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The Feldstein-Horioka Puzzle and a New Measure of International Capital Mobility[1].

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Abstract

In intertemporal optimization models of current account dynamics, the budget constraint will induce high degrees of positive comovement in the levels of savings and investment and the two variables are likely to be cointegrated. Error correction will then also influence the correlations of the cyclical components which will therefore be uninformative about capital mobility.

As an alternative we suggest a new measure of long-run capital mobility based on Johansen's (1988) procedure. We apply our method to historical British and US data and find surprisingly high levels of long-run capital mobility throughout the century.

Keywords: International Capital Mobility, Feldstein-Horioka Puzzle, Intertemporal approach to the Current Account, Cointegration, Permanent-Transitory (P-T) Decompositions

JEL Classification numbers: C32, F21, F32

1 Introduction

In a world with perfect capital mobility, a country can always run current account deficits if its desire to consume and invest cannot be funded domestically. This basic insight provided the motivation for the seminal paper by Feldstein and Horioka (1980) in which the authors found very high savings-investment correlations for a large cross-section of countries. Their result has long been perceived as a puzzle and constitutes a challenge to the view that world capital markets are well integrated. In the presence of perfect capital mobility, investment should go where it yields the highest real returns, whilst consumption should depend only on the permanent value of income, not on contemporaneous investment decisions.

Subsequent research has rationalized the comovement of domestic saving and investment even in the presence of perfect capital mobility. Obstfeld (1986, 1995) and Obstfeld and Rogoff (1995) have pointed to two possible mechanisms that can generate the observed correlation. In a small open economy, total factor productivity shocks that are sufficiently persistent can create positively correlated impulse responses of savings and investment. This mechanism is also suggested in Mendoza (1991). The second mechanism relies on global shocks that impinge on both savings and investment simultaneously. This is the channel formally explored in Baxter and Crucini (1993).As Coakley, Kulasi and Smith (1998) point out, the consequence of these theoretical results was that it has become a consensus in the profession that savings-investment correlations are not very informative about capital mobility.

In the present paper, we provide further justification for this view but contrary to the aforementioned rationalizations it is based on the reduced-form implications of the intertemporal approach to the current account. Hence, it does not have to rely on structural assumptions about the kind of shocks that are hitting an economy. We find that any correlation between savings and investment can ensue in a simple model of current account behaviour with perfect capital mobility and that under reasonable assumptions this correlation can be close to unity. Yet, the spirit of the Feldstein-Horioka approach, namely that inference on international capital mobility is possible from savings and investment data alone, can be preserved.

Under the assumptions of the theory and the additional assumption that the macroeconomic aggregates savings investment and output are very persistent, non-stationary processes , the joint dynamics of savings and investment is appropriately specified in the form of a vector error-correction model (VECM). This econometric specification allows to distinguish clearly between short-run and long-run capital mobility.

The measure of short-run capital mobility is a suitably adjusted correlation, similar to the one suggested by Feldstein and Horioka, whereas the measure of long-run international capital mobility (ICM) is based on Johansen's (1988) procedure for estimating the cointegrating space.

The original work by Feldstein and Horioka (1980) emphasised the high correlation of savings and investment in a cross-section, whereas formal theoretical rationalizations of the correlation - like the ones mentioned before - mainly aim at explaining the time series behaviour of the two variables. Also in the present paper, the analysis will be confined to the time series properties of savings and investment[1].

It is not within the scope of this paper to attempt to survey the huge literature on the Feldstein-Horioka finding (for a recent survey see Coakley, Kulasi and Smith (1998) or Obstfeld and Rogoff (1995)). There is, however, a recent trend towards vectorautoregressive and cointegration methods to address the topic. As this paper makes use of these techniques, we will briefly summarize some of this research:

Ghosh (1995) has used an intertemporal model to derive a desired current account from observed data. He finds that the desired current account tracks the actual current account reasonably well, hence providing evidence in favor of perfect capital mobility.

Moreno (1997) has suggested to interpret the degree of short-run divergence in the impulse responses of savings and investment as a measure of capital mobility.

Taylor and Sarno (1997) used the structural VAR approach pioneered by Blanchard and Quah (1989) to decompose savings and investment into permanent and transitory components. They find that transitory components of UK/US savings and investment are more highly correlated than changes in the permanent components. They claim that this finding is consistent with the presence of frictions in international capital markets. Only if innovations are permanent does investment flow abroad and the link between savings and investment is loosened. If, however, shocks are transitory, then the cost of investing abroad might be too high due to market frictions and a high correlation between saving and investment comes about. However,their results are supportive of the notion that capital mobility has increased in the 1980s: they report short-run correlations between savings and investment for the period 1979-1994 that are significantly lower than for the 1955-1979 period.

The remainder of the paper is organized as follows: section 2 presents

[1] It should be noted however, that a time series-rationalization is in some way more fundamental: if savings and investment move one to one over time in an individual economy and do so for all economies under study, then, of course, the cross-section correlation will be trivially unity as well.

a simple model of current account dynamics based on intertemporal optimization. These models were first applied to current account dynamics by Sachs (1981). Section 3 discusses the classical Feldstein-Horioka regression. We demonstrate that any correlation between the transitory parts of savings and investment can ensue and that these correlations *per se* do not contain any information about capital mobility. In Section 4 we suggest a new measure of long-run international capital mobility (ICM) which is easily calculated as a by-product of Johansen's (1988) procedure for the estimation of the cointegrating space. Section 5 applies our insights to a unique set of long-run historical data from the United Kingdom and the United States. Section 6 concludes.

2 Current account models and cointegration

This section examines the implications of the intertemporal model of the current account in the spirit of the work by Sachs (1981) or as discussed in Obstfeld and Rogoff (1995). We use a simple variant of the model which considers a small open economy where the world interest rate is fixed at r and utility is quadratic in consumption. In such a model, the current account can be represented as the discounted sum of expected changes in net output:

$$CA_t = -\sum_{i=1}^{\infty} R^{-i} E_t(\Delta NO_{t+i}) \quad (1)$$

Here, $R = 1 + r$ and net output is defined as gross national product minus government consumption and investment:

$$NO_t = Y_t - I_t - G_t \quad (2)$$

The current account itself is defined as the difference between savings and investment:

$$CA_t \equiv S_t - I_t \quad (3)$$

The present-value relationship (1) together with the definition (3) defines a cointegrating relationship that is typical of present-value models: If net output, saving and investment can be characterized as $I(1)$-processes, then ΔNO_t will be $I(0)$ and so will be CA_t as the discounted sum of ΔNO_t. Hence, saving and investment cointegrate with cointegrating vector

$$\boldsymbol{\beta} = \left[1, -1\right]' \quad (4)$$

This result of current account stationarity is very robust with respect to the specification of the intertemporal model. In particular, the assumptions made above about quadratic utility and a fixed world interest rate can be relaxed. As Obstfeld (1995) has discussed, present-value relationships like (1) will arise in much more complicated and richer models. In particular, it is likely to survive in a model setup where there are barriers to capital mobility; the nation's budget constraint has to be respected no matter how mobile or immobile capital is.

3 The Feldstein-Horioka regression

In their seminal paper, Feldstein and Horioka (1980) performed a regression of the form

$$i_t = a + bs_t + u_t \tag{5}$$

where lower case letters denote variables as shares of GDP, i.e.$i = I/Y$ and $s = S/Y$. We will refer to (5) as the "classical" FH regression and the FH puzzle has generally been expressed in terms of estimates of b that are found to be close to one.

We will now look at two notions of correlation between savings and investment and explain how these correlations can be high if savings and investment are cointegrated. Throughout the remainder of the paper, we will deal with savings and investment *rates*, even though we will at times leisurely refer to i and s as 'investment' and 'savings'.

Suppose, i_t and s_t can be characterized as $I(1)$-processes. Then the present-value relation (1) requires that the two variables cointegrate with cointegrating vector $[1, -1]$ and hence there will be an error-correction representation of the form[2]:

$$\mathbf{\Gamma}(\mathbf{L})\mathbf{\Delta}\begin{bmatrix} s_t \\ i_t \end{bmatrix} = \boldsymbol{\alpha} CA_{t-1} + \boldsymbol{\varepsilon}_t = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} CA_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{6}$$

where $\Gamma(L) = I - \sum_{i=1}^{k} \Gamma_i L^i$ is a 2×2–matrix polynomial in the lag-operator L , ε_{1t} and ε_{2t} are white-noise disturbances and Δ is the difference operator.

The cointegrating relationship imposes a long-run one-to-one relationship between investment and saving. Hence, the typical Feldstein-Horioka regression of investment on saving rates is just a cointegrating regression in the sense of Engle and Granger (1987). The OLS-estimator is known to be superconsistent in this case and a regression coefficient of unity just reflects the long-run relationship between savings and investment. The permanent value of savings and investment are equal in this case:

$$i_t^p = s_t^P \tag{7}$$

Can the Feldstein-Horioka intuition be applied to transitory components then? In the appendix we derive the following expression for the

[2] We will ignore the constant term in our theoretical derivations.

transitory components of saving and investment:

$$\begin{bmatrix} s_t - s_t^P \\ i_t - i_t^P \end{bmatrix} = \mathbf{C}^*(\mathbf{L})\boldsymbol{\varepsilon}_t = \boldsymbol{\psi} CA_t + \boldsymbol{\beta}_\perp f_t \tag{8}$$

where $\mathbf{C}^*(\mathbf{L})\boldsymbol{\varepsilon}_t$ is the cyclical component of the Beveridge-Nelson decomposition, $\boldsymbol{\beta}'_\perp = \begin{bmatrix} 1, 1 \end{bmatrix}$ is the orthogonal complement of $\boldsymbol{\beta}$, f_t is a univariate stationary stochastic process and $\boldsymbol{\psi}' = \begin{bmatrix} \psi_1, \psi_2 \end{bmatrix}$ a two-dimensional vector.

Equation (8) states that $\mathbf{C}^*(\mathbf{L})\boldsymbol{\varepsilon}_t$ can be decomposed into one part which captures the error correction of the model, $\boldsymbol{\psi} CA_t$, and another part, given by $\boldsymbol{\beta}_\perp f_t$ which is pure short-run dynamics. Note that $\boldsymbol{\beta}'_\perp = \begin{bmatrix} 1, 1 \end{bmatrix}'$ and therefore the pure short-run dynamics of savings and investment are perfectly positively correlated. But note that also the error correction dynamics are perfectly correlated, either positively ($\psi_1 \psi_2 > 0$) or negatively ($\psi_1 \psi_2 < 0$).

In the stationary case, the Feldstein-Horioka approach predicts that under high capital mobility the current account should act as a buffer between savings and investment. Hence, the ratio

$$\frac{Var(CA_t)}{Var(s_t) + Var(i_t)} \tag{9}$$

should be near unity. This insight, however, does not carry over to the non-stationary case because the unconditional second moments of s and i will not exist. Could the intuition still be applied if savings and investment were appropriately detrended?. Equation (8) states that this will not be the case. Even if

$$\frac{Var(CA_t)}{Var(s_t - s_t^p) + Var(i_t - i_t^p)} = 1$$

i.e. in the absence of pure short-run dynamics ($f_t = 0$), the correlation between the transitory parts of savings and investment will be perfect. In particular, the correlation will be positive whenever $\psi_1 \psi_2 > 0$.

Hence, if savings and investment are non-stationary, error-correction behaviour, embodied in the coefficients ψ_1 and ψ_2, is likely to obscure the informational content of savings-investment correlations with respect to capital mobility, even after the variables have been rendered stationary. In the next section, we address the issue whether savings and investment data contain information about capital mobility at all. We are going to argue that it is just the error-correction dynamics itself that are interesting.

4 Inference on international capital mobility using savings and investment data

In this section, we will argue that the essence of the Feldstein-and-Horioka argument can be saved: inference on capital mobility is possible from saving and investment data alone.

To illustrate our notion of long-run capital mobility, consider the case of current account targeting discussed in Artis and Bayoumi (1992). Past current account deficits might incur government action in the sense that the government tends to offset private sector behaviour by increasing public sector savings or by trying to induce the private sector to increase its savings through policy action such as capital controls or monetary policy measures such as higher interest rates. No matter what the details of government action look like, however, in these circumstances one would probably expect a stronger predictive power of past current account (levels) for today's movements in national savings.

To measure capital mobility, we suggest to look at the adjustment coefficients in the bivariate VECM representation of our savings-investment system, i.e. at $\alpha = \left[\alpha_1\, \alpha_2\right]$.

Suppose α_1, is close to zero. In this case, past current accounts have only a small impact on present changes in savings, i.e. today's savings decision is relatively independent of the budget constraint and hence savings and investment become dichotomous in the sense implied by Feldstein and Horioka. Conversely, a small absolute value of α_2 indicates that domestic investment opportunities can be exploited, regardless of what the current account, i.e. the country's past savings and investment decisions used to be.

While the information we could gain by looking at α_1 and α_2 separately is certainly valuable, the focus in the literature on univariate modelling can also be explained in terms of the desire to have a composite measure of capital mobility. We will therefore suggest a measure of long-run capital mobility that arises naturally as a function of the parameters of our reduced-form model.

Johansen (1988), (1991) has shown that the estimation of the cointegrating space in a VECM is essentially a generalized eigenvalue problem. The maximum eigenvalue ensuing from the solution of this problem can be given the representation

$$\Lambda = \widehat{\alpha}' \widehat{\Sigma}_{00}^{-1} \widehat{\alpha} \tag{10}$$

where $\widehat{\Sigma}_{00}$ is the estimate of the variance-covariance structure of the first auxiliary regression in the Johansen (1988) procedure. The asymptotic distribution of Λ and procedures for the estimation of its covariance have recently been worked out by Hansen and Johansen (1998).

A nice property of Λ is that it is always between zero and one. Our argument here is that a high value of Λ implies low capital mobility whereas a low value of Λ is tantamount to a high level of capital mobility. Once Λ is zero the system has no cointegrating relationships, hence s and i are difference stationary but do not cointegrate. Under perfect capital mobility, the system should still revert to equilibrium, i.e. cointegration and error correction should be present but should not be very strong. This implies a small (but significant) Λ. It is in this sense that Λ formalizes the Feldstein-Horioka notion of 'independence' of savings and investment in a non-stationary setting. In fact Λ is just the dominant canonical correlation between the errors of the auxiliary regressions in the Johansen procedcure. Note that Λ is not a persistence measure of the current account because the persistence of the current account would also depend on the typical shock by which the system is hit[3]. This is not the case for Λ which is the normalized length of the vector α, i.e. nothing else than the typical tendency of the system towards error correction, *net* of the variability of shocks.

Let us relate our indicators of long-run capital mobility to others suggested in the literature:

In a recent paper, Feldstein and Bacchetta (1991) estimated a specification of the form

$$i_t = a + b(i_t - s_t) + u_t \tag{11}$$

thus modifying the classical FH regression to allow for some kind of long-run equilibrium adjustment. As Taylor (1996) pointed out, if i and s are non-stationary but cointegrate, (11) will be misspecified. He suggested to estimate a univariate error correction model (ECM)

$$\Delta i_t = a^{ECM} + b^{ECM}\Delta s_t + c^{ECM}(s_t - i_t) + v_t \tag{12}$$

He then proposed to interpret the coefficient b^{ECM} as a measure of short-run capital mobility and c^{ECM} as a measure of long-run capital mobility. This line of reasoning is very close to ours. Notice, however, that in terms of the parameters of the VECM, Taylor's regression can be interpreted as a conditional model of investment, given savings. Conditioning investment on savings yields

$$\Delta i_t = \omega \Delta s_t + (\alpha_2 - \omega\alpha_1) ca_{t-1} + lagged\ dynamics \tag{13}$$

where ω is a linear function of the covariance structure of the reduced form errors given by

$$\omega = \Omega_{12}\Omega_{11}^{-1} \text{ and } \Omega = \begin{bmatrix} \Omega_{11}\,\Omega_{12} \\ \Omega_{21}\,\Omega_{22} \end{bmatrix} = E(\varepsilon_t \varepsilon_t')$$

[3] A pesistence measure in this sense is the persistence profile suggested by Lee, Pesaran and Pierse (1992).

The coefficient ω measures short-run capital mobility - it is often referred to as a short-run savings retention coefficient (Taylor (1996)). It is a function of the covariance of the reduced form errors, i.e. those innovations in savings and investment that are unexplained by our model. And as such, for once, a high value of ω is nothing that we should expect from the theory. Hence, low values of ω can be interpreted as indicative of high short-run capital mobility: changes in savings do not have high predictive power for contemporaneous changes in investment.

In as far as ω is interpreted as measure of short-run capital mobility, note that the coefficient c^{ECM} from equation (12) is a function not only of both coefficients of $\boldsymbol{\alpha}$ but also of short-run capital mobility. Hence, c^{ECM}does generally not tell us anything about how sustainable a country's current account position actually is, and hence is informative about the true adjustment process only if $\alpha_1 = 0$.

The system approach we suggest in this paper, gives us two measures of international capital mobility: one, the short-run retention coefficient is nothing else than a regression of the reduced form errors of investment on those of savings and tells us how investment and savings are correlated *net* of the working of the intertemporal model. The other one, based on the generalized eigenvalue problem underlying the estimation of a cointegrated system, is a measure of how persistent a country's current account position is and, as such, measures long-run mobility. To our knowledge, the literature has so far not exploited such a system-based approach to disentangle short-run and long-run capital mobility cleanly.

In the next section we apply our insights to a unique data set due to Taylor (1996).

5 Empirical Results

In this study we use a unique set of long-range annual data on national savings and investment rates compiled and first used by Obstfeld and Jones (1994) and Taylor (1996) to study international capital mobility. Data for the United Kingdom range from 1850-1992, data for the United States is from 1874 to 1992. Figures 1 and 2 provide a plot of the data set for the two countries.

To conform with the literature that reports Feldstein-Horioka regressions, we report the results of a simple regression of i on s and a constant in table 1. Whereas for the US we find a regression coefficient very close to unity, the coefficient for the UK is somewhat lower. For both countries the coefficients are highly significant. This finding is in line with the estimates in the literature. We will not discuss it further and proceed to the system-modelling approach suggested in the previous sections.

We first estimated an unrestricted VAR with a constant. Following the Schwarz-, Hannan-Quinn and Akaike criteria we specified the model with two lags. We performed Johansen's test for cointegration. The results, given in table 2, suggested one cointegrating relationship for the US whereas in the model for the UK, no cointegrating relationship was detected. Once we imposed two step dummies for WWI and WWII, however, we found cointegration also in the UK-model. Table 3 gives our estimates of the cointegrating space and tests of $\boldsymbol{\beta}' = \begin{bmatrix} 1, -1 \end{bmatrix}$. At conventional significance levels, both tests suggest that the stationary relation we detected is indeed the current account.

Visual inspection of the data, suggests that there are a number of structural breaks, most notably the two world wars. Following our theoretical specification, we imposed one cointegrating relationship and then proceeded to estimate Λ recursively, following the procedure developed in Hansen and Johansen (1998): if the maximum eigenvalue vanishes, there will be no cointegration between the variables.

Figure 3 and 4 give the results of this recursive estimation for the UK and the US respectively. It becomes apparent that the parameters of the model are not stable over the sample period and that a secular break occurred during WWI.

For the United States, WWI seems to have been very disruptive to long-run international capital mobility. Surprisingly, our estimates suggest that long-run capital mobility suffered a setback in the period up to the great depression during which it reached pre-WWI levels. After that, international capital mobility for the U.S. seems to have remained more or less constant over the rest of the sample period, with no major disruptions during the second world war nor further marked changes in the Bretton Woods or post-Bretton Woods periods.

For the UK our recursive estimates suggest that long run capital mobility was actually lower in the pre-WWI period than in the post-war era.. However, the informational content of our estimate may be reduced due to the parameter instability brought about by WWI. Also, the variance of the pre-WWI estimate is rather high. In the UK the sustainability of the current account position recovers even quicker than in the United States and stays roughly constant for the rest of the sample period, with the exception of WWII where Λ seems to reach a new peak. We believe that this is due to the exceptional financial aid the UK received from the United States during WWII. Current account deficits have been large in that period but will not have triggered appropriate reactions in savings and investment rates. This will bias the estimates of α downwards.

In spite of high correlations between savings and investment as found from the FH regressions reported in table 1, long-run capital mobility over the century seems to have been remarkably high in the two countries we examined. The first world war seems to have been disruptive to long run capital mobility but both countries were able to recover long-run sustainable current account positions soon. Our findings seem to suggest that the role of the great depression as a watershed for ICM, as found by Eichengreen (1990) and Taylor (1996), is not quite warranted for the two countries. However, the difference in our results vis-à-vis Eichengreen and Taylor might arise because our analysis so far has exclusively focused on long-run capital flows. As argued earlier, thel setup of our model allows us to distinguish cleanly between the short and the long-run and it seems plausible that short-run capital mobility has varied more over the century than has long-run capital mobility.

Figures 5 and 6 plot the estimate of the short-run savings retention coefficient. Here a break occurs during WWI but whereas in the United States short-run (SR) capital mobility recovers after the war, it remains low in the UK. In contrast to LR capital mobility, SR capital mobility seems to have suffered a further setback during the great depression and during WWII from which it did not recover after 1945. Rather, for the UK, SR capital mobility tends to decline and only the demise of the Bretton Woods system seems to have brought it back to pre-WWII levels. For the US the demise of Bretton Woods does not seem to have influenced the savings-investment correlation.

In line with Taylor (1996), figures 5 and 6 do indeed suggest that there are four regimes governing short-run capital mobility in the twentieth century:

- the pre-world war I period of the classical gold standard, 1880-1913. As Bayoumi (1990) has claimed this was the one historical period that came closest to the paradigm of perfect capital mobility.

- The interwar period that Taylor (1996) and Obstfeld and Taylor (1996) have found to be one of secular barriers to capital mobility.

- The postwar period up to the breakdown of the Bretton Woods system, 1946-71.

- The post Bretton Woods period, 1971-92, stretching to the end of the sample.

According to our recursive estimates, the demise of Bretton Woods had differential effects on short-run capital mobility in the two countries: for the U.S. it is hard to perceive any effect whereas for the UK the move to flexible exchange rates also marks the begin of an era of quickly increasing short-run capital mobility.Our findings corroborate the results obtained by Eichengreen and Taylor. However, we find that these findings are largely driven by fluctuations in short-term capital mobility whereas long term capital flows seem to have been much less affected over the century. Rather our recursive estimates suggest that long-run ICM was higher rather than lower in the post-WWI period.

To further check this claim we compared our measure of long-run capital mobility across sub-periods. Due to small-sample problems, estimating our long-run model for all post-WWI sub-periods separately is not likely to be informative. However, from inspection of figures 3 and 4 the two post-WWII periods seem to be more homogenous than the interwar period in the sense that our estimates of long-run ICM become more stable. Dropping the immediate aftermath of the war, we used data from 1950 to the end of the sample, 1992. To account for potentially remaining parameter instability, we included a step-dummy for the post-Bretton-Woods period and the oil price for the UK which became an oil exporter in the late seventies. Information criteria suggested three lags for the two country models and we estimated both with an unrestricted constant. One cointegrating relationship was found at the 10-percent level in both cases, the maximum eigenvalue test even indicated cointegration at the 5 percent level for the UK.

Correspondingly, we estimated the same model (with two lags) for the period 1880-1913. For the U.S., tests did not suggest cointegration but due to our theoretical priors and the low power of cointegration tests in small samples[4], we imposed one cointegrating restriction. Table 4 summarizes the results of the cointegration tests.

Table 5 gives the estimates of Λ and their standard errors for the two periods of interest. For the post-WWII period, we found values of 0.30 for the UK and 0.19 for the US whereas for the gold-standard period we found 0.37 and 0.23 respectively. This result is interesting: the point estimates of Λ for the earlier period are higher, indicating lower long-run capital mobility. However, there is large overlap of the confidence intervals and for both countries the null that Λ in the post-WWII period is in fact the same as in the gold-standard period can be just accepted at the 5 percent significance level.

Whereas for neither of the two countries have levels of short-run capital mobility been reached subsequently that are comparable to those that prevailed under the classical gold standard, long-run capital mo-

[4] Under high capital mobility, as we find it for the gold standard era, cointegration tests are likely to have particularly low power, as the system's equilibrium correction, as reflected by α, is very weak.

bility seems to have been relatively high and - with the exception of the WWI-experience - also relatively constant over the whole century. In particular, we cannot reject that post-WWII and pre-WWI levels of long-run capital mobility are equal.

6 Conclusion

In this paper we have investigated in what sense correlations between savings and investment are informative about international capital mobility. Our reasoning uses insights from the theory of cointegrated systems and permanent-transitory decompositions and demonstrates that time series correlations between savings and investment are *per se* uninformative about the degree of international capital mobility. The findings of Feldstein and Horioka (1980) can therefore be rationalized even when capital mobility is perfect.

Even though this result is not new and has been put forward in the literature, the advantage of our approach is that we derive these conclusions from the reduced-form implications of an intertemporal maximization model. Hence, the results prevail independently of assumptions about the structure of underlying economic shocks. In particular, the implications of error correction for the cyclical dynamics of s and i have to our knowledge not been spelled out.

Still, the suggestion made by Feldstein and Horioka to make inference about international capital mobility from savings and investment data alone remains appealing. After all, theory *does* suggest that investment should flow where it yields the highest real returns and that savings depend on the intertemporal consumption decision alone.

In this paper, we have argued that the long-run adjustment process in a cointegrated system is informative about capital mobility. We have suggested a measure of long run capital mobility that arises naturally in the context of a cointegrated model and can be calculated easily as a by-product of Johansen's (1988) procedure. The measure has the advantage that it represents a standardized index of international capital mobility that is between zero and one. Also, standard errors of this index can be calculated and hence it becomes possible to compare capital mobility intertemporally and between countries.

We have applied our insights to a unique data set of historical savings and investment rates for the United States and the United Kingdom.The data are taken from Taylor (1996).

In the United States and the United Kingdom, long-run capital mobility over the century seems to have been remarkably high. WWI appears as the major disruption to long-run capital mobility in this century but in both countries long-run sustainable current account positions were restored soon after the war.

Whereas these findings seem somewhat at odds with the literature, we show that they are due to the fact that earlier studies tended to entangle the short and long-run dynamics of savings and investment. Our approach allows us to show that variations in capital mobility over the century have largely been reflected in changes in the short-run savings retention coefficient and whereas long-run capital mobility has been fairly high throughout the whole century. In particular, we cannot reject the hypothesis that long-run capital mobility was as high in the post-WWII period as under the classical gold standard.

This paper has concentrated on what we consider the essence of the Feldstein-Horioka approach: the claim that inference on capital mobility is possible from savings and investment data alone. The bottomline of our argument is that this approach is valid if the appropriate reduced form that is suggested by the theory, i.e. a vector error correction model, is chosen.

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7 Figures and Tables

Table 1: FH-regression $i_t = a + bs_t + u_t$

	UK (1850-1992)	US (1874-1992)
a	0.02	-0.003
	(0.007)	(0.004)
b	0.69	0.99
	(0.05)	(0.03)

standard errors in parantheses

Table 2

	Trace Statistics	Max EV Statistics
a)	cointegration tests for the US 1874-1992	
$0 < h \leq 1$	22.29	16.73
$1 < h \leq 2$	5.564	5.564
b)	cointegration tests for the UK 1850-1992	
$0 < h \leq 1$	13.91	11.37
$1 < h \leq 2$	2.54	2.54
c)	UK 1850-92 with dummies for WWI&II	
$0 < h \leq 1$	59.3	56.96
$1 < h \leq 2$	2.34	2.35
Critical values 10% (5%)	0<h≤ 1	1<h≤ 2
trace test:	15.58 (17.48)	6.69 (8.803)
max-Eigenvalue-test:	12.78 (14.6)	6.69 (8.083)

Table 3

Estimated cointegrating vectors $\beta' = \left[1\, \beta_2\right]$ and test of $\beta_2 = -1$

	US (1874-1992)	UK (1850-1992)
β_2	-0.85	-0.65
LR	3.22	1.96
p-value	0.07	0.16

Table 4: Cointegration Tests 1950-92

	Trace Statistics		Max EV Statistics	
	1950-92	1880-1913	1950-92	1880-1913
a)	cointegration tests for the US			
$0 < h \leq 1$	15.88	10.70	9.23	8.85
$1 < h \leq 2$	6.645	1.85	6.64	1.85
b)	cointegration tests for the UK			
$0 < h \leq 1$	16.24	15.71	15.24	15.66
$1 < h \leq 2$	0.99	0.048	0.99	0.048
Critical values 10% (5%)	0<h≤ 1		1<h≤ 2	
trace test:	15.58 (17.48)		6.69 (8.083)	
max-Eigenvalue-test:	12.78 (14.6)		6.69 (8.083)	

Table 5 Index of International Capital Mobility, $\Lambda = \alpha\Sigma_{00}^{-1}\alpha$

	UK	US
1880-1913	0.37	0.23
	$\begin{pmatrix} 0.27 & 0.5 \end{pmatrix}$	$\begin{pmatrix} 0.18 & 0.30 \end{pmatrix}$
1950-1992	0.30	0.19
	$\begin{pmatrix} 0.24 & 0.37 \end{pmatrix}$	$\begin{pmatrix} 0.16 & 0.23 \end{pmatrix}$

95% lower and upper confidence bounds after Hansen and Johansen (1998) in brackets

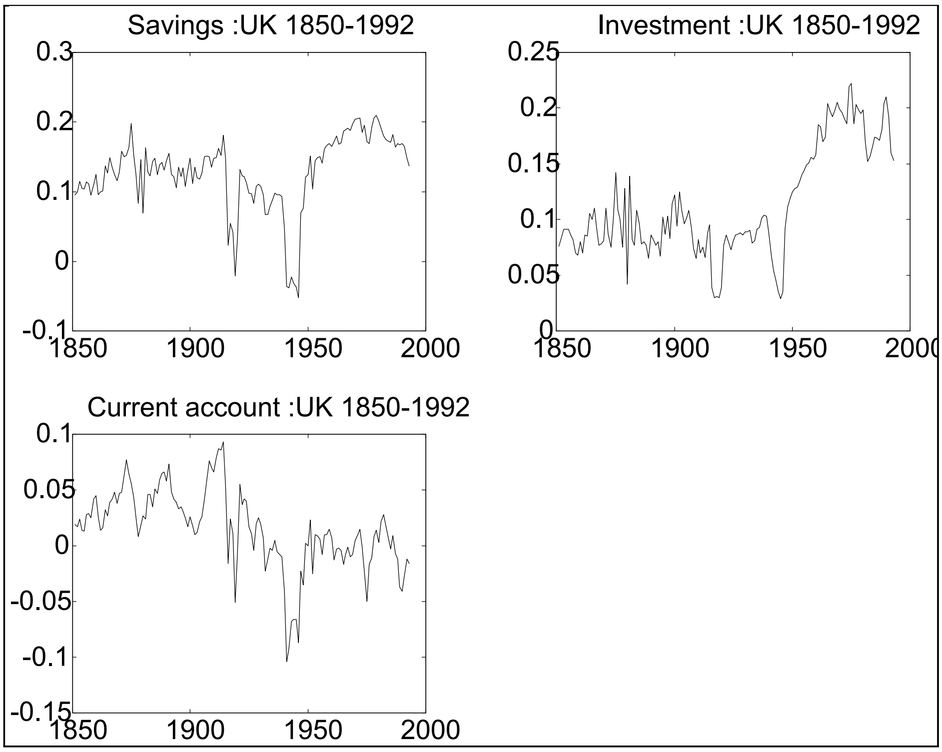

Fig 1: The UK Data 1850-1992

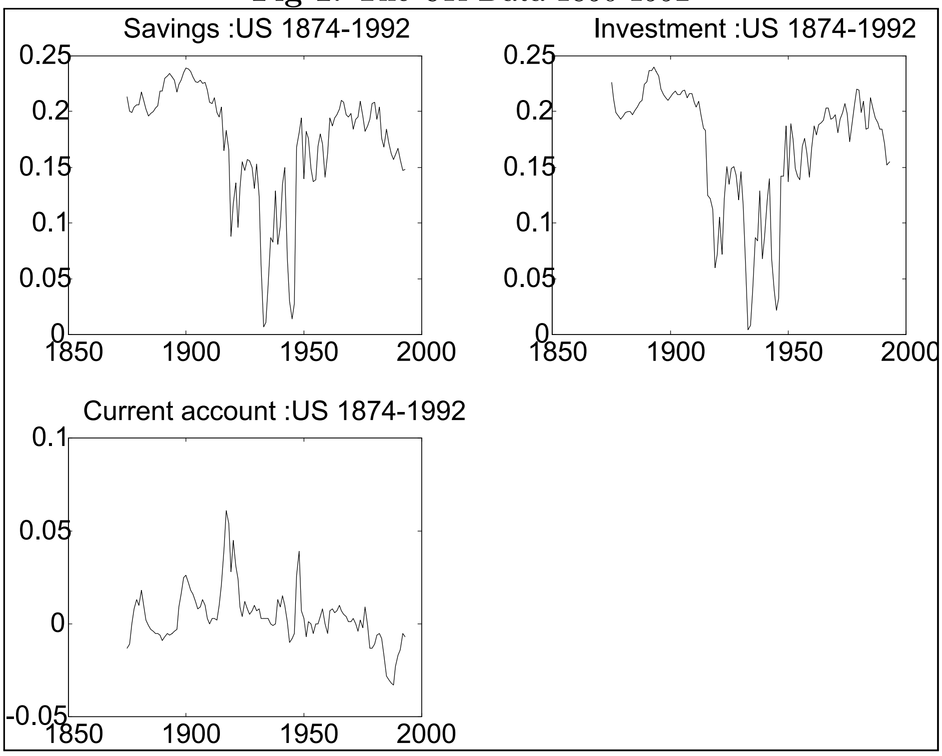

Fig 2: The US Data 1874-1992

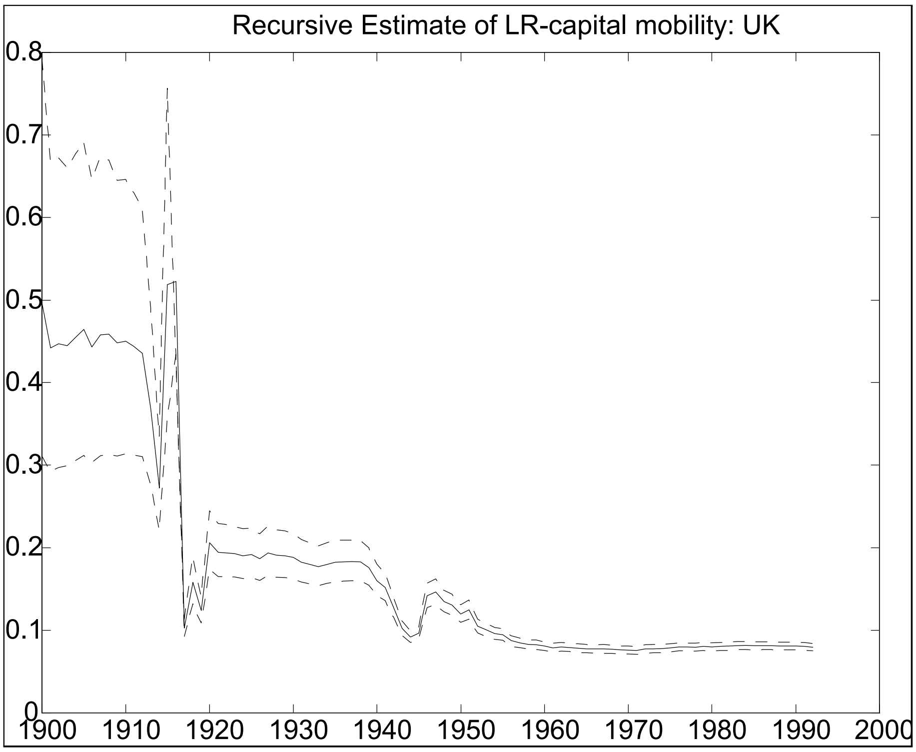

Fig. 3: Long run capital Mobility in the UK

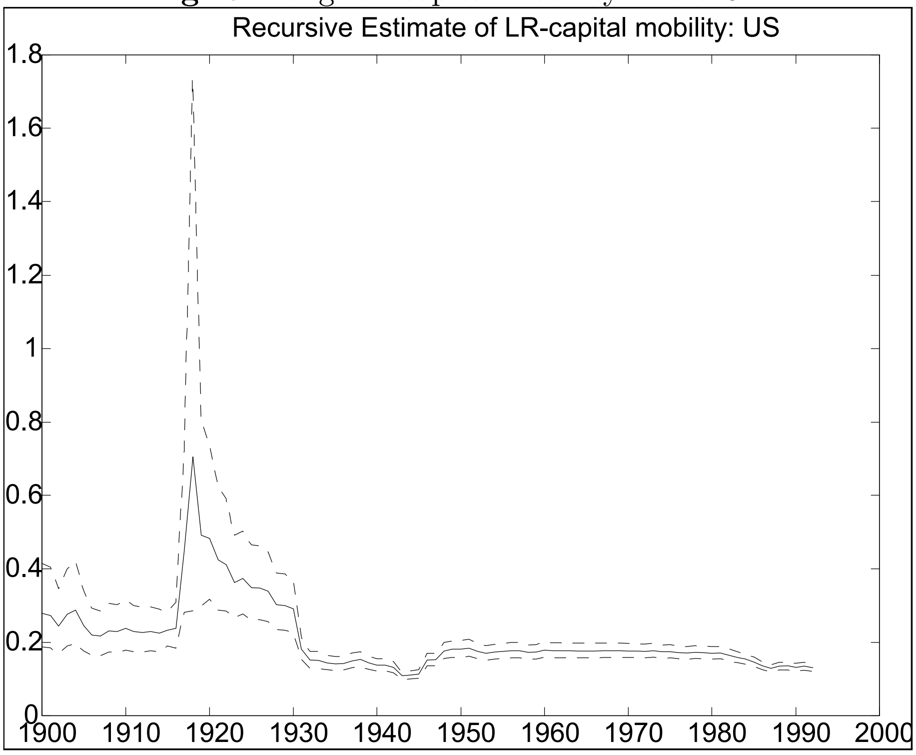

Fig. 4: Long run capital mobility in the U.S.

Fig. 5: Short run capital mobility in the UK

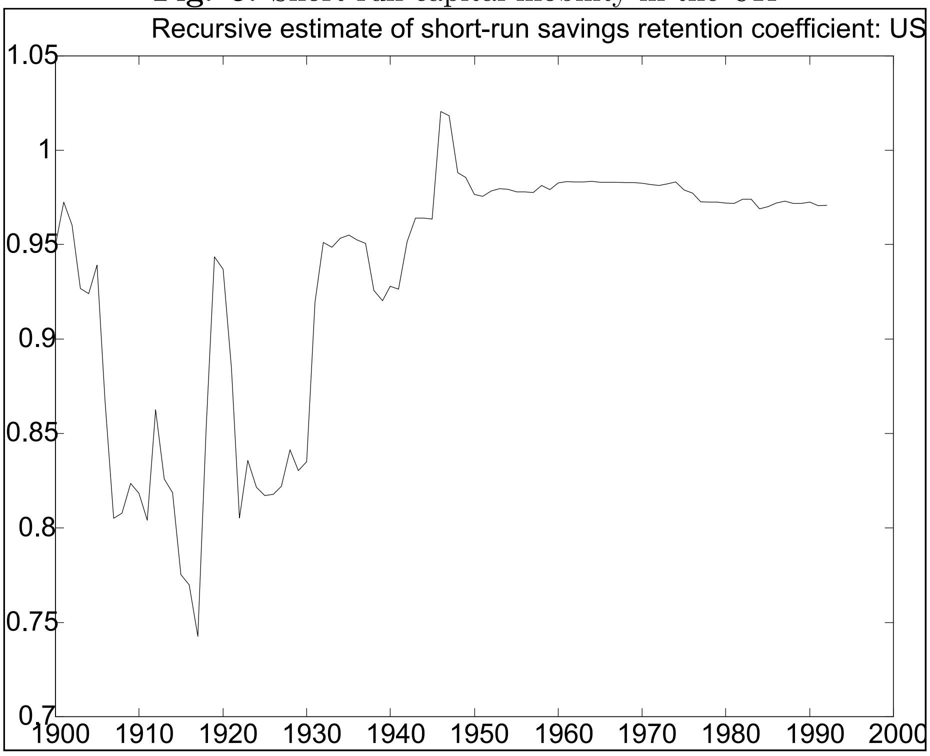

Fig. 6: Short run capital mobility in the U.S.

8 Appendix

We define the permanent component of the $I(1)$ vector process X_t as its current value plus the sum of all forecastable changes:

$$\mathbf{X}_t^p = \mathbf{X}_t + \sum_{i=1}^{\infty} \mathbf{E}(\mathbf{\Delta X}_{t+i})$$

This leades naturally to the Beveridge-Nelson (1981) decomposition where

$$\mathbf{X}_t^P = \mathbf{C}(\mathbf{1}) \sum_{l=1}^{t} \boldsymbol{\varepsilon}_l \tag{14}$$

where $\{\varepsilon_l\}$ is the series of innovations to $\mathbf{X}_t$ and $\mathbf{C}(\mathbf{1}) = \sum \mathbf{C}_i$ where the C_i are the coefficients of the moving-average (Wold) representation of $\mathbf{\Delta X}_t$.

To derive our results, we draw heavily on work done by Johansen (1997), Proietti (1997) and Granger and Gonzalo (1995). We restate the VECM-representation:

$$\mathbf{\Gamma}(\mathbf{L})\mathbf{\Delta X}_t = \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{X}_{t-1} + \boldsymbol{\varepsilon}_t \tag{15}$$

The transitory part of savings and investment is a moving average of reduced-form innovations (Beveridge-Nelson (1981)):

$$\begin{bmatrix} s_t - s_t^P \\ i_t - i_t^P \end{bmatrix} = \mathbf{C}^*(\mathbf{L})\boldsymbol{\varepsilon}_t$$

The idea is to approximate the transitory part by a linear combination of the current account. Premultiplying the VECM-representation by $\mathbf{C}(\mathbf{1})$ we obtain:

$$\mathbf{C}(\mathbf{1})\mathbf{\Gamma}(\mathbf{L})\mathbf{\Delta X}_t = \mathbf{C}(\mathbf{1})\boldsymbol{\varepsilon}_t \tag{16}$$

because $\mathbf{C}(\mathbf{1})\boldsymbol{\alpha} = \mathbf{0}$. Integrating yields:

$$\mathbf{C}(\mathbf{1})\mathbf{\Gamma}(\mathbf{L})\mathbf{X}_t = \mathbf{C}(\mathbf{1}) \sum_{l=0}^{t} \boldsymbol{\varepsilon}_l \tag{17}$$

We now have a representation of the permanent component in terms of present and past levels of the process itself. Accordingly, we get for the transitory component:

$$\{I - C(1)\Gamma(L)\}\,\mathbf{X}_t = \mathbf{C}^*(\mathbf{L})\boldsymbol{\varepsilon}_t \tag{18}$$

Let us now rewrite

$$\mathbf{C(1)\Gamma(L)} = \mathbf{C(1)\Gamma(1)} + \mathbf{\Delta C(1)\Gamma^{*}(L)}$$

where $\mathbf{\Gamma}_i^{*} = -\sum_{j>i}\mathbf{\Gamma}_j$. Then, in the above, we obtain:

$$\mathbf{C}^{*}(\mathbf{L})\boldsymbol{\varepsilon}_t = \{I - C(1)\Gamma(1)\}\,\mathbf{X}_t - \mathbf{C(1)\Gamma^{*}(L)\Delta X}_t \tag{19}$$

It is worthwhile to contemplate this result for a second. The transitory component is a linear combination of the levels of the process plus some moving average of past changes. Note in particular, that $\{I - C(1)\Gamma(1)\}$ has rank $n - h = 1$ where $n = 2$ is the dimension of the system and $h = 1$ the number of cointegrating relations. Hence, the components of $\{I - C(1)\Gamma(1)\}\,\mathbf{X}_t$ are perfectly correlated, but the correlation can be both positive and negative. It is also important to note that $\{I - C(1)\Gamma(1)\}\,\mathbf{X}_t$ is just a linear combination of the equilibrium error $\boldsymbol{\beta}'\mathbf{X}_t = CA_t$. This can be seen from the following representation of the matrix $\{I - C(1)\Gamma(1)\}$ which has been derived by Proietti (1997):

$$\mathbf{I} - \mathbf{C(1)\Gamma(1)} = (\mathbf{\Gamma}(1) + \boldsymbol{\alpha\beta}')^{-1}\boldsymbol{\alpha}\left[\boldsymbol{\beta}'(\mathbf{\Gamma}(1) + \boldsymbol{\alpha\beta}')^{-1}\boldsymbol{\alpha}\right]^{-1}\boldsymbol{\beta}' = \boldsymbol{\psi\beta}' \tag{20}$$

The expression $\{I - C(1)\Gamma(1)\}\,\mathbf{X}_t$ therefore captures the error correction mechanism of the model and we can rewrite:

$$\{\mathbf{I} - \mathbf{C(1)}\Gamma(1)\}\,\mathbf{X}_t = \boldsymbol{\psi\beta}'\mathbf{X}_t = \boldsymbol{\psi}CA_t \tag{21}$$

For the second expression on the RHS of (19), we can write

$$\mathbf{C(1)\Gamma^{*}(L)\Delta X}_t = \boldsymbol{\beta}_\perp f_t \text{ where } f_t = (\alpha_\perp'\Gamma(1)\beta_\perp)^{-1}\boldsymbol{\alpha}_\perp'\mathbf{\Gamma}^{*}(\mathbf{L})\mathbf{\Delta X}_t$$

Here, f_t is a common factor and, since $\boldsymbol{\beta}_\perp = \begin{bmatrix}1\,1\end{bmatrix}'$, the components of $\mathbf{C(1)\Gamma^{*}(L)\Delta X}_t$ will be perfectly positively correlated.