paper is organized as follows. Section 2 presents the selection process of the meta-sample and reports its main characteristics. Section 3 analyses the sources of the publication bias. Section 4 reports the result of the meta-regression and discusses the possible sources of heterogeneity of the saving retention parameters across studies. Section 5 concludes.

## 2. The meta-sample

### 2.1 The database

The first step of the analysis is to select a sample of papers that can be handled with the standard econometric tools of meta-analysis. The meta-sample should be both representative of this strand of literature and of a manageable size. This last aspect is critical for the literature on the Feldstein and Horioka puzzle, as this topic appears to have remained popular over the last thirty years. Searching in the EconLit database with the keywords related to the seminal publication we get 994 published articles as of December 2008, thus averaging 3 monthly papers over the period. This is also a safe way to avoid additional biases from more recent studies including “atypical” values for macroeconomic series such as Gross Domestic Product, investment and saving as a result of the recent financial crisis.

To proceed to a homogenous treatment of this literature, we have selected papers according to the following criteria: (i) The title of the paper should contain terms directly related to “Feldstein and Horioka”, “Saving”, “Investment”, “Current Account” or “Capital Mobility”; (ii) The paper should provide quantitative results (we have neglected fully theoretical papers). (iii) An abstract should be presented so that the presence of econometric estimations of the Feldstein and Horioka coefficients can be checked; (iv) The paper should be written in

English; (v) The paper should have been published in peer-reviewed journals or working paper series (in particular we have neglected book chapters and PhD dissertations). Studies that failed to satisfy at least one of the criteria (i)-(v) have been excluded from the meta-sample.

After having examined the remaining 159 articles, we then skipped studies that do not include any original econometric estimation of the Feldstein and Horioka model. As previously noticed in the study of Bineau (2010), many studies do not include any original econometric estimation of the Feldstein and Horioka model. Furthermore, most papers have been sorted out of the meta sample as they do not give enough precision concerning the type of estimated model (in particular, endogenous/exogenous variables should be clearly defined), the database (in particular, initial/final dates and periodicity should be clearly presented) or the empirical results (in particular, the coefficient of correlation, the estimated parameters, and the standard errors should be clearly reported). Each time one of these rather stringent criteria is not met, the study has been excluded from the meta sample. This stringent selection leaves us with only 49 papers. Noticeably, despite this selection, we have kept a total number of 1651 Feldstein and Horioka coefficients, each corresponding to one regression. Thus, our dataset is quite large with regard to the standard meta-analyses that have already been performed in international macroeconomics.

Table 1 presents (by chronological order of publication) the papers that have been selected in the meta-sample with regard to the number of provided estimates and the average value of the Feldstein and Horioka coefficient. Although our dataset spans from 1980 to 2008 two parts are worth noting: in the first 15 years, we only get 12 studies that conforms to our criteria while from 1996 to 2008, we have 41 papers. Thus the Feldstein and Horioka puzzle has remained a lively area of research in international macroeconomics during the last decade.

Furthermore, given our selection criteria, the dataset contains at least one paper per year since 1995, while we do not get any paper in 1982, 1985, 1988, 1993-1995, and 1997. However, as shown below, these publication characteristics do not significantly affect the “underlying true value” found for the Feldstein and Horioka coefficient in the meta-regression. The number of estimated Feldstein and Horioka parameters per paper ranks from 1 in Kim (2001) to 211 in Obstfeld (1996). The reported average value of the coefficient varies from 0.07 in Sinha and Sinha (2004) to 1.01 in Yamori (1995).

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Table 1. The meta-sample.

Publication year	Authors	Number of estimates	Average value of parameter	Publication year	Authors	Number of estimates	Average value of parameter
1980	Feldstein M., Horioka C.	20	0.85	2000	Decressin J. & Disyatat P.	58	0.51
1981	Sachs J.	14	0.56	2000	Coiteux M., Olivier S.	4	0.39
1983	Feldstein M.	12	0.85	2001	Obstfeld M., Rogoff K.	4	0.55
1984	Penati, A., Dooley M.	24	0.21	2001	Bordo M.D., Flandreau M.	12	0.58
1986	Frankel J.A.	48	0.56	2001	Corbin A.	16	0.63
1986	Obstfeld M.	19	0.6	2001	Kim S. H.	1	0.69
1987	Dooley M., Frankel J.A., Mathieson D.	24	0.67	2002	Blanchard O., Giavazzi F.	15	0.43
1989	Feldstein M., Bacchetta P.	81	0.62	2002	De Vita G., Abbott A.	4	0.62
1990	Bayoumi, T.	100	0.25	2002	Ho T.-W.	4	0.65
1991	Tesar L.	37	0.77	2003	Amirkhalkhali S., Dar A., Amirkhalkhali S.	20	0.55
1992	Simm S.	32	0.72	2003	Ho T.-W.	3	0.5
1995	Yamori N.	9	0.07	2003	Pelagidis T., Mastroiannis T.	1	0.91
1996	Coakley J., Kulasi F., Smith R.	4	0.77	2004	Kasuga H.	66	0.49
1996	Armstrong H., Balasubramanyam V., Salisu M.	18	-0.14	2004	Sinha, T., Sinha, D.	123	0.67
1996a	Jansen, W. J.	8	0.56	2005	Desai M., Foley C., Hines J.	3	0.69
1996b	Jansen W. J.	131	0.64	2005	Georgopoulos G.J., Hejazi W.	2	0.65
1996	Krol R.	12	0.41	2005	Kongkee K., Oh K., Jeong C.	12	0.58
1996	Obstfeld M.	211	0.50	2005	Boyreau-Debray G., Wei S.-J.	50	0.4
1996	Taylor A.M.	20	0.87	2005	Payne J.	2	0.23
1996	Krol R.	12	0.41	2006	Bagnai A.	143	0.59
1998	Hussein K.A.	46	0.87	2007	Kasuga H.	14	0.38
1998	Vamvakidis, A., Wacziarg, R.	84	0.28	2008	Nell K.-S., Santos L.D.	8	0.62
1998	Jansen, W. J.	40	0.72	2008	Pelgrin F., Schich S.	61	0.23
1999	Buch C.	8	0.52	2008	Fouquau J., Hurlin C., Rabaud I.	1	0.97
1999	Helliwell J.F., Mc Kittrick R.	10	0.52			1651	

## 2.2 The econometric practice

Besides heterogeneity in the (per paper) number and reported values of the saving retention coefficient, the meta-sample reveals the variety of practices adopted in the literature.

First it affects the choice of countries. As shown in figure 1a, 72% of the parameters have been estimated in papers with OECD data, 23% in papers with developing or emerging data while only 5% of the parameters have been estimated in papers with a database that combines developed, developing, and emerging countries. Second, as reported in Figure 1b, 45% of the parameters have been estimated in papers with cross section data, 35% in papers with time series data, while 20% of the parameters have been estimated with panel data.

Figure 1. Some characteristics of the meta-sample.

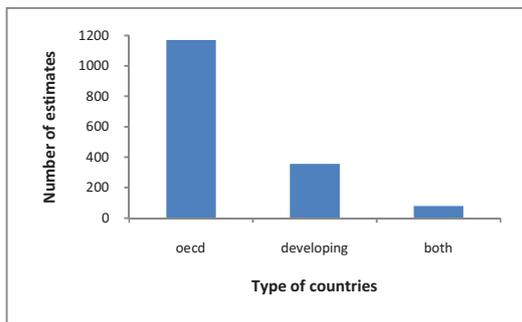


Figure 1a. Countries

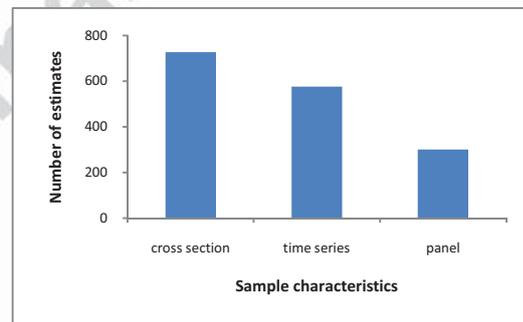


Figure 1b. Data pooling or ordering

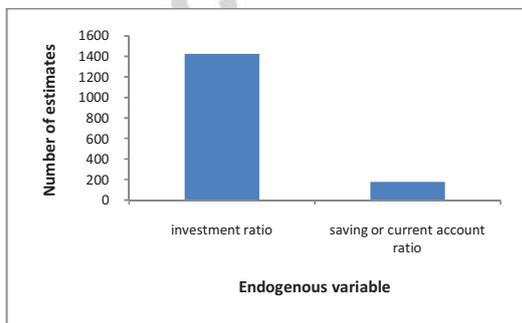


Figure 1c. Choice of endogenous variable

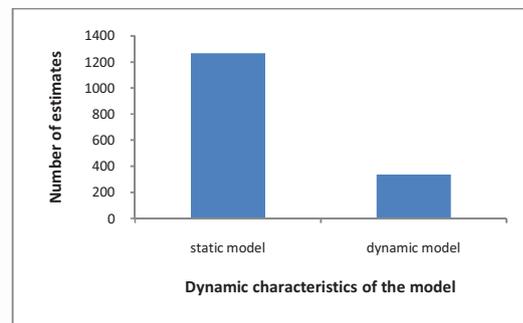


Figure 1d. Econometric specification

Econometric methods are also rather diversified, with regard to the choice of endogenous variable. The first estimated version of the Feldstein and Horioka coefficient that can be found in their original 1980 Economic Journal article is,

$$(I/Y)_i = \alpha + \beta(S/Y)_i + u_i, \quad i = 1, 2, 3, \dots, N. \quad (1)$$

In this relation,  $I$  is national investment,  $S$  national saving,  $Y$  national income and the subscript  $i$  refers to countries. Parameter  $\beta$  is the Feldstein and Horioka coefficient. Under the null hypothesis of perfect capital mobility,  $\beta$  is expected to be equal to zero.

While many papers have checked for the empirical validity of this standard version of the model with cross section models or panel data models, some other papers have proposed an alternative version focusing on current account developments. Since, the current account ( $CA$ ) is defined as the saving-investment gap,  $CA = S - I$ , equation (1) can be rewritten as,

$$(CA/Y)_i = -\alpha + (1 - \beta)(S/Y)_i + u_i, \quad i = 1, 2, 3, \dots, N. \quad (2)$$

According to this modified version, changes in saving are fully reflected in changes in investment and have no impact on the current account in a situation of capital market fragmentation. In this case,  $\beta = 1$ . However, as shown in Figure 1c, almost 90% of the Feldstein and Horioka coefficients of the meta-sample have been estimated by treating the investment ratio as the dependent variable, in line with Feldstein and Horioka's original paper.

As shown in Figure 1d, 75% of papers in the meta-sample take into account the dynamic aspects of the investment-saving relationship by estimating modified versions of equations (1) and (2) including lags of both the endogenous and/or exogenous variable. In this case, the model is estimated with time series data for a given country according to,

$$(I/Y)_t = \alpha + \sum_{k=1}^q \beta_k (S/Y)_{t-k} + \sum_{k=1}^p \gamma_k (I/Y)_{t-k} + \varepsilon_t, \quad t = 1, \dots, T, \quad (3)$$

in the case of a dynamic version of equation (1) with  $\varepsilon_t$  a white noise process.

The former specification allows one to distinguish short-term from long-run full capital mobility. In the short-run, the null hypothesis corresponding to complete capital market integration is given by:  $\beta_k = 0, \forall k = 1, \dots, q$ . Over a longer horizon, the null hypothesis is based on the moving average representation of equation (3). The resulting ratio of lag polynomials must equal zero if capital is perfectly mobile across countries:

$$\left( \sum_{k=1}^p \gamma_k L^k \right) \left( 1 - \sum_{k=1}^q \beta_k L^k \right)^{-1} = 0, \text{ setting the lag operator } L \text{ equal to one.}$$

Finally, some authors have selected a first difference version of the original regression (with or without co-integration relationships). Using time-variations instead of levels accounts for possible non-stationarity of the investment and saving variables and is more consistent with macro models based on intertemporal tradeoffs (Apergis and Tsoumas, 2009). In the case of no co-integration, the first-difference version of the relationship may be written as,

$$\Delta(I/Y)_t = \alpha + \sum_{k=0}^q \beta_k \Delta(S/Y)_{t-k} + \sum_{k=1}^p \gamma_k \Delta(I/Y)_{t-k} + e_t, \quad t = 1, \dots, T. \quad (4)$$

As shown in Figure 1, it should be noted that a majority of papers selected in our sample clearly adopt the main characteristics of the original analysis of Feldstein and Horioka. Besides the heterogeneity in the econometric practice encountered in the literature, they report estimations based upon cross section and OECD countries and treat investment as the endogenous variable.

### 2.3. Summary statistics

Figure 2 reports the distribution of the 1651 estimated values of the Feldstein and Horioka coefficient. As shown, this parameter varies from -1.70 to 2.09. The average value of the

Feldstein and Horioka coefficient is 0.498, the mode is 0.70 and the median is 0.56. It is clear from Figure 2 that the distribution is skewed to the left.<sup>3</sup>

Figure 2. The distribution of the Feldstein and Horioka coefficient estimates

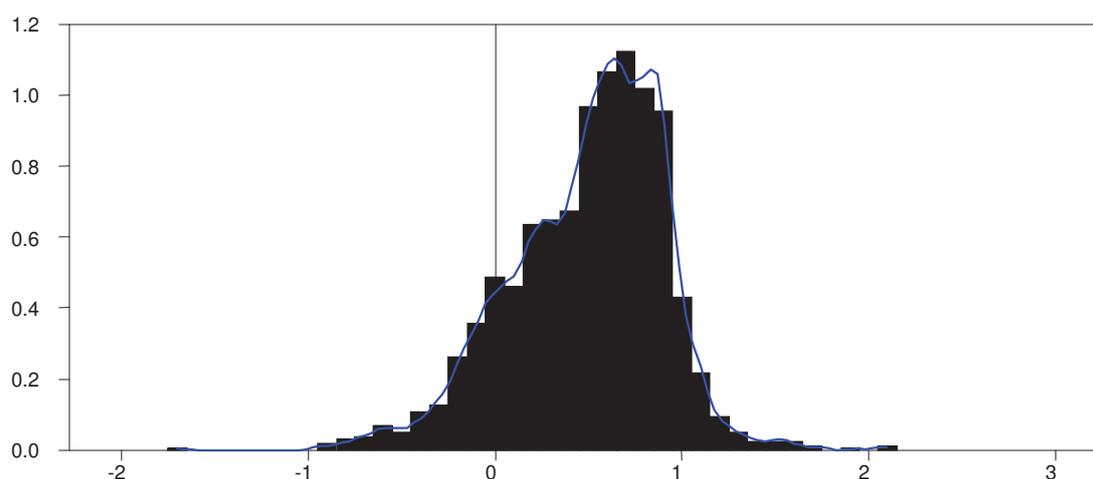


Table 2 reports additional descriptive statistics to outline some possible sources of heterogeneity in the estimates. The first row presents the statistics for the whole sample of Feldstein and Horioka coefficient estimates. The standard deviation is quite large (0.412) and there is a large variation in the reported parameters, as revealed by the comparison of the 10th and 90th deciles. This feature is in line with the high degree of heterogeneity in the estimates of the Feldstein and Horioka coefficient frequently encountered in the literature for individual

<sup>3</sup> Like Bineau (2010), we have found that some published papers provide some relatively high values of FH parameters. We have dismissed studies with beta values higher than 2.5. Actually, it concerns only one study reporting a beta value of 4.06. Such values are difficult to interpret since the beta coefficient is expected to lie somewhere between 0 and 1 to reflect the degree of international capital market integration. Keeping the corresponding study in our sample would have required a specific treatment to avoid the potential bias of this outlier.

countries. However, as the median and the mean values do not differ widely, the Jarque-Bera test statistics leads to rejection of the null hypothesis that the Feldstein and Horioka coefficient is normally distributed (P. value = 0.000).

We provide a preliminary inspection of the basic influence of sample details and equation characteristics on the Feldstein and Horioka coefficient estimates, by reporting descriptive statistics obtained for alternative sub-samples. As can be seen, the mean value of the coefficient is sensitive to the characteristics of the sample and to the specification of the model. The largest mean is obtained with cross section samples while the lowest is obtained for the panel data sub-sample. Moreover, the mean value of the Feldstein and Horioka coefficient is lower with models in variations than with models in levels. These results might indicate that while models estimated with cross section samples capture some form of long-run equilibrium relationship between saving and investment, the Feldstein and Horioka coefficients estimated with panel data are affected by both the long-run equilibrium and the short-run temporary co-variation between saving and investment.

Table 2. Summary statistics of the sample

	Mean	Std. error	10th percentile	Median	90th percentile	Observations
Whole sample	0.498	0.412	-0.060	0.563	0.930	1651
Cross section <sup>(a)</sup>	0.550	0.391	-0.054	0.660	0.916	375
Time series <sup>(a)</sup>	0.489	0.442	-0.076	0.530	1.020	297
Panel <sup>(a)</sup>	0.389	0.379	-0.056	0.440	0.760	154
Level <sup>(a)</sup>	0.530	0.401	-0.027	0.601	0.933	611
Variation <sup>(a)</sup>	0.405	0.429	-0.117	0.430	0.926	214

### 3. The publication bias

As underlined by Havranek and Irsova (2011), the average value of the estimated parameter is a biased estimate of its underlying true value. The meta-sample may be subject to some bias as some coefficient values may be over represented in our selection. Before proceeding to the meta-regression we thus investigate whether the meta-sample at hand is subject to publication bias. It is also important to know whether that sample reveals a “true” underlying value for the Feldstein and Horioka coefficient that is unaffected by the publication process. In what follows we distinguish between these Type I and Type II biases.

#### 3.1 Type I publication bias

Type I bias occurs when editors, referees, and/or researchers favor a particular direction of results. Following the underlying theory that links saving, investment, and the current account, estimates of the Feldstein and Horioka coefficient are expected to lie between 0 and 1. Thus, negative estimates of the Feldstein and Horioka coefficient, for instance, might be ignored as an increase in national saving that reduces national investment could be puzzling.

The detection of a Type I publication bias commonly starts with the so called “funnel plot” (Egger et al., 1997) which compares the value of the Feldstein and Horioka coefficient with the inverse of its standard error. The meta-sample is bias free, if the plot represents an inverted funnel: with rising sampling error, estimated Feldstein and Horioka coefficients are expected to scatter more widely. Indeed, observations with high precision should be concentrated closely around the true effect, while those with lower precision should spread at

the bottom of the plot. In the absence of Type I publication bias, the funnel plot is thus symmetric around the genuine empirical effect.

Figure 3. Funnel plot

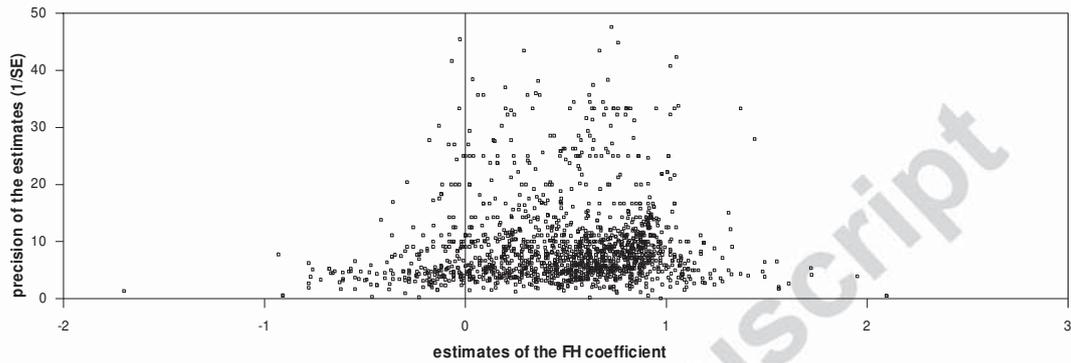


Figure 3 displays the funnel plot for the whole sample (but without outliers). Although the scatter plot does not exhibit the typical perfect shape of an inverted funnel, it globally shows the expected pattern: wide variation of point estimates at the bottom and lower variation at the top. Clearly, there is an apparent overrepresentation of studies with low standard errors as it is supposed to be the case without publication bias. The results with greater standard errors move widely but are underrepresented. While the figure seems to have two peaks which could be considered as an indication of two different groupings of coefficients, this visual impression is mainly the result of a small set of estimates with an inverse of their standard error larger than 40. Moreover, a visual inspection places the top portion of this funnel close to zero and the average value of the top ten points on Figure 3 is close to 0.35.

This visual investigation can be supplemented with explicit regression tests. To implement the Funnel Asymmetry Test (FAT) we run the following regression,

$$FHC_i = \delta + \theta SE_i + u_i, \quad i = 1, \dots, 1651, \quad (5)$$

where  $FHC_i$  is the  $i^{\text{th}}$  estimate of the Feldstein and Horioka coefficient,  $SE_i$  is the standard error of the  $i^{\text{th}}$  point estimate, and  $u_i$  is the regression error term. In this equation,  $\delta$  denotes the true Feldstein and Horioka coefficient and  $\theta$  is the size of the publication bias. However the stochastic term in equation (5) is heteroskedastic because  $SE_i$  is a sample estimate of the standard deviation of the dependent variable  $FHC_i$ . Stanley (2008) suggests dividing equation (5) by the standard error of the Feldstein and Horioka coefficient, to perform a weighted least squares estimation. This is achieved by running a simple OLS estimation on the transformed bivariate meta-regression,

$$t_i = \theta + \delta \left( \frac{1}{SE_i} \right) + v_i, \quad i = 1, \dots, 1651, \quad (6)$$

where  $t_i$  is the  $t$ -statistic measuring the significance of the  $i^{\text{th}}$  Feldstein and Horioka coefficient. Equation (6) represents a regression line through the funnel graph, rotated by 90 degrees and adjusted for heteroskedasticity. The Funnel Asymmetry Test (FAT) for publication bias is a simple  $t$ -test on the intercept of equation (6): a value of  $\beta$  significantly different from 0 indicates a publication bias in the sample. Moreover, values of  $\beta$  close to 2 may also be taken as a signal of extreme publication bias and may be consistent with a situation such that all studies display positive and significant estimated Feldstein and Horioka coefficients while the underlying true one is zero. Moreover, if  $\beta$  is significantly positive (or negative), then the effect size is subject to an upward (or downward) bias.

However, as 96% of the studies selected in the meta-sample report more than one value for the Feldstein and Horioka coefficient, estimates from the same study are likely to be dependent. By so, according to Disdier and Head (2008), equation (6) is likely to be misspecified. Thus we must run a mixed-effects multilevel model and account for within-study dependence (Doucouliagos and Stanley, 2009) by incorporating a random individual effect for each study, so as to capture between-study heterogeneity. According to the mixed-effects multilevel model, the regression for the  $t$ -statistic of coefficient  $i$  in study  $j$  ( $t_{ij}$ ) should be,

$$t_{ij} = \theta + \delta \left( \frac{1}{SE_{ij}} \right) + \lambda_j + \eta_{ij}, \quad i = 1, \dots, 1651, \quad (7)$$

where  $\lambda_j$  is the study level random effect and  $\eta_{ij}$  is a disturbance term. Moreover, as the process of selecting estimates from the literature makes the meta-analysis highly vulnerable to data contamination, the robustness of the funnel asymmetry test is checked by re-estimating equations (6) and (7) with the robust Least Absolute Deviations (LAD) estimation procedure. Results are reported in Table 3.

Table 3. Tests for Type I publication bias.

Dependent variable = <i>t</i> -statistic on the Feldstein Horioka coefficient				
	$\theta$	$\delta$	Sample	$R^2$
	(bias)	(precision effect)	size	
OLS estimator				
Basic model (Eq. 6)	-0.117 (-0.69)	0.534*** (37.46)	1651	0.47
Mixed effect multilevel model (Eq. 7)	2.011 (0.99)	0.493*** (30.74)	1651	0.63
Least Absolute Deviations estimator				
Basic model (Eq. 6)	-0.318* (-1.85)	0.615*** (42.38)	1651	0.53
Mixed effect multilevel model (Eq. 7)	0.869 (0.41)	0.602*** (35.81)	1651	0.66

Notes: Absolute values of the *t*-statistics in parentheses. \*\*\*, \*\*, and \* indicate significance at the level of 1%, 5%, and 10%, respectively.

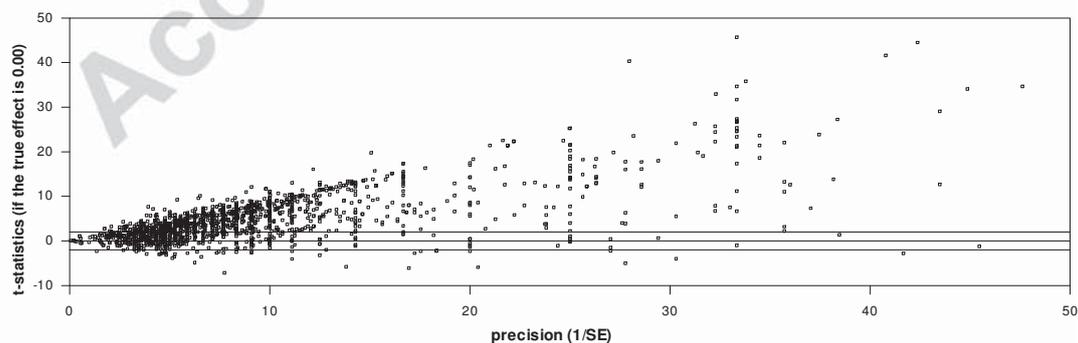
The  $\theta$  coefficient (intercept term) is statistically non significant in nearly all cases. It appears as marginally significant at the 10% confidence level only in the case of the Least Absolute Deviations estimation of the basic model that does not correct for within study dependence. Thus we can sensibly accept the null hypothesis of no Type I publication bias.

### 3.2 Type II publication bias

Type II publication bias occurs when editors, referees, and/or researchers promote results that are statistically significant. This kind of bias may be induced by the self-censoring behavior of authors or by the decision process of peer-reviewed journal editors which favors papers with high significance levels for the main estimates. Smaller samples and limited degrees of freedom reduce the probability of finding significant results. Type II publication bias may thus appear when researchers using small samples are inclined to search across econometric “tools” (proxies, estimators, specifications) to produce more significant results. Type II bias can thus make empirical effects appear larger than the true effect (Stanley et al. 2008).

Type II bias can be detected with the Galbraith (1988) plot that reports the estimated precision of the Feldstein and Horioka coefficient against the corresponding  $t$ -statistics and the assumed true effect. In case of Type II selection bias, large values (in absolute terms) will be over reported and there will be an excessive likelihood of reporting significant results. In case of no Type II publication bias and of the true effect (labeled TE) was really true, the statistics  $\left| (FHC_i - TE) / SE_i \right|$  should not exceed 2 more than 5% of the time and the cloud should be randomly distributed around 0, with no systematic relation to precision.

Figure 4. Galbraith plot for the whole sample.



As shown in Figure 4, the reported  $t$ -statistic exhibits both a wide variation and seems to increase with rising precision. Assuming that there is no underlying true effect ( $TE = 0$ ), only 5% of the studies should report  $t$ -statistics larger than 2. However, we find that about 58% of

the studies report  $t$ -statistics greater than the associated critical value for a 5% threshold (the test that the proportion of significant  $t$ -statistic is equal to the expected 5% is strongly rejected with  $z = 62.02$  and  $p < 0.0000$ ). Alternatively, if we use the top ten points of the funnel graph to estimate the true effect as 0.35, the null hypothesis that the proportion of significant  $t$ -statistic is equal to 5% is still clearly rejected by the data ( $z = 62.57$  with  $p < 0.0000$ ). While the Feldstein and Horioka coefficient seems unaffected by Type I publication bias, the Type II bias is clearly present among the studies at hand, according to the Galbraith plot. This result is in line with the nature of the meta-sample that mostly incorporates peer-reviewed journal articles. This result is consistent with Bineau (2010) who also finds an evidence of publication bias with a funnel graph analysis. However, while he leaves the correction for publication bias for future research, the present paper uses a multivariate empirical framework which explicitly deals with the correction for publication bias.

### 3.3 The underlying true effect

Besides the detection of publication bias, we check whether the meta-sample delivers an underlying true value for the Feldstein and Horioka coefficient. The true effect is a generic term used in meta-analysis. Its computation rests on two assumptions: first, there exists a unique value for the Feldstein-Horioka parameter for a given degree of capital mobility; second, the two previous publication biases have been cleaned from the estimates.

The method of testing for Type I bias can be used to test the significance of the true effect irrespective of the publication selection process. The Precision Effect Test (PET) is a simple  $t$ -test on the slope coefficient  $\theta$  of equation (6). Monte Carlo simulations show that publication bias is quite efficiently filtered out by equation (6) so that the true effect seems to be adequately estimated. Empirical results presented in Table 3 show that the null hypothesis of no underlying true effect is always rejected at 5% since the estimated true effects are statistically significant for the whole sample and for both subsamples. These results are insensitive to the estimation procedure. For the whole sample, the 95% confidence intervals reported by the Precision Effect Test are [0.506; 0.562] with OLS estimators and [0.587; 0.644] with Least Absolute Deviations estimators for the simple bivariate model (6). For the mixed-effects multilevel model (7), the 95% confidence intervals are [0.462; 0.525] with OLS and [0.569; 0.635] with the Least Absolute Deviations method. As can be seen, the sensitivity of the results is rather weak with regard to the estimation procedure. Thus, the underlying true effect obtained for the Feldstein and Horioka coefficient corrected for Type I bias is rather stable.

As a robustness check (Stanley, 2005), we must take into account that this procedure for testing for the underlying true effect is reliable only if  $\sigma_v^2 \leq 2$ . Misspecification biases can lead to overestimated true effect when  $\sigma_v^2 > 2$ . As both the null  $H_0: \sigma_v^2 \leq 2$  and the null of no true effect are systematically rejected by the data, we use the Precision Effect Estimate with Standard Error (PEESE) introduced by Stanley et al. (2008) to estimate the size of the underlying true effect. The PEESE assumes that publication bias is related to the variance of the estimate of the TE instead of the standard error (as with the PET). Equations (6) and (7) thus respectively becomes,

$$t_i = \rho SE_i + \delta \left( \frac{1}{SE_i} \right) + v_i ,$$

$$i = 1, \dots, 1651, \quad (8)$$

and,

$$t_{ij} = \rho SE_{ij} + \delta \left( \frac{1}{SE_{ij}} \right) + \lambda_j + \eta_{ij} ,$$

$$i = 1, \dots, 1651. \quad (9)$$

With the PEESE estimates, the

$\delta$  coefficient is still strongly significant in both (8) and (9). When estimating (8), the corresponding 95% confidence intervals are

[0.510;0.544] with OLS and

[0.563;0.598] with Least Absolute Deviations. Alternatively, the 95% confidence intervals become

[0.471;0.539] and

[0.587;0.659] when (9) is estimated with OLS and Least Absolute Deviations estimators respectively.

#### 4. The meta-regression

The aim of this section is to determine whether the choice of a particular econometric approach affects the estimated value of the Feldstein and Horioka coefficient of the meta-base. Besides the bias introduced by the publication process studied in the previous section, we now focus on the impact of modeling and data choices on the value of the estimated parameters. To understand how these factors may affect the estimated value of the saving retention coefficient, we use the general version of the FAT-PET method to estimate the multivariate meta-regression,

$$t_i = \beta + \alpha^2 \left( \frac{1}{SE_i} \right) + \sum_{k=1}^K \gamma_k^2 \left( \frac{Z_{ki}}{SE_i} \right) + \omega_i, \quad i = 1, \dots, 1651, \quad (10)$$

where each variable  $Z_{ki}$ , ( $k = 1, \dots, K$ ) is a meta-independent variable that is assumed to potentially affect the estimate of the saving retention coefficient and where  $\omega_i$  is the meta-regression disturbance term, with standard characteristics. Each of the  $Z_{ki}$  variables is weighted by  $(1/SE_i)$  and the  $\gamma_k$  are  $K$  coefficients to be estimated, where each one measures the impact of the corresponding variable on the saving retention coefficient.

#### 4.1 Selection of explanatory variables

The nature and coding adopted for the explanatory variables  $Z_{ki}$  are presented in table 4. As shown, each of the 1651 point estimates of the Feldstein and Horioka coefficient have been coded with regard to  $K=19$  main characteristics related to the data, the specification of the estimated equation, the estimation method, and the publication features.

First, regarding data characteristics, we include dummy variables to account for cross sectional data (CROSS), time series data (TIME), and panel data (PANEL). We also distinguish between samples dealing with country (COUNTRY), and regional (REGIONS) datasets. Finally regarding the nature of the dataset used in papers we distinguish between papers that mix developed, and developing or emerging countries (MIXED), papers centered on OECD countries (DEVED) and papers focusing only on developing and emerging countries (DEVING). In order to control for possible structural changes in the Feldstein and Horioka coefficient, we finally include the average year of the data period (AVGYEAR).

Second, the specification of the estimated relation distinguishes between equations in which investment is the endogenous variable (ENDOINV) and equations with saving (or current account) as the endogenous variable (ENDOSCA). Dummies have also been introduced to account for variables aimed at controlling for the macroeconomic characteristics of the country. With regard to the literature, three variables have been selected: the level of public deficit (PUBDEF), the level of foreign investment (FORINV) and a measure of the country size (COUNTSIZE).

Table 4. Acronyms and description of regression variables

Variable	Description of code	Obs
Data characteristics		
CROSS	= 1, if cross-sectional data are used, 0 otherwise	782
TIME	= 1, if time series data are used, 0 otherwise	620
PANEL	= 1, if panel data are used, 0 otherwise	323
COUNTRY	= 1, if national data are used, 0 otherwise	1553
REGION	= 1, if only regional data are used, 0 otherwise	172
MIXED	= 1, if developed and developing countries data are mixed, 0 otherwise	84
DEVED	= 1, if the analyzed countries are developed countries, 0 otherwise	1258
DEVING	= 1, if the analyzed countries are developing or emerging, 0 otherwise	383
AVGYEAR	The average year of the data used	1651
Specification characteristics		
ENDOINV	= 1, if investment is the dependent variable, 0 otherwise	1536
ENDOSCA	=1, if saving or the current account is the dependent variable, 0 otherwise	189
PUBDEF	= 1, if an indicator of public deficit is included, 0 otherwise	154
FORINV	= 1, if an indicator of foreign investment is included, 0 otherwise	87
COUNTSIZE	= 1, if an indicator of the country size is included, 0 otherwise	140
Estimation characteristics		
LEVEL	= 1, if the regression model is in levels, 0 otherwise	1302
DIFF1	=1, if the regression model is in first differences, 0 otherwise	423
STEM	= 1, if standard estimation methods such as OLS, IV, GMM, Panel fixed effects or random effects procedures are used, 0 otherwise	1425
NSTEM	= 1, if non standard estimation methods are used, 0 otherwise	300
Publication characteristics		
PUBYEAR	Year of publication	1651

Third, regarding estimation characteristics we proceed as follows: we first distinguish between models in level (LEVEL) and models in first differences (DIFF1) to control for the dynamic properties of the estimated models. We also create dummies for standard econometric methods such as OLS, IV, GMM, panel fixed effects or random effects (STEM) and for all other estimation procedures (NSTEM).

Finally, regarding publication characteristics, the publication year is also included in the list of explanatory variables in order to capture a possible publication trend induced by advances

in the econometric methodology or the inclusion of new variables with different properties in terms of a deeper integration of financial markets.

#### 4.2 Results of the multivariate meta-regression

We report the results of the multivariate meta-regression in Table 5. As it is well known, dummies have to be omitted to avoid linear dependence. In this case, the constant term represents the effects of omitted dummies. Here, the constant term captures the influence of CROSS, COUNTRY, MIXED, ENDOINV, LEVEL and STEM. This choice, that reflects the most standard practices encountered in our dataset, does not affect the whole results of the analysis. We begin the multivariate analysis by including all explanatory variables into the regression and estimating the resulting model with OLS. As a robustness check, random individual effects for each study are added to the meta-regression model (as in the mixed-effects multilevel model).

As indicated by the F-statistics, the estimated coefficients of the meta-regression are jointly significant. The overall quality of fit is good for both models, although it is higher with the mixed-effects multilevel model than with the basic MRA FAT-PET model. In addition to the highly significant coefficient on the PRECISION variable, the estimated coefficients associated with the fifteen explanatory variables are significant at the ten percent confidence level for nine variables in the basic meta-regression FAT-PET model and for eight variables in the mixed-effects multilevel model.

Table 5. Estimated parameters of the meta-regression.

Dependent variable: t-statistic of the estimated Feldstein and Horioka coefficient		
	Basic MRA FAT-PET model	Mixed-effects multilevel model
Explanatory variables		
CONSTANT	-0.692 (-4.13)***	
PRECISION	0.677 (8.78)***	0.562 (5.80)***
TIME	0.09 (3.16)***	0.012 (0.29)
PANEL	-0.041 (-1.58)	-0.100 (-3.03)***
REGIONS	-0.019 (-0.70)	-0.009 (-0.24)
DEVED	0.149 (5.05)***	0.097 (2.73)***
DEVING	-0.046 (-1.37)	-0.046 (-1.25)
ENDOSCA	-0.321 (-12.18)***	-0.309 (-10.12)***
PUBDEF	-0.175 (-4.91)***	-0.316 (-5.99)***
COUNTSIZE	-0.219 (-4.94)***	-0.37 (-5.12)***
FORINV	0.064 (1.79)*	0.055 (0.95)
DIFF1	-0.321 (-13.98)***	-0.352 (-10.86)***
NSTEM	0.308 (9.87)***	0.464 (10.00)***
AVGYEAR	-0.001 (-1.11)	0.001 (0.92)
PUBYEAR	-0.001 (-0.42)	0.000 (0.01)
R <sup>2</sup>	0.653	0.844
F-test <sup>(a)</sup>	210.22 (P. value = 0.000)	66.83 (P. value = 0.000)

Notes: t-statistics in parentheses. \*\*\*, \*\*, \* denote significance at the level of 1, 5, and 10%, respectively. <sup>(a)</sup> H0: Independent variables are jointly equal to zero.

Results reported in Table 5 should be interpreted as follows: a positive and significant coefficient on a given variable suggests that this study characteristic increases the reported Feldstein and Horioka coefficient with regard to its underlying true value. Conversely, a negative and significant coefficient suggests that the corresponding study characteristic reduces the reported Feldstein and Horioka coefficient with regard to its underlying true

value. As the inverse of the standard error (precision) affects all the moderator variables in (9), the underlying true effect (or the authentic effect) is captured by a combination of all explanatory variables in the multivariate meta-regression.

However, the coefficient associated with the PRECISION variable cannot be interpreted as the estimated underlying true Feldstein and Horioka coefficient. More precisely, the omitted dummies are CROSS, COUNTRY, MIXED, ENDOINV, LEVEL and STEM. The second and third columns of Table 5 suggest that the underlying true coefficient is between 0.562 and 0.677 in the sub-sample of studies with the following characteristics: the ratio of investment to GDP is used as the dependent variable, the database contains cross section data and only includes country data for both developed and developing countries, the model is specified in levels and is estimated with standard econometric procedures. Though being of the same order of magnitude, the PRECISION estimate from the basic model (column 2) is significantly higher<sup>4</sup> than the corresponding estimate from the mixed effect models (column 3).

The effect of the sample structure is measured through the dummies TIME and PANEL (the CROSS variable is excluded from the model). As can be seen, the effect of the TIME dummy is unclear since it is significant in the basic FAT-PET meta-regression model but insignificant in the mixed effect multilevel model. The effect of the PANEL dummy may also be considered as statistically unclear: While it is significant with the mixed effect multilevel model, it is marginally significant with the basic FAT-PET meta-regression model. Moreover, as it is negative in both models, it seems that panel data studies are more likely to report lower Feldstein and Horioka coefficients.

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<sup>4</sup> A comparison test for equal means yields a t-statistic equal to 37.73 that is far above the standard critical value at the 5 percent level from a standard Gaussian distribution given the (relatively large) sample size.

The REGIONS and DEIVING dummies are always non significant, thereby suggesting that the use of regional data instead of country data and/or the use of datasets including only developing countries does not change significantly the underlying true Feldstein and Horioka coefficient. Only the DEVED dummy is significant in both models. As the associated coefficient is systematically positive, studies using only developed countries datasets yield a larger Feldstein and Horioka coefficient. This result which is consistent with Dooley et al. (1987) may be attributed to the “country size” factor. Samples of developed countries include countries that are able to affect world interest rates. Thus their saving-investment correlation may be biased upwards even under conditions of perfect capital mobility.

The characteristics of the estimated equation also matters. First, the coefficient associated with the ENDOSCA dummy is negative and highly significant so that there is some evidence that estimated Feldstein and Horioka coefficients are lower when the estimated model uses saving or the current account as the endogenous variable instead of investment. Second, the dynamic structure of the model affects the estimated value of the saving retention coefficient as shown by the significance of the DIFF1 dummy. Models in first differences produce lower estimated values of the Feldstein and Horioka coefficient. As models in first differences are generally designed to capture the short run temporal characteristics of the data, this result might indicate that these models only capture the short run co-movement between investment and saving and tend to underestimate the underlying true Feldstein and Horioka coefficient.

These two effects are rather large in absolute value so that the size of the estimated investment-saving correlation is significantly influenced by the structure and the specification of the selected empirical model. The point estimate of the ENDOSCA dummy implies that the investment-saving correlation is reduced by an amount close to 0.3 in the subsample of studies using saving or the current account as the endogenous variable. More precisely, the choice of the saving ratio or of the current account ratio instead of the investment ratio as the

dependent variable in the regression model lowers the estimate from 0.677 to 0.356 (with the basic FAT-PET model) or from 0.562 to 0.353 (with the mixed-effects multilevel model). Because the point estimate of the DIFF1 dummy is also close to 0.3, the estimated Feldstein and Horioka coefficient is lowered by a similar amount in the subsample of studies using a regression model including first differences of the variables instead of levels.

While the inclusion of an indicator of foreign investment (FORINV) has no significant effect on the estimated Feldstein and Horioka parameter, the coefficients of PUBDEF and COUNTSIZE are always significant and negative. Thus specifications in which indicators of public deficit and/or indicators of the country size are used as additional explanatory variables are more likely to report lower Feldstein and Horioka coefficients. Overall, the significance of variables aimed at controlling for different specifications of the regression models (ENDOSCA, PUBDEF, COUNTSIZE, DIFF1) clearly suggests that the reported Feldstein and Horioka coefficients are highly sensitive to the modeling strategy and to the inclusion of additional explanatory variables besides the investment and/or the saving variable.

Turning to the NSTEM variable added to control for the method of estimation, the associated positive and significant coefficient seems to show that studies using no standard estimation procedures report a higher level of the Feldstein and Horioka coefficient than in the baseline case. Finally, the estimates of the saving-investment correlation are not significantly dependent upon the estimation period, as indicated by the non significance of the variable AVGYEAR. This lack of any upward or downward trend in the result is in line with Coakley et al. (1998). Moreover, the reported estimates of the Feldstein and Horioka coefficient are not dependent upon the publication year.

In order to evaluate the sensitivity of this result to the choice of the control variable, the model has also been estimated using the first year instead of the average year of the sample<sup>5</sup>.

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<sup>5</sup> We thank an anonymous referee for this suggestion.

This alternative choice may be justified by the fact that the average year of the sample is closer to the year of publication (control variable PUBYEAR) than the first year of the sample. While the coefficient associated with this alternative control variable is negative and significant with the basic MRA-FAT PET model (coefficient: -0.0017, t.stat: -3.29) it turns out to be non significant with the mixed effect multilevel model (coefficient: -0.0003, t-stat: -0.53). In contrast, all the remaining coefficients and t-stats are qualitatively and quantitatively unchanged with both estimation procedures. This alternative control variable thus seems to yield mixed results which do not invalidate the conclusion that there is no clear empirical evidence that the Feldstein and Horioka coefficients are dependent upon the sample years.

## 5. Conclusion

This paper has provided a meta-analysis of the empirical literature on the investment-saving correlation. The multivariate meta-regression reports a underlying true coefficient lying between 0.562 and 0.677 for studies with the following characteristics: i) the ratio of investment to GDP is the dependent variable, ii) the database contains only cross section data, iii) the database includes only country data (no regional data), iv) the database includes both developed and developing countries, v) the model is specified in levels, and vi) it is estimated with standard econometric procedures.

With regard to this benchmark value, the heterogeneity reported in the estimates of the Feldstein and Horioka coefficient can be explained by a limited number of variables. First, characteristics of the retained countries do matter. Using databases including only developed countries leads to coefficients that are larger than those obtained with mixed date bases including both developed and developing or transition countries, by an amount comprised between 0.10 and 0.15. Moreover, the specification of the regression model has sizeable

influences on the estimated Feldstein and Horioka coefficient. The authentic Feldstein and Horioka coefficient seems to be systematically underestimated with models written in first differences, models using the saving ratio or the current account ratio as the dependent variable instead of the investment ratio, and models including indicators of the public deficit or indicators of the country size as additional explanatory variables.

There could be two interpretations for the high value of the saving retention parameter found in this study. On the one hand, since this abnormally strong figure is at odds with financial integration, it questions the relevance of the Feldstein and Horioka regression as a way to measure capital mobility. In this case studies should focus on other indicators such as the importance and structure of gross (rather than net) capital inflows and outflows. On the other hand, one may be interested in identifying the external factors behind such a high correlation in a world of high capital mobility. In this alternative view, our reported value can be used as a benchmark for model calibration to assess the relative importance of the various sources of correlation between domestic savings and investment (e.g. Bai and Zhang, 2010, for a model with financial friction to solve the puzzle).

Although the present meta-analysis was successful in explaining up to 85 per cent of the variations in the estimated values of the Feldstein and Horioka coefficient, a significant part remains unexplained. Given its renewed interest since the recent Great Financial Crisis (Bautista and Maveyraud-Tricoire (2007), Boubakri et al. (2012), and Chu (2012) to cite a few), subsequent research will be necessary to improve our understanding of the reasons why the empirical estimates of the investment-saving correlation may be so imprecise.

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