International Capital Mobility in History: The Saving-Investment Relationship*

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Abstract

Recent trends in the globalization of markets have refocused attention on the evolution of international capital mobility over the long run. This paper augments the literature by investigating criteria for capital mobility using time-series and cross-section analysis of saving-investment data for fifteen countries since circa 1850. The results present a nuanced picture of capital market evolution. The sample shows considerable cross-country heterogeneity. Broadly speaking, the inter-war period, and especially the Great Depression, emerge as an era of diminishing capital mobility, and only recently can we observe a tentative return to the degree of capital mobility witnessed during the late nineteenth century.

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Introduction

Although economic historians have long been concerned with the evolution of international capital markets over the long run, empirical testing of market integration criteria has been limited. The conventional wisdom suggests that late-nineteenth century capital markets were relatively well integrated under the classical gold standard centered on London; that the inter-war period was one of disintegration and imperfect capital mobility, especially after 1929; and that the postwar period has been characterized by gradually increasing capital market integration. This paper seeks to confront and test such hypotheses using quantity criteria based on the current account and the saving-investment relationship. To that end I have constructed the longest and broadest panel data set assembled for this purpose.

The evolution of international capital mobility is, in principle, closely tied to the trends and cycles in foreign lending. Yet the presence of flows, is neither a necessary nor sufficient condition for market integration: a small autarkic country with capital scarcity no different from the "world" market will exhibit no incipient flows upon opening itself to capital flows. Conversely, countries with substantial barriers to capital mobility may nonetheless experience capital flows of some sort provided international rate-of-return differentials are sufficiently large. Here, then, is the handicap of using quantity rather than price criteria as yardsticks of market integration.[1]

Still, despite shortcomings, a substantial literature has evolved using quantity criteria for evaluating capital mobility. A seminal contribution was that of Feldstein and Horioka (FH) (1980) which used data for the 1960s and 1970s on saving and investment rates to assess whether incremental savings were retained in the home country or else entered the global capital market seeking out the highest return. This paper develops and extends the historical application of saving-investment analysis, and seeks to extend its theoretical and empirical scope in several ways. Methodologically, my main contribution is to go beyond the traditional and static

[1] Is there any logic to using quantity criteria at all? First, price criteria are not without problems. They are intense in data requirements, and studies need to focus on *identical* assets in different markets, such as the onshore-offshore price differential on a given asset — and, in practice, such data series are few (Obstfeld 1994). Second, quantity criteria do bear on certain predictions of economic theory. For example, presumptions of consumption-smoothing preferences can be tested by looking at quantity data on consumption and income across time, to see whether income shocks are adequately smoothed away: that is, whether international risk-sharing functions satisfactorily. Of course, income minus consumption is equal to saving, so this is not unrelated to the saving-investment criterion, which instead asks whether shocks to investment are constrained by local saving supply, or whether they are met by the global pool of capital.

FH test, and to offer an alternative time-series approach based on a more explicit dynamic model. A major criticism of the FH method is that one might expect saving and investment to be highly correlated once time-averaging is performed in cross-section, simply because all countries must abide by a long-run version of current account balance in order to satisfy their intertemporal budget constraint. This leads to a very different modeling approach. In a standard framework, a small-open economy with initial capital scarcity will invest so long as its interest rate exceeds the world rate. And the country will initially consumption-smooth by borrowing against permanent income. But in the long run, investment will settle down to a replacement level, and saving will settle down to a positive level to offset earlier loans. The current account will reach an equilibrium. Satisfaction of the national long-run budget constraint (LRBC) in this type of model leads to a hypothesis that saving and investment may have trends or unit roots, but that the current account will be stationary (that is, investment and saving will be cointegrated). Moreover, a vector error-correction model (VECM) emerges as a natural theoretical framework, where shocks to saving and investment can be modeled in the context of a long-run equilibrium relationship between the two.

The precise international finance model is not so important here, as several models could yield this prediction. The econometric implication is very important here, however, and invites a new specification which is highly applicable given the very long and broad panel I have developed. My results indicate that our impressions of international capital mobility given by the raw data and the simple FH tests are not wholly misleading, but can be better understood using the more sophisticated VECM specification I apply. Simulation analysis indicates that changes in current-account dynamics associated with less flexibility do indeed translate into FH regression parameters closer to unity. As for the empirical results applied to the actual data, they tell a story consistent with the stylized facts for most countries; but within this general picture, the more refined model can pick out considerable cross country heterogeneity: some countries followed this pattern, but some did not, and thus the membership of the "world capital market" might be thought to have changed over time, as individual countries' policies and institutions evolved. Though the full extent of this kind of "market segmentation" in the global market for capital remains conjectural, it could have had important implications for the efficient allocation of world capital in history, for international growth and convergence, and for our understanding of national economic policies and development. The findings thus encourage more detailed and disaggregated work on the international capital market and on individual country experience to corroborate and refine these interpretations.

Capital Flows in Two Centuries

Analysis of the saving-investment relationship is closely tied to the study of the pattern of capital flows, by dint of the saving-investment identity. Some basic definitions and notation will now prove useful. Define gross domestic product Q as the sum of goods produced, which, with imports M, may be allocated to private consumption C, public consumption G, investment I, or export X, so that $Q + M = C + I + G + X$. Rearranging, GDP is given by GDP $\equiv Q = C + I + G + NX$, where $NX = X - M$ is net exports. If the country's net credit (debt) position vis-à-vis the rest of the world is B $(-B)$, and these claims (debts) earn (pay) interest at a world interest rate r, then gross national product is GDP plus (minus) this net factor income from (to) the rest of the world, GNP $\equiv Y = Q + rB = C + I + G + NX + rB$.

It is then straightforward to show that the net balance on the current account CA satisfies $CA \equiv NX + rB = (Y - C - G) - I = S - I$, where $S \equiv Y - C - G$ is gross national saving.[2] Finally, the dynamic structure of the current account and the credit position is given by the equality of the current account (CA) and the capital account (KA), so that $B_{t+1} - B_t \equiv KA_t = CA_t$.

Since the current account is so central to the analysis it is worth spending a moment to look at the long-run behavior of capital flows in my sample. A sense of the changing patterns of international financial flows can be gleaned by examining their trends and cycles. A normalization is needed: measurement traditionally focuses on the size of the current account balance CA, equal to net foreign investment, as a fraction of national income Y. Thus $(CA/Y)_{it}$ becomes the variable of interest, for country i in period t.

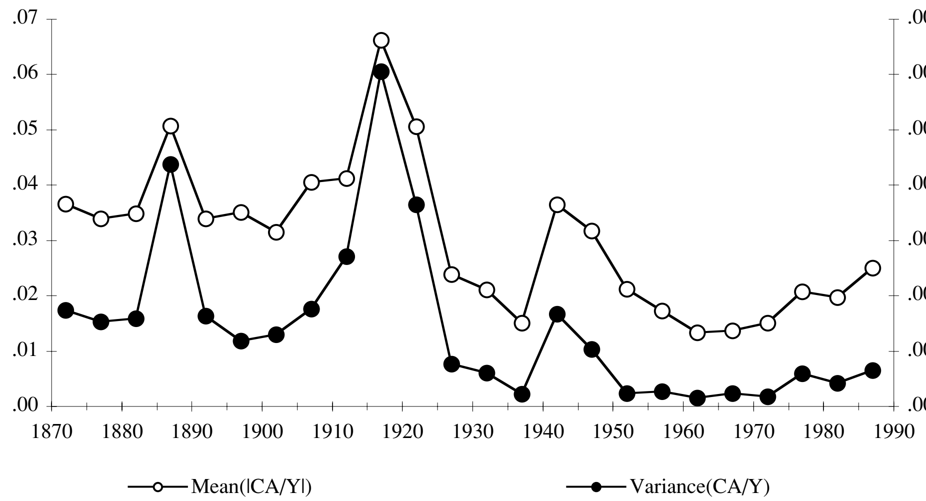
Figure 1 present the basic trends in foreign capital flows. Two measures of the extent of capital flows are used, both of which measure the cross-sectional dispersion of $(CA/Y)_{it}$ for fixed t. First, the variance $\sigma^2_{CA/Y,t}$; second, the mean absolute value $\mu_{|CA/Y|,t}$. Quinquennially averaged data are used throughout.[3].

Both measures show similar patterns across time. Consider $\mu_{|CA/Y|}$. The average size of capital flows in this sample was often as high as 4%–5% of national income before World War I. At its first peak it reached 5.1% in the overseas invest-

[2] S is thus equal to the sum of private saving $S_{\text{priv}} \equiv Y - T - C$ and public saving $S_{\text{pub}} \equiv T - G$, where T is tax revenue. The basic identity, $CA = S - I$, is central to my analysis. In terms of historical data collection, it proves essential to utilize the identity to measure saving residually, as $S = I + CA$, because no national accounts before the 1940s supply independent saving estimates; rather, we have access only to investment and current-account data.

[3] The data are in an appendix available from the author

Figure 1
Current Account Relative to GDP: Summary Statistics



Notes and sources: See text and appendix.

ment boom of the late 1880s. This dropped back to around 3% in the depression of the 1890s. The figure approached 4% again in 1905–14, and wartime lending pushed the figure over 6% in 1915–19. Flows diminished in size in the 1920s, however, and international capital flows were less than 2% of national income in the late 1930s. Again, wartime loans raised the figure in the 1940s, but in the 1950s and 1960s, the size of international capital flows in this sample declined to an all time low, around 1.3% of national income. Only in the late 1970s and 1980s have flows increased, though not to levels comparable to those of a century ago.

Of course, mere flow data, as a quantity criterion, serves only as weak evidence of changing market integration. However, these basic descriptive tables and figures do illustrate the record of capital flows, and offer *prima facie* evidence that the globalization of the capital market has been subject to major dislocations, most notably the inter-war period, with a dramatic contraction of flows seen in the Depression of the 1930s. Moreover, this low level in the volume of flows persisted long into the postwar era. We now turn to more formal tests to see whether this description, and the conventional historiography of world markets that points to the Depression as an era of disintegration, has broader support.

Saving-Investment Correlations

One starting point for the quantity-based criteria used to assess capital mobility in this paper is the seminal paper by Feldstein and Horioka (1980). Feldstein and Horioka reasoned that, in a world of perfectly mobile capital, domestic savings would seek out the highest returns in the world capital market independent of local investment demand. Thus, Feldstein and Horioka expected to find low correlations of domestic saving and investment rates among developed countries given the conventional wisdom that international capital markets were well integrated by the 1960s and 1970s. In a surprising and provocative result, they discovered a high and significant investment-saving correlation in regressions of the form $(I/Y)_i = a + b(S/Y)_i + u_i$, with b typically close to unity for a cross section of OECD countries with 5-year period averaging. It appeared that changes in domestic saving passed through almost fully into domestic investment, suggesting imperfect international capital mobility. [4]

Some applications of the Feldstein-Horioka approach in economic history, the natural antecedents of this paper, therefore warrant mention. Bayoumi (1989) applied the FH criterion to the classic gold-standard period before 1914 for a sample of eight countries. His finding that the fit was poorer, and the correlation lower, than for contemporary data, suggested that capital markets might well have been better integrated in the late-nineteenth century than today. Similar findings were also shown by Zevin (1992), using data for eight countries: his b was no higher than 0.51 for decades from the 1870s to the 1920s, certainly no higher than the measurements of the same coefficient for the 1960s and 1970s.[5]

Do these conclusions hold for a broader sample of countries and a longer span of data? The results of applying the FH test to my panel data are shown in Figures 2 and 3. Figure 2 displays the coefficient b for both 5-year and ten-year averaging patterns. Figure 3 shows Sinn's (1992) coefficient for annual data.[6] What do

[4]Feldstein and Horioka coined the term "savings-retention coefficient" to describe the regression coefficient b. Their finding has been replicated many times, so much so as to be now considered a robust result — a stylized fact, as it were (Feldstein and Bacchetta 1991; Frankel 1991; Obstfeld 1986; Tesar 1991; Sinn 1992).

[5]Bayoumi's data excluded the United States for what seemed like arbitrary reasons, drawing criticism from, and prompting a reevaluation by, Eichengreen (1990). Eichengreen concluded that Bayoumi's conclusions were not so robust: the long-run correlations were typically different from zero at conventional significance levels, except for the 1902–1913 period. However, the conventional view that the inter-war period marked a significant curtailment in capital mobility was not overturned.

[6]The table includes the estimated coefficient b and various statistics for each cross-section re-

the results show? Before FH-type coefficients can be interpreted we require a benchmark for what constitutes a "high" or a "low" b. Put another way, b comes equipped with no intrinsic absolute yardstick: we need to find a period we consider one of undisputed capital mobility and then compare other b observations to this benchmark. Alternatively, we might search for movements in b as indicators of whether saving-investment interdependence was relatively high or low for a given period. The estimated coefficient is significant in most periods, and usually positive. It occasionally exceeds unity. The results reveal considerable fluctuation in the magnitude of b over the long run that do correspond to the stylized facts in historical narratives on capital mobility.[7]

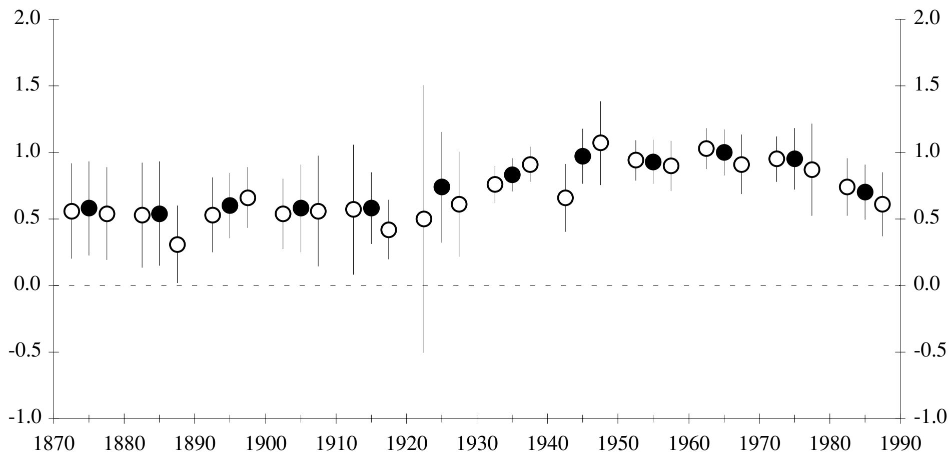
Capital mobility was thought to have been high (low b) during the 1880s, when financial markets were engaged in a frenzy of foreign investment. The crash of the early 1890s brought this phase to a halt (higher b), and capital mobility diminished markedly. Gradually, closer to World War One, capital mobility again increased (falling b) in the last great foreign investment boom during the age of high imperialism, propelled largely by British capital flows (Edelstein 1982). The Wars and Great Depression are supposed to have ushered in a time of increased autarky (Temin 1989; Eichengreen 1990; Eichengreen 1992). This phase was associated with increased capital controls and other impediments to capital mobility (Nurkse 1944; Einzig 1935). The structural change is also reflected in other measures of capital mobility, marking the Depression as a watershed in international capital mobility. The regime switch effectively limited international capital mobility for several decades (rising b), as capital controls persisted under Bretton Woods. With the collapse of Bretton Woods in the early 1970s, the move to floating exchange rates, and the easing of capital controls this permitted, b began to decline in the late 1970s and 1980s, albeit to a limited degree (Feldstein and Bacchetta 1991; Obstfeld 1994; Taylor 1994).[8]

gression: the R^2, plus the t-statistic and standard error of b. After 1870 the sample always includes between 12 and 15 countries — not a huge sample, but comparable in size to Feldstein and Baccheta's (1991) sample of nine EC countries.

[7] On these stylized facts see Obstfeld and Taylor (1997).

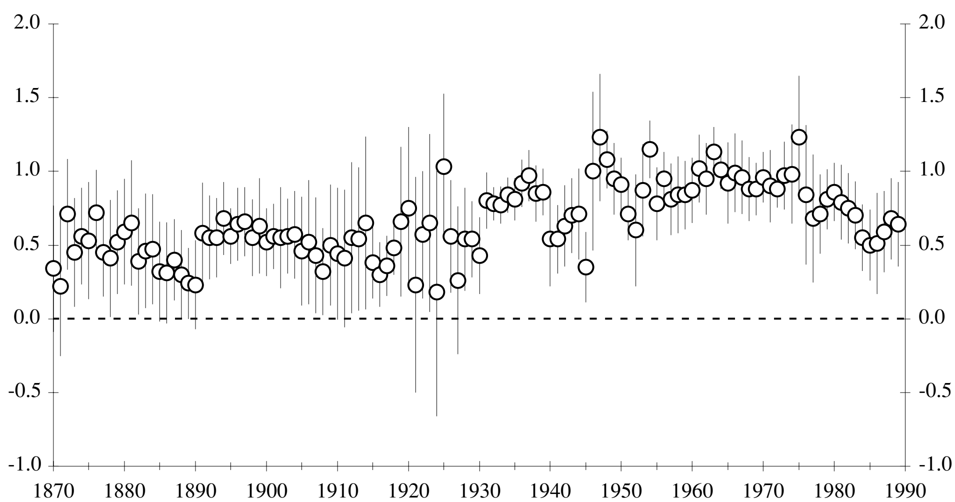
[8] We may note the remarkable relationship between the results of the FH test and the historical patterns of institutional change, monetary experiments, and policy regimes. Note the dramatic, but not entirely unsurprising, correlation between periods of tight saving-investment correlation and periods of crisis: the fit of the regression is much stronger in the 1870s and 1890s depressions, during the Great Depression (with especially tight correlations), and again in the 1970s crisis (oil shocks, collapse of Bretton Woods, stagflation). This would be expected if autarkic policy responses and or just greater uncertainty in such episodes acted as barriers to the free movement of capital.

Figure 2
Feldstein-Horioka Estimation: FH Coefficient ± 2 standard errors



Notes and sources: See text and appendix.

Figure 3
Sinn's Cross-Section Coefficient ± 2 standard errors



Notes and sources: See text and appendix.

Caveats: What is b?

Still, we might ask, what does the FH coefficient mean and how do we measure it accurately? The key issue for interpretation is, I think, how one can argue for a meaningful FH regression given the fundamental macroeconomic intertemporal identities, which assert that, in the long run, permanent investment must equal permanent saving plus some constant (initial wealth). In this context, period averaging, if the periods are long enough, may lead to a misspecification in the cross-section approach by creating the estimation of an identity (or an approximation thereof), and a regression with b *ipso facto* equal to one.

Several authors see these — and other — issues as a potentially fatal problem with the cross-section methodology (Sinn 1992; Obstfeld 1994; Jansen 1996). Thus, many prefer instead to estimate the time-series specification only. Some work in this vein has used a cointegration approach that incorporates a long-run equilibrium relationship between saving and investment and admits short-run disequilibrium dynamics (Miller 1988; Vikøren 1991; Jansen and Schulze 1996). Another general criticism here is essentially an argument against the "pooling" of time-series data, inherent in the "between" estimator used by Feldstein-Horioka, an approach which assumes away cross-country heterogeneity in the coefficients; time-series analysis provides a test for these restrictions, as shown by Fujiki and Kitamura (1995), and they find that pooling is easily rejected in most cases, as it is for my data at the 1% level.

This suggests we look at each country separately, or at least in addition to pooling, and examine saving-investment dynamics and equilibria in the context of a more formal small-open-economy model. Clearly, we are well placed to employ such an alternative methodology here, given a large panel data set. However, I do not intend to dismiss the relevance of the FH criterion as a useful diagnostic tool. In fact, at the end of the analysis in the next section, I will show through some simulations that *dynamic* measures of capital mobility have a monotonic relationship with the *static* FH parameter estimate. In this sense, I still defend the idea that the FH parameters have been telling us all along what the originators claimed, a conclusion supported by the historical patterns already discussed. However, I also suggest that my alternative measures of capital mobility can offer a deeper insight by revealing the underlying dynamic properties of saving, investment, and the current account.

A Dynamic Model

Long-Run Budget Constraints and Current Account Stationarity

The theory of the long-run budget constraint is well-developed and need not be repeated here. We will be applying it at the level of the national economy, following earlier studies like Trehan and Walsh (1991), Hakkio and Rush (1991), and Wickens and Uctum (1993).

The theory focuses on the intertemporal restriction that the present discounted value of the current account, plus the initial debt of the economy, must equal zero, or,

$$D_0 = \int_0^\infty CAe^{-rt} = \int_0^\infty (S - I)e^{-rt}.$$

It is the presence of saving and investment in this final term that guarantees at least some "long-run" relationship between the two, absent some Ponzi scheme to allow a violation of this constraint. Note that $dB/dt = CA = X - M + rB$; we may now employ integration by parts, to show that

$$B_0 = \lim_{t\to\infty} Be^{-rt} - \int_0^\infty rBe^{-rt}.$$

Under no-Ponzi conditions, the present discounted value of debt goes to zero, $\lim_{t\to\infty} Be^{-rt} = 0$. The econometric implications of this transversality condition can then be derived (Trehan and Walsh 1991): the interest-inclusive external deficit $CA = X - M + rB$ must be stationary for solvency to hold.[9]

Although such a framework is useful in a static economy, we must adapt it for our purposes where we study over 100 years of data for many countries. In this setting long-run growth obviously occurs. Can we adjust the transversality condition for the possibility that economies can "grow out of debt"? This was one concern discussed by Hakkio and Rush (1991): the transversality condition $\lim_{t\to\infty} Be^{-rt} = 0$ might be too harsh. A country with long-run growth might be able to maintain a level of debt that declines as a fraction of output in current and present value terms, but which grows faster than the rate of interest.[10] It might be argued that such a country is still solvent. To adapt the stationarity test, we scale

[9] This is true when primary deficits are difference stationary. Trehan and Walsh work in a government budget context, so their terminology is different, but translates to the current account directly. Thus, it can also be shown that the "primary" deficit $X - M$ (the trade balance) is the error-correction term for "revenues" X and "expenditures" M.

[10] Obviously, we restrict attention to cases where dynamic efficiency holds, with $r > g$.

Table 1
DF-GLS Unit Root Tests

Series	S/Y	S/Y	S/Y	I/Y	I/Y	I/Y	CA/Y	CA/Y	CA/Y	T
Detrending	(0)	(1)	(1,t)	(0)	(1)	(1,t)	(0)	(1)	(1,t)	
Argentina	-1.39	-1.00	-1.64	-0.59	-0.98	-1.82	-3.95 **	-1.59	-1.59	108
Australia	-1.80	-1.01	-1.98	-0.89	-1.22	-1.46	-4.30 **	-1.35	-1.37	132
Canada	-0.49	-1.04	-2.08	-0.55	-1.42	-1.20	-2.18 *	-1.72	-1.47	123
Denmark	-0.11	-0.86	-2.36	-0.50	-1.80	-2.27	-4.21 **	-0.80	-1.12	113
Finland	-1.31	-1.51	-1.30	-0.57	-1.07	-1.29	-3.70 **	-4.25 **	-4.16 **	133
France	-0.55	-0.99	-1.91	-1.33	-1.22	-1.62	-7.44 **	-1.36	-1.78	134
Germany	-0.32	-1.34	-1.15	-0.54	-1.08	-1.29	-3.53 **	-1.17	-2.07	99
Italy	-1.17	-1.05	-1.77	-0.92	-1.02	-1.38	-3.60 **	-2.29 *	-1.61	132
Japan	0.44	-1.24	-1.19	0.73	-1.40	-2.30	-4.98 **	-1.15	-1.17	107
Netherlands	-1.60	-1.39	-1.43	-0.90	-2.49 *	-2.20	-4.36 **	-1.11	-1.67	119
Norway	-0.68	-1.08	-1.94	-1.13	-3.72 **	-2.10	-4.70 **	-1.08	-1.28	122
Spain	-0.45	-0.98	-2.83	0.04	-1.05	-1.38	-5.14 **	-2.54 *	-1.47	143
Sweden	-0.45	-1.03	-3.50 **	-0.17	-1.01	-2.89	-4.69 **	-2.96 **	-1.56	132
United Kingdom	-0.89	-1.65	-1.47	0.05	-0.92	-1.50	-3.09 **	-1.42	-1.48	143
United States	-1.06	-1.36	-1.32	-1.10	-1.11	-1.90	-3.42 **	-1.44	-3.47 *	124

Notes and sources: See text and appendix. On the DF-GLS test see Elliott, Rothenberg, and Stock (1996). (0) denotes no detrending; (1) denotes a constant term; (1,t) a constant and time trend. T is sample size.

all variables by output Y_t. Following Hakkio and Rush (1991), the new solvency condition would be that CA/Y be stationary.[11]

Based on these criteria, we examine whether countries are obeying their LRBC by testing for the stationarity of CA/Y using the full time dimension of the data, around 100 years in all cases. Table 1 shows the results of applying the DF-GLS test (Elliott, Rothenberg, and Stock 1996), the most powerful of current univariate unit root tests, to the series S/Y, I/Y, and CA/Y for each country in our data set. The results are shown for various detrending methods, and it is apparent that whereas the saving and investment ratios are nonstationary, the current account-to-GDP ratio is stationary for all countries in the raw data (with neither demeaning nor detrending). That is, every country in our sample appears to be obeying its long-run budget constraint in the long sweep of history from the late nineteenth century to the present.

[11] Another way to look at Hakkio and Rush's methodology would be to focus on heteroskedasticity in their estimating equation. Their method implies that the LRBC is satisfied if and only if "revenues" X_t and interest-inclusive expenditures $M_t - rB_t$ are cointegrated, with $X_t = \alpha + \beta(M_t - rB_t) + \epsilon_t$, and $b = 1$. This may be restated as saying that the difference between the two (up to a constant $\epsilon_t = CA_t$) be stationary. But the problem with running such a test on long run data is that we expect long-run growth to cause heteroskedasticity and bias the test: swings in ϵ may be expected to grow large as the economy grows large. Hence we should normalize by dividing through by Y.

Current Account Dynamics and Capital Mobility

It is of interest to do more than just verify that CA/Y is stationary. In fact, the dynamics of CA/Y can tell us a great deal about capital mobility. We can investigate the adjustment seed of CA/Y back towards its equilibrium value — a value that, as the previous table showed, appears to be zero. To do this I implemented simple AR(1) regressions of the form

$$\Delta(CA/Y)_t = \alpha + \beta(CA/Y)_{t-1} + \epsilon_t.$$

and examined the convergence speed β and error variance σ^2 in each case. I did this for samples with pooling across space and for each of the 15 individual countries; and for pooling across time as well as for four subperiods.

How should we interpret these parameters? I take the strong view that they are summary statistics, derivable from the dynamic processes of saving and investment (which I consider in a moment) and that they something about the nature of underlying capital mobility in the system, at lea so far as capital mobility pertains to the ability of countries to intertemporally smooth shocks to saving and investment by use of the current account. Thus, I consider these parameters to be related to the true, underlying transaction costs that might impede perfect capital mobility — where costs are broadly construed to include distortions and barriers arising from policies, institutions, and underdevelopment that impinge on the efficient workings of external capital markets.

If β is small (close to zero) we would infer that the country has a very flexible current account and the capacity to run persistent deficits or surpluses. Conversely, if β is high (close to one) the country has a very rigid current account where deviations from balance are hard to sustain. In this dynamic framework, we would consider the former to be evidence of relatively high capital market integration as compared to the latter. In addition, we must also consider the other parameter estimated here, the error variance σ^2. If this is high, it indicates a large range of real shocks to the current account, whereas a small variance indicates more tranquil times in the external balance.

These parameters also have a direct bearing on the earlier puzzle, the frequently "low" measured size of capital flows (Figure 1) and, corresponding to that, the often "high" FH coefficient (Table 1). Obviously, if capital flows are small, the FH coefficient is bound to be close to unity. But now that we have a dynamic AR(1) model of the current account, we see that the expected variance (for a one country sample, in the time dimension) of CA/Y is just given by

$$\text{Var}(CA/Y) = \frac{\sigma^2}{1-\rho^2},$$

where $\rho = 1 - \beta$ is a persistence parameter. Hence, as is intuitively obvious, countries will only have large current accounts (according to this variance measure used in Figure 1) if their dynamics allow it: if shocks are large or if the convergence speed is slow (persistence is high). Thus, one way to resolve the Feldstein-Horioka puzzle is to see exactly what kind of sustained current account imbalances the dynamics do in fact permit.

Table 2 and Figure 4 show the results. These tables are very striking in that they confirm, for the first time in a *dynamic* model of current account adjustment, the stylized facts of the historical literature concerning capital mobility. This is best illustrated by referring to Table 2 for the pooled samples, or to Figure 4, which shows a distillation of the parameters in individual country samples.[12]

Looking first at the pooled data we see that the convergence speed (β) was very low in the pre-1914 era, about 16% per annum. That is, current account deviations had a half-life of about 3 years, suggesting considerable flexibility to smooth shocks over medium to long horizons. This freedom to adjust was much reduced in the interwar period, as the convergence speed doubled to about 34% per annum, implying a half-life of about 1.5 years. It was curtailed yet further under the Bretton Woods era when the convergence speed doubled again to 65%, with a half-life now under one year. Only in the recent floating period has flexibility returned to the current account in this sample, with a convergence speed of 22%, not significantly different from the pre-1914 estimate, though still a little higher as a point estimate. This accords with the notion that the Bretton Woods re-design of the international financial architecture, as it sought to avoid a repeat of volatile interwar conditions, had as its intent a virtual shutting down of international capital markets – and was very successful in achieving that end.

A brief look at the error variance (σ) reveals no surprises given our historical priors. Shocks were largest during the turbulent interwar years, just as flexibility started to be lost. Shocks were smallest in both postwar periods, both during and after Bretton Woods — and that seems entirely consistent with the long-lasting impact of a highly controlled system designed to both limit capital mobility and prevent shocks. The pre-1914 had shocks larger than the postwar period, smaller than the interwar; yet it also had the flexibility to handle them rather well. Thus,

[12]Individual country results are available from the author upon request.

Table 2
Current Account Dynamics (Pooled Sample)

						Specification Tests		
Countries	Periods	β	σ	R^2	T	No Lags	Pooling Periods	Pooling Countries
Pooled	Pooled	-0.27 (0.02)	0.028	.14	1606	.00	.00	.00
Pooled	Gold Std.	-0.16 (0.03)	0.028	.07	498	.00		.00
Pooled	Interwar	-0.34 (0.04)	0.037	.17	417	.00		.01
Pooled	B. Woods	-0.65 (0.04)	0.022	.38	376	.08		.00
Pooled	Float	-0.22 (0.04)	0.017	.10	315	.03		.45

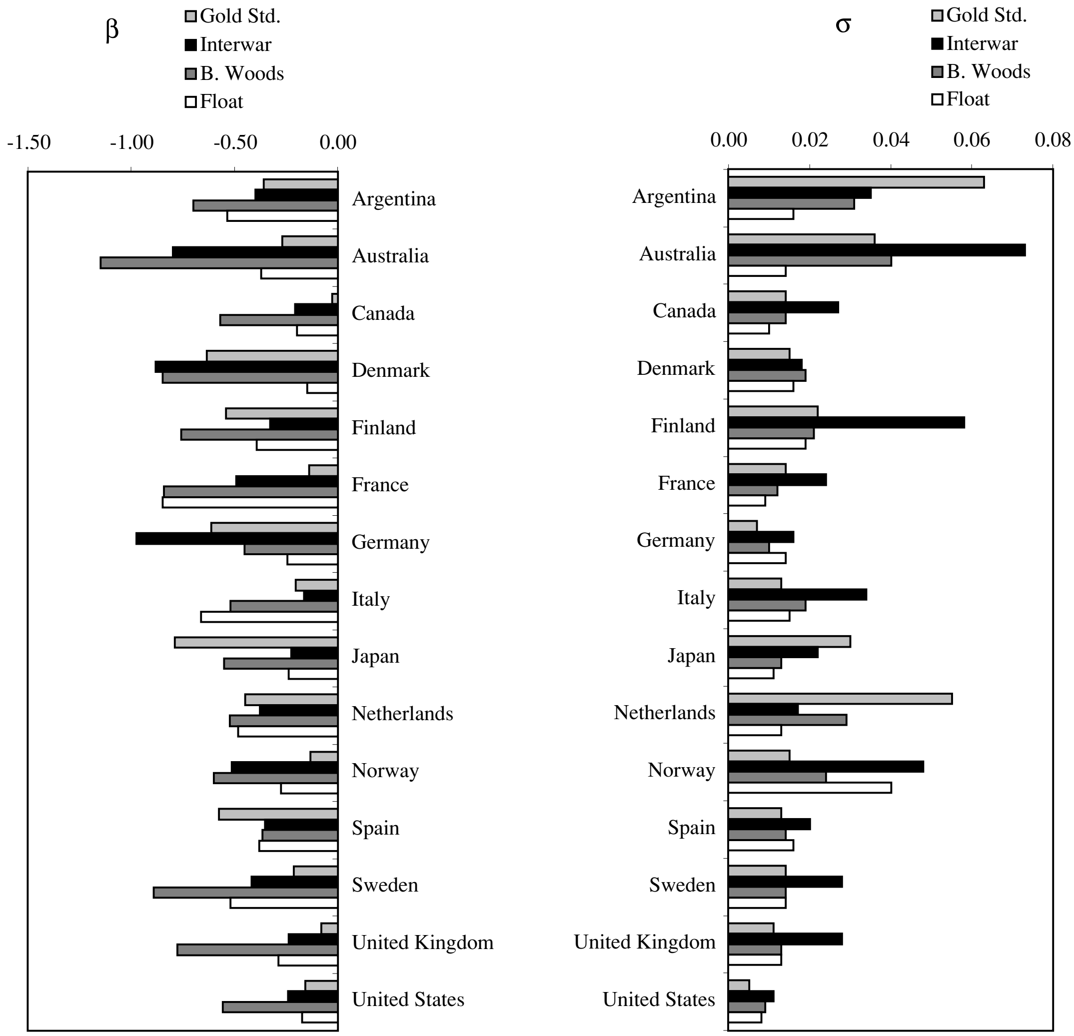
Notes and sources: See text and appendix.

the Bretton Woods re-design was based on a valid premise — high volatility in the interwar period. But the solution was based not a return to market-based smoothing of shocks, as in the pre-1914 era, with highly flexible capital flows, but rather an attempt to shut down both the flows and the shocks themselves.

Cross-Country Variation and the Stylized Facts

Are such inferences valid in all countries? The trouble with the pooled samples is that they may not be a reasonable sample given the implied restrictions on the regressions. As Table 2 shows it is easy to reject pooling across countries, at the 1% level in all cases except the float. It is also the case that the simple specification with no lags of $\Delta(CA/Y)_t$ is doubtful, given a specification test on the inclusion of additional (up to six) lags. (With country-by-country estimation, the absence of a complex lag structure is usually accepted.) Furthermore, loosening up the specification in this way, whilst allowing us to admit different dynamics for each country, does not significantly alter our historical interpretation. In Figure 4 we see that for most countries the peak in the adjustment speed is experienced in the Bretton Woods period (11 out of 15 cases). Denmark is too close to call, which leaves three exceptions. Germany has its peak in the interwar period, which is as expected given the severe constraints on borrowing imposed after Versailles, and only briefly eased by the Dawes plan. Japan has a much larger peak in the pre-1914 period, which is no surprise given the then-recent advent of the Meiji reforms. Spain's pre-1914 peak might be reasonable given that she was a country on the periphery at that time, and somewhat isolated from the group of well-integrated

Figure 4
Current Account Dynamics: Adjustment Speeds and Error Variance



Notes and sources: See text and appendix.

gold standard countries by dint of her preference for silver money.

The error variances also accord well with the pooled results, with peak volatility in the interwar period again in 11 out of 15 cases. Unsurprisingly, volatility is much larger for the smaller economies: the U.S. variance is very small indeed as compared to countries like Argentina, Australia, Netherlands, and Norway. The Danish case is also too close to call, and there are three exceptions to worry about once more. Argentina has its biggest error variance before 1914, which is no news to anyone familiar with the massive disruptions that caused, and then were caused by, the Baring Crisis — as massive herding in of foreign capital gave way to a sharp reversal and several years of austerity and outflows to settle debts. Even so, Argentina's interwar variance is still very high by world standards. Japan and Netherlands also have high variance before 1914. In each country we have fragile data in this period, so that is one possible source of noise — as is also true of Argentina. The Dutch were big players, as capital exporters, in the global capital market at this time, relative to country size, so that also argues for a volatile external balance. Newly-opened Japan also might have been exposed as an emerging market, like Argentina, to a good deal of volatility in this era.

I do not wish to claim that we can, nor that we should desire, an historical account of this sort to say why each and every parameter has the value it does at each moment in time. There is an obvious danger of overexplanation. It is merely worth noting at this juncture that, given the historical priors we have garnered from various sources over the years — concerning capital market flexibility and the shocks to the external balances seen over time and across countries — we have been able to validate such claims in the first dynamic model of the current account applied to long-run data.

A Vector Error-Correction Model of Saving and Investment

Thus far we have dynamically modeled only the current account, but the saving-investment dynamics are closely related. And since our motivation was to link the static FH criterion to a well-founded dynamic model, it is now time to see how our modeling strategy, and our parametrization of capital mobility, relate to the common saving-investment regressions and slope parameters — if at all.

We have shown that the current account ratio CA/Y is stationary. It immediately follows that the saving and investment ratios, S/Y and I/Y, must be cointegrated, since $CA/Y = S/Y - I/Y$ is an identity. Hence, without loss of generality, we can adopt a vector error-correction representation as a dynamic model of saving and investment. Let $s = S/Y$, $i = I/Y$, and let $z = CA/Y$ be the cointegrating term. Then, the dynamics of s and i take the form,

$$\begin{pmatrix} \Delta s_t \\ \Delta i_t \end{pmatrix} = \begin{pmatrix} \alpha_s \\ \alpha_i \end{pmatrix} + \sum_{j=1}^{p} \begin{pmatrix} \beta_{ssj} & \beta_{sij} \\ \beta_{isj} & \beta_{iij} \end{pmatrix} \begin{pmatrix} \Delta s_{t-j} \\ \Delta i_{t-j} \end{pmatrix} + \begin{pmatrix} \gamma_s \\ \gamma_i \end{pmatrix} z_{t-1} + \begin{pmatrix} \epsilon_{st} \\ \epsilon_{it} \end{pmatrix},$$

where we expect $\gamma_s < 0$ and $\gamma_i > 0$, implying that current account deficits (surpluses) bring about adjustment via savings increases (decreases) and investment decreases (increases).

The model presented here has a very general lag structure, and it is clear that it implies a more general dynamic model for $z = CA/Y$ than we have seen in the previous section. Subtracting row two from row one in the above equation, we find that

$$\Delta z_t = \alpha_z + \sum_{j=1}^{p} \left(\beta_{ssj} - \beta_{isj} \quad \beta_{sij} - \beta_{iij} \right) \begin{pmatrix} \Delta s_{t-j} \\ \Delta i_{t-j} \end{pmatrix} + \gamma_z z_{t-1} + \epsilon_{zt},$$

where $\alpha_z = \alpha_s - \alpha_i$, $\gamma_z = \gamma_s - \gamma_i$, and $\epsilon_z = \epsilon_s - \epsilon_i$. Only under certain restrictions would a pure AR representation of CA/Y obtain, independent of lagged S/Y and I/Y, and this would depend on having identical β coefficients in each row.

The dynamic saving and investment model avoids some of the pitfalls of the FH approach. The model is not *ad hoc*, and it does directly account for the LRBC problem. And because it links to the current account dynamics it gives us a way of comparing flexibility in the current account to saving and investment dynamics. In particular, changes in the adjustment speeds $\gamma_s < 0$ and $\gamma_i > 0$ will directly affect the current account adjustment speed, $\gamma_z = \gamma_s - \gamma_i < 0$. And changes in the saving-investment error variance $\text{Var}(\epsilon_t)$ will affect the current account error variance, $\text{Var}(\epsilon_z) = \text{Var}(\epsilon_s - \epsilon_i) = \text{Var}(\epsilon_s) - 2\text{Cov}(\epsilon_s, \epsilon_i) + \text{Var}(\epsilon_i)$.

Dynamic Model Parameters and FH Regression Implications

We have a dynamic model of s, i, and $z = s - i$, and we can interpret adjustment speeds and error variances as telling us something about current account flexibility and volatility. How do these time series parameters relate to the FH cross-section results? Is there any relationship between capital market integration as measured by the dynamic parameters and the FH coefficient?

To assess this link I undertook the following simulation exercise. First, I fit the model on actual data. Next, I simulated 100 years of data from a 1900 starting point for all 15 countries. Then I took the simulated 1990–99 data and performed cross-section one-year (5-year and 10-year) FH regressions. I found the b (FH) coefficient for each simulation, and repeated for 1,000 simulations. This yielded the distribution of the b coefficient.[13]

Finally, I repeated the whole exercise for different adjustment speeds $\gamma_z = \gamma_s - \gamma_i$, and different error variances $\text{Var}(\epsilon_z) = \text{Var}(\epsilon_s - \epsilon_i)$. How did I choose a range of parameters? I took the base calibration of the (s, i) model and left the lag structure and its parameters unchanged. But I did change convergence speeds and error variances. I replaced γ with $\phi\gamma$ for various multipliers ϕ, and similarly I replaced $\text{Var}(\epsilon)$ with $\phi\text{Var}(\epsilon)$. I then tabulated the results so as to see how changes in the underlying dynamic parameters of the (s, i) model — the parameters that I am taking as the true measures of the underlying mobility of capital — affect b, the FH coefficient.[14]

Table 3 shows the basic results for changes in one set of parameters at a time. Holding the error variance fixed, and rescaling the convergence speed in the (s, i) model shows that faster convergence speeds (of s, i, and, hence, z) are associated with larger FH coefficients, and the whole range runs from a low of $b = 0.5$ (when the convergence speed is cut by a factor of $\phi = 0.01$) to a high of $b = 1$ (for $\phi = 5$).[15] This is intuitive: if the current account adjusts very quickly back to zero, then for a given distribution of shocks we will very rarely see saving and investment taking on unequal values and we'd expect a high b estimate. The fact that this relationship is monotonic, at least in our discrete range of simulation parameters, suggests that the FH coefficient does have some meaning as a measure

[13]The fitted model had

$$\begin{pmatrix} \gamma_s \\ \gamma_i \end{pmatrix} = \begin{pmatrix} -0.12 \\ 0.08 \end{pmatrix}$$

and

$$\text{Var}\begin{pmatrix} \epsilon_s \\ \epsilon_i \end{pmatrix} = \begin{pmatrix} 0.00100 & 0.00046 \\ 0.00046 & 0.00065 \end{pmatrix},$$

Thus, implying $\gamma_z = -0.20$ and $\text{Var}(\epsilon_z) = 0.00073$.

[14]The first draft of this paper approached the dynamic modeling exercise with a single-equation ECM model following Jansen and Schulze (1996). The VECM model developed here is much more general, and does not require a weak-exogeneity assumption for saving. Using the single-equation ECM framework, in independent work, Jansen (1997) used a simulation approach to show how parameter shifts in the ECM could affect the cross-sectional implied FH coefficient. Our exercise is in the same vein, but it is calibrated to actual historical processes, whereas Jansen used *ad hoc* parameter choices to make an artificial cross-section of countries. We also do not assume a random walk for saving as he did, but instead model saving as part of a VECM process.

[15]When $\phi > 5$ the convergence speed γ_z exceeds one, the model implies unrealistic oscillations, and the results are suppressed.

Table 3
Simulated FH Parameters

Scaling Factor: Adjustment Speed	Scaling Factor: VCV Matrix	FH Regression Coefficient: Annual	5-Year	10-Year
0.01	1.00	0.48 (0.19)	0.51 (0.16)	0.48 (0.16)
0.05	1.00	0.56 (0.16)	0.61 (0.15)	0.59 (0.17)
0.10	1.00	0.71 (0.12)	0.70 (0.13)	0.72 (0.14)
0.20	1.00	0.81 (0.14)	0.82 (0.11)	0.84 (0.11)
0.50	1.00	0.91 (0.09)	0.91 (0.07)	0.94 (0.07)
1.00	1.00	0.96 (0.07)	0.97 (0.05)	0.97 (0.05)
2.00	1.00	0.97 (0.06)	0.98 (0.04)	0.99 (0.03)
5.00	1.00	0.98 (0.06)	1.00 (0.02)	1.00 (0.01)
1.00	0.01	1.00 (0.02)	1.00 (0.01)	1.00 (0.01)
1.00	0.05	0.98 (0.04)	0.99 (0.03)	0.99 (0.03)
1.00	0.10	0.97 (0.05)	0.97 (0.04)	0.98 (0.04)
1.00	0.20	0.96 (0.06)	0.97 (0.05)	0.97 (0.05)
1.00	0.50	0.96 (0.06)	0.97 (0.06)	0.97 (0.04)
1.00	1.00	0.94 (0.07)	0.97 (0.06)	0.97 (0.05)
1.00	2.00	0.94 (0.06)	0.96 (0.06)	0.97 (0.06)
1.00	5.00	0.95 (0.07)	0.95 (0.06)	0.97 (0.05)
1.00	10.00	0.94 (0.07)	0.96 (0.06)	0.96 (0.05)
1.00	20.00	0.94 (0.07)	0.96 (0.06)	0.97 (0.05)
1.00	50.00	0.94 (0.07)	0.96 (0.06)	0.96 (0.05)

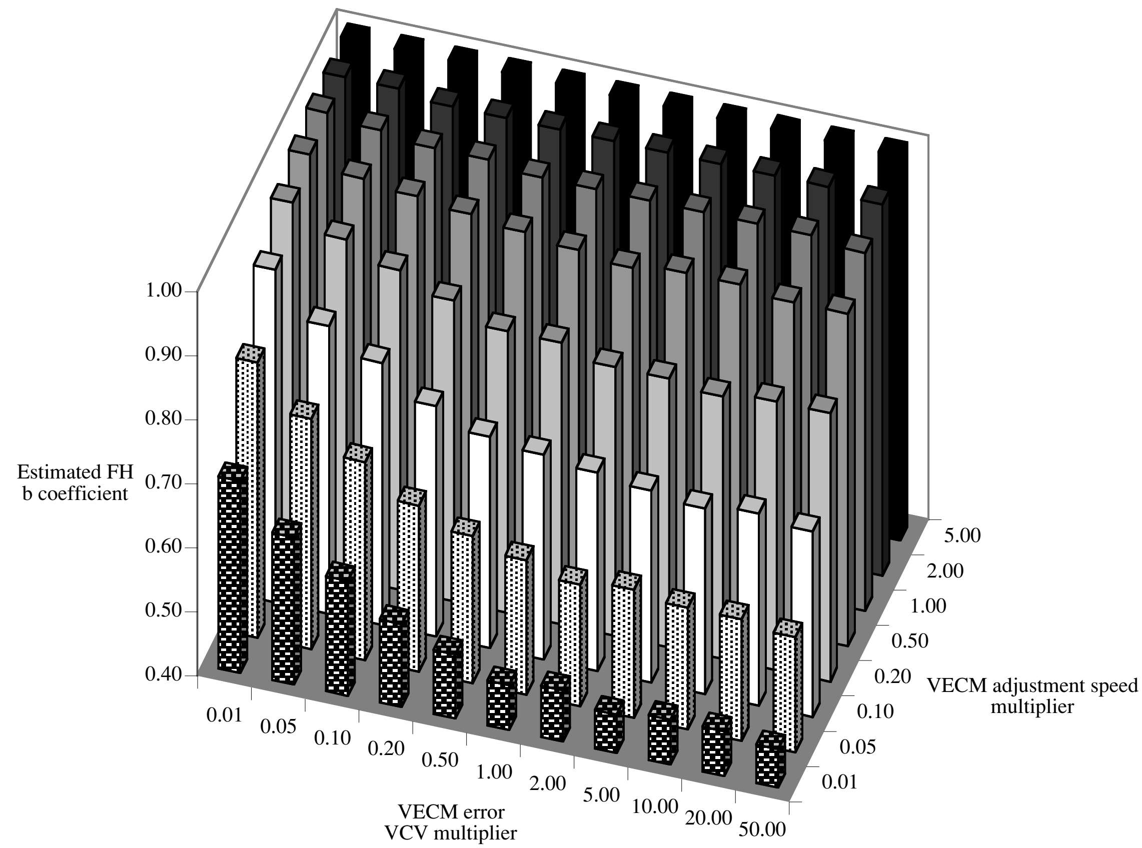
Notes and sources: See text and appendix.

of capital market integration under certain assumptions.

An alternative experiment holds the convergence speeds fixed and rescales the size of the error shocks, again using the real data for the base calibration. When I perform this experiment there is a monotonic relationship of sorts, but the magnitude of the changes in b are very small as the rescaling of shocks ranges over a multiplicative factor of $0.02 \leq \phi \leq 50$. This is a very wide range over which to see practically no variation in the FH parameter (with $0.96 < b < 1$). Clearly, though, we could be holding γ_z fixed at a value where the response of b to $\text{Var}(\epsilon_z)$ is small. The response could be bigger at other values of γ_z. Figure 5 confirms that this is indeed the case: at slower convergence speeds (smaller levels of γ_z), higher volatility (larger $\text{Var}(\epsilon_z)$) translates into a lower value of b, the FH coefficient. This is also an intuitive finding: bigger disturbances in the (s, i) model, should, holding the convergence speed constant, lead to bigger differences between saving and investment levels in each country, and, hence, a lower correlation of s and i in cross section.[16]

[16] Figure 5 shows only the results for 10-year-averaged samples. The results are similar for 1-year and 5-year averaging.

Figure 5
Simulated FH Parameters



Notes and sources: See text and appendix.

Conclusion; Or, Can The Long Run Budget Constraint Explain the Feldstein-Horioka Puzzle?

This paper has sought to deconstruct the Feldstein-Horioka puzzle by relating their 'savings retention coefficient' to a more formal, well-specified dynamic model of saving and investment. Econometric estimation and simulation exercises apply this model and show that dynamic model parameters for a panel of 15 countries over 100 years deliver a similar interpretation of changes in global capital mobility as the FH coefficient — and, reassuringly, an account consistent with the conventional wisdom of our traditional historical narratives. Are these conclusions limited and model-specific? They should not be. The LRBC and its implied solvency condition (TVC) must be a common feature of all useful models in international finance. From that restriction, some implied time-series dynamics for debts and the current account must follow — dynamics that must resemble the models estimated here.

Although our dynamic model might offer a more sophisticated view of the mechanics of saving, investment, and current-account adjustment — and a richer parametrization of capital mobility as it affects such adjustment — the results indicate that such measures of capital mobility are directly related to the traditional FH parameter in cross sections, and for intuitively appealing reasons. With that in mind, we arrive at a kind of rapprochement between the new empirical results of our dynamic models and the prevailing wisdom based on the FH regression applied to the same historical data. When convergence speeds have been low and shocks large (like in the pre-1914 era), the FH parameter was always likely to be low. But when convergence speeds were fast and shocks small (as in the Bretton Woods era) were almost sure to find a high FH coefficient.

But what is "high" and what is "low"? For a very wide range of convergence speeds and error variances in the underlying model — a wider range than is seen in the actual data – we find that simulated data from the dynamic model generates a range of FH parameters between 0.5 and 1, an interval that encompasses the actual range seen in most FH tests, and which explains why truly small FH parameters (close to zero) are unlikely to be seen. Thus, we might even claim to have attained some kind of holy grail: a meaningful, albeit deformed, yardstick for the FH tests can be based on these simulations. For such dynamics, *very* low convergence speeds can push b as low as about 0.5 — but rarely lower in practice; so this is a plausible lower extreme for the yardstick in most FH tests, and corresponds to a highly flexible current account. Conversely, fast convergence speeds soon push b close to one, the plausible high extreme on the yardstick.

Future studies might extend this result with applications to other samples, and closed form solutions might be obtainable for some models. It would also be nice to see the econometric parameters related to adjustment speed derived from optimizing models, or at least their linearization around steady states. For now the devotees of FH method can find a modicum of comfort in the results; there is a kernel of truth to claim that *b* does measure capital mobility. Still, it isn't the only possible measure, and, when there is sufficient data in the time dimension, the time-series approach offers a more direct method of evaluating capital mobility that might be preferred for its richer description of dynamics, its firmer basis in the theory of the long run budget constraint, and its ability to detect country-specific differences in the world capital market.

References

Bayoumi, T. "Saving-Investment Correlations: Immobile Capital, Government Policy or Endogenous Behavior?" IMF Working Paper no. 89/66, Washington, D.C., August 1989.

Edelstein, M. *Overseas Investment in the Age of High Imperialism*. New York: Columbia University Press, 1982.

Eichengreen, B. J. "Trends and Cycles in Foreign Lending." In *Capital Flows in the World Economy*, edited by H. Siebert. Tübingen: Mohr, 1990.

Eichengreen, B. J. *Golden Fetters*. Oxford: Oxford University Press, 1992.

Elliott, G., T. J. Rothenberg, and J. H. Stock. 1996. Efficient Tests for an Autoregressive Unit Root. *Econometrica* 64 (July): 813Ð36.

Feldstein, M., and P. Bacchetta. "National Savings and International Investment." In *National Saving and Economic Performance*, edited by B. D. Bernheim and J. B. Shoven. Chicago: University of Chicago Press, 1991.

Feldstein, M., and C. Horioka. "Domestic Saving and International Capital Flows." *Economic Journal* 90 (June 1980): 314–29.

Frankel, J. A. "Quantifying International Capital Mobility in the 1980s." In *National Saving and Economic Performance*, edited by B. D. Bernheim and J. B. Shoven. Chicago: University of Chicago Press, 1991.

Fujiki, H., and Y. Kitamura. "Feldstein-Horioka Paradox Revisited." *Bank of Japan Monetary and Economic Studies* 13 (July 1995): 1–15.

Hakkio, C. S., and M. Rush. 1991. Is the Budget Deficit 'Too Large'? *Economic Inquiry* 29 (July): 429–45.

Jansen, W. J. "The Feldstein-Horioka Test of International capital Mobility: Is It Feasible?." IMF Working Paper no. 96/100, 1996.

Jansen, W. J. 1997. Can the Intertemporal Budget Constraint Explain the Feldstein-Horioka

Puzzle? *Economics Letters* 56 (September): 77–83.

Jansen, W. J., and G. G. Schulze. "Theory-Based Measurement of the Saving-Investment Correlation with an Application to Norway." *Economic Inquiry* 34 (January 1996): 116–132.

Miller, S. "Are Saving and Investment Cointegrated?" *Economic Letters* 27 (1988): 31–34.

Obstfeld, M. "Capital Mobility in the World Economy: Theory and Measurement." *Carnegie-Rochester Conference Series on Public Policy* no. 24, 1986.

Obstfeld, M. "International Capital Mobility in the 1990s." International Finance Discussion Papers no. 472, Board of Governors of the Federal Reserve System, Washington, D.C., June 1994.

Obstfeld, M., and A. M. Taylor. "The Great Depression as a Watershed: International Capital Mobility in the Long Run." In *The Defining Moment: The Great Depression and the American Economy in the Twentieth Century*, edited by M. D. Bordo, C. D. Goldin and E. N. White. Chicago: University of Chicago Press, 1997. Forthcoming.

Sinn, S. "Saving-Investment Correlations and Capital Mobility: On the Evidence from Annual Data." *Economic Journal* 102 (September 1992): 1171–83.

Taylor, A. M. "Domestic Saving and International Capital Flows Reconsidered." Working Paper Series no. 4892, National Bureau of Economic Research, 1994.

Taylor, A. M. "Argentina and the World Capital Market: Saving, Investment, and International Capital Mobility in the Twentieth Century." *Journal of Development Economics* (1998). Forthcoming.

Taylor, A. M., and J. G. Williamson. "Capital Flows to the New World as an Intergenerational Transfer." *Journal of Political Economy* 102 (April 1994): 348–371.

Temin, P. *Lessons from The Great Depression*. Cambridge, Mass.: MIT Press, 1989.

Tesar, L. L. "Savings, Investment and International Capital Flows." *Journal of International Economics* 31 (August 1991): 55–78.

Trehan, B., and C. E. Walsh. 1991. Testing Intertemporal Budget Constraints: Theory and Applications to U.S. Federal Budget and Current Account Deficits. *Journal of Money, Credit, and Banking* 23 (May): 206–23.

Vikøren, B. "The Saving-Investment Correlation in the Short and in the Long Run." Working Paper no. 91/7, Norges Bank, 1991.

Wickens, M. R., and M. Uctum. 1993. The Sustainability of Current Account Deficits: A Test of the U.S. Intertemporal Budget Constraint. *Journal of Economic Dynamics and Control* 17 (May): 423Ð41.

Zevin, R. B. "Are World Financial Markets More Open? If So, Why and With What Effects?" In *Financial Openness and National Autonomy: Opportunities and Constraints*, edited by T. Banuri and J. B. Schor. Oxford: Clarendon Press, 1992.