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CAPITAL MOBILITY IN THE WORLD ECONOMY: THEORY AND MEASUREMENT

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ABSTRACT

This paper is a critical assessment of some recent empirical evidence on the extent of international capital mobility. Its major conclusion is that while much of this evidence is difficult to interpret without ambiguity, it is consistent with a world economy in which the degree of capital mobility is high and increasing. Two main approaches to the measurement of capital mobility are discussed. The first, traditional, approach is based on comparing expected yields on assets located in different countries. The second, and more novel, approach is based on comparing national saving rates and domestic investment rates.

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I. Introduction

Since late 1980, real interest rates around the world have risen and remained at levels unprecedented in the postwar era.[1] While the increase in real rates awaits a full explanation, the worldwide nature of the phenomenon is itself less of a puzzle. Both widespread financial deregulation and modern communication technologies have created close linkages among the financial markets of the industrialized countries. Economic theory suggests that if capital is internationally mobile, rates of return in different countries will tend to move in a synchronized fashion as investors continually shift their portfolios toward assets offering relatively high yields. Capital is said to be mobile between two regions if some of their residents may engage in inter-regional asset trades. Correspondingly, the degree of capital mobility is measured by the scope for such trades, a scope which might be limited by transaction costs, taxes, or official regulations.

How mobile is capital in the world economy? Empirical research into this question has proceeded along two major lines. The first line of research is based on the comparison of expected yields on alternative assets. The second, and more novel, line of research, originated by Feldstein and Horioka (1980), is based on the comparison of national saving and domestic investment rates. In an economy that is closed to intertemporal trade with the outside world, overall national saving and domestic investment must be equal, that is, the current account of the balance of payments must be zero. The Feldstein-Horioka approach is based on the premise that the degree of correlation between saving and investment rates is therefore a barometer of the extent of capital mobility.

This paper is a critical assessment of some recent empirical evidence on the extent of international capital mobility. Free capital mobility is in general a necessary condition for the efficient international allocation of the world's saving.[2] The efficient allocation of risks in the world economy requires international asset trade and the portfolio diversification it allows. Further, the extent to which capital is mobile is important in assessing the efficacy of financial policies in open economies, the incidence of certain taxes, and the impact on capital accumulation of changes in government and private saving. The discussion emphasizes that conclusions about efficiency cannot be drawn from any set of empirical results unless some benchmark model of an "efficient" world economy is specified in advance. Similarly, positive as well as normative conclusions are extremely sensitive to the empirical assumptions embedded in the benchmark model.

The remainder of this paper is organized as follows:

Section II describes recent work on the relation between measured rates of return on assets denominated in different currencies. It is argued that in models of any generality, the observed international linkages between these rates may be loose even if there are no serious imperfections in world capital markets. The discussion suggests that the tests most likely to be informative about the extent of capital mobility involve assets denominated in the same currency but issued in different political or regulatory jurisdictions. Available evidence is consistent with strong cross-border linkages between OECD-country capital markets.

Section III describes the Feldstein-Horioka approach and results, and then presents a life-cycle model in which countries' saving and investment rates are correlated even though capital is perfectly mobile. A simulated regression using data generated by the model yields estimates quite similar to those found by Feldstein and Horioka and others. However, the policy implications of the estimates are very different from those that are usually drawn. For example, fiscal policies that encourage saving have no effect on domestic capital stocks in spite of the strong statistical correlation between long-run saving and investment rates.

The empirical findings of Feldstein and Horioka are for the most part based on cross-sectional comparisons of countries' saving and investment rates over periods of five years or more. Sections IV through VI of this paper explore the saving-investment relation in a short-run, time-series context.

Section IV develops a simple open-economy model suitable for analyzing comovements between innovations in saving and innovations in investment. Both Feldstein (1983) and Murphy (1984) have used aggregative IS-LM models for this purpose, but the modelling strategy here is different in that the possibility of a saving-investment correlation is derived explicitly from the maximizing behavior of households and firms rather than imposed a priori.

The model of section IV highlights the fact that data from national income accounts do not yield an accurate representation of national saving in a world where shares in the ownership of domestic firms can be held by foreigners. Section V shows how this problem can increase measured correlations between saving and investment.

Section VI presents estimates of the time-series correlation between quarterly changes in saving rates and in investment rates for seven OECD countries. Although these estimates need to be interpreted with caution, they provide empirical facts with which macroeconomic theories must be consistent. The estimated correlation coefficients turn out to be highest for economies which are either very large (the United States) or have had extensive capital controls over much of the sample period (Japan). They are smaller for medium-sized countries, and may be insignificantly different from zero for the smallest economies. In all cases but those of the U.S. and Japan, the estimated saving-investment correlations over the entire sample period considered differ significantly from the value of 1 that would obtain under complete capital immobility. Further, for six of the seven countries, the measured correlation drops in the period after 1972. An interpretation of the data consistent with these findings is suggested. This interpretation, which postulates substantial and increasing capital mobility among OECD countries, receives indirect support from evidence on the United Kingdom under the pre-1914 gold standard.

The paper's main conclusions are summarized in section VII.

II. Interest, Exchange Rates, and Inflation

The international integration of national financial markets implies important linkages between the returns offered by assets issued in different countries. These links can be weakened by transaction costs, taxes, capital controls, sovereign risk, and other market imperfections. Even in the absence of imperfections, the nature of the linkage depends on investors' preferences and the stochastic structure of the world economy. The most straightforward approach to evaluating the mobility of capital is the direct comparison of rates of return on physical capital in various countries. Although such comparisons have been attempted [for example, by Harberger (1978)], the problems of measurement, of diverse tax treatment, and of converting measured returns into a common numeraire, are severe. Much recent research has therefore limited itself to comparing returns within a rather narrowly delimited group of relatively homomgeneous financial assets.[3]

It is convenient to motivate some of the recent empirical tests on international rate of return linkages by developing a simple two-good model of international nominal interest rate differentials with risk-averse investors.[4] The model makes the point that many of the empirical tests have unambiguous implications about capital mobility only under some rather stringent assumptions. It is concluded that the comparisons most likely to be informative about the extent of international capital mobility involve assets denominated in the same currency but issued in different countries.

There are two countries in the world, a "home" country and a "foreign" country, each with its own, country-specific currency. On any date t, the domestic-money price of a unit of domestic currency to be delivered with certainty on date t+1 is just $1/(1 + R_t)$, where R_t is the domestic nominal interest rate. The foreign nominal interest rate R_t^* is similarly defined, and the spot exchange rate, X_t, gives the price of a unit of foreign currency delivered at time t in terms of a unit of home currency also delivered at time t. Note that the nominal interest rates that have just been defined are risk-free nominal rates. Each country is specialized in the production of its characteristic output. The domestic-money price of home output at time t is denoted P_t, while P_t^* denotes the foreign-currency price of foreign output.

Individuals in the two countries have identical, time-separable utility functions of the form

$$E_1[\Sigma_{t=1}^{\infty} \beta^{t-1} u(c_t, c_t^*)],$$

where $E_t(.)$ is a conditional expectation based on time-t information, β

< 1 is a fixed subjective time-preference rate, c_t (c_t^*) is time-t consumption of the home (foreign) good, and the instantaneous utility function u(.,.) is strictly concave. Given these preferences, what conditions will characterize asset-market equilibrium in the absence of imperfections? Consider the position of a representative investor. If there are no cash-in-advance constraints, he may use a domestic currency unit to increase consumption of the home good today, to increase consumption tomorrow after a one-period investment in domestic-currency loans, or to increase consumption tomorrow after a one-period investment in foreign-currency loans; and in equilibrium, he must be indifferent among these three alternatives. Define $u_{c,t} = u_c(c_t, c_t^*)$, $u_{c*,t} = u_{c*}(c_t, c_t^*)$. Then the implied intertemporal arbitrage conditions are

$$(1)\quad u_{c,t}/P_t = \beta E_t[(1+R_t)u_{c,t+1}/P_{t+1}] = \beta E_t[(1+R_t^*)X_{t+1}u_{c,t+1}/P_{t+1}]/X_t.$$

Because the marginal rate of substitution between current consumption of home goods and current consumption of foreign goods foreign goods always equals the relative price of those goods,

$$(2)\quad u_{c*,t}/u_{c,t} = X_t P_t^*/P_t,$$

(1) implies that the individual is also indifferent between consuming the foreign good today and shifting that consumption forward a period through an investment in domestic or foreign bonds.[5]

The second equality in (1) may be rewritten in a way that illustrates the link between nominal interest rates and the exchange rate. Let $Cov_t(.)$ denote a covariance conditional on time-t information. Then (1) implies that

$$(3)\quad \frac{1+R_t}{1+R_t^*} = \frac{E_t(X_{t+1})}{X_t} \times \left[\frac{Cov_t(u_{c,t+1}/P_{t+1}, X_{t+1})}{E_t(u_{c,t+1}/P_{t+1})E_t(X_{t+1})} + 1\right].$$

Expression (3) reveals that, absent imperfections, the nominal interest differential between the home and foreign currencies is determined by two factors. First, there is the expected depreciation of the domestic currency against the foreign currency, $E_t(X_{t+1})/X_t$. Second, there is the covariance term, which may be interpreted as a risk premium.

The intuition behind the covariance term in (3) is as follows. The quantity $u_{c,t+1}/P_{t+1}$ measures the marginal consumption value of the domestic currency at time t+1, the utility obtained then by spending another unit of home money to consume the domestic good. [By (2), this is the same as the utility that would be obtained by spending the money to raise consumption of the foreign good.] The greater is the covariance between the future exchange rate X_{t+1} and the marginal consumption value of domestic currency, the more effective is the foreign bond relative to the domestic bond as a hedge against consumption risk. This is because the stochastic payoff on foreign assets, in terms of domestic currency, tends to be surprisingly high when the consumption value of the currency is surprisingly high. A rise in this covariance therefore leads to a fall in the nominal interest rate on foreign bonds relative to that on domestic bonds.

When the risk premium in (3) is zero, interest rates are linked by the uncovered interest parity condition

(4) $(R_t - R_t^*)/(1 + R_t^*) = [E_t(X_{t+1}) - X_t]/X_t$

which relates the interest differential exclusively to expected depreciation. Under the assumption that expectations are rational, approximations to condition (4) have been tested extensively on recent data. These tests are unanimous in rejecting the condition as a characterization of asset-market equilibrium [see Cumby and Obstfeld

(1981,1984), Hansen and Hodrick (1980,1983), Hodrick and Srivastava (1984,1985), and the references therein]. But it should be clear that the assumptions required to proceed from (3) to (4) are not innocuous.[6] Most authors have therefore regarded rejections of (4) as indicating the presence of a time-varying consumption risk premium rather than irrationality or market imperfections. Because expectations (and, by implication, risk premia) are not directly observable, this is just one of several possible interpretations. Only after making some strong prior assumptions on expectations and the nature of the risk premium can one extract conclusions about the functioning of international asset markets from tests of (4).[7]

It is noteworthy that the concept of uncovered interest parity may not always be well defined. By using (2), one can manipulate (3) to obtain

$$(5)\quad \frac{1 + R_t^*}{1 + R_t} = \frac{E_t(1/X_{t+1})}{1/X_t} \times \left[\frac{\mathrm{Cov}_t(u_{c*,t+1}/P^*_{t+1}, 1/X_{t+1})}{E_t(u_{c*,t+1}/P^*_{t+1})E_t(1/X_{t+1})} + 1 \right],$$

which is just equation (3) viewed from the perspective of the foreign currency. If the risk premium in (5) is zero, (4) will not generally hold because, by Jensen's inequality, $E_t(1/X_{t+1})$ need not equal $1/E_t(X_{t+1})$. In fact, uncovered interest parity can be uniquely defined only in a nonstochastic environment. This fact is sometimes called "Siegel's paradox" [Siegel (1972)].

Tests of uncovered interest parity typically use interest rates on Eurocurrency deposits, which, unlike U.S. Treasury bills, are not widely believed to be free of default risk. This raises two further problems of interpretation. The first of these arises from the assumption underlying (3) that interest rates are risk free-rates. The second problem, which is more serious, involves the question of whether inferences concerning international capital mobility can in fact be made from the tests.

The presence of default risk indicates that the reasoning leading to (3) or (5) is not valid when applied to Eurocurrency rates. The use of Eurocurrency rates is typically justified, however, by the argument that Eurocurrency deposits have identical risk characteristics (at least when issued by the same bank). And indeed, a particular formalization of this idea does yield (3) and (5). Suppose that the Eurobank honors its deposits with probability ε_{t+1} on date t+1 but defaults with probability $1 - \varepsilon_{t+1}$, paying depositors no compensation in that case. Let Ω_{t+1} be a random variable that assumes the value 1 with probability ε_{t+1} and the value 0 with probability $1 - \varepsilon_{t+1}$. Then the stochastic payoff on home-currency Eurodeposits is $\Omega_{t+1}(1 + R_t)$, with an expected value of $E_t[\Omega_{t+1}(1 + R_t)] = \varepsilon_{t+1}(1 + R_t)$, while that on foreign-currency Eurodeposits is $\Omega_{t+1}(1 + R^*_{t+1})$, with an expected value of $\varepsilon_{t+1}(1 + R^*_t)$. If Ω_{t+1} is distributed independently of all other relevant variables, then conditions (3) and (5) follow exactly as before. Of course, a failure of the foregoing independence assumption makes it even more difficult than otherwise to interpret rejections of condition (4).

The second problem of interpretation is that tests of interest parity based exclusively on Eurocurrency rates simply may not yield any information about the extent of capital mobility among countries. These tests typically assess the efficiency of arbitrage among deposits issued in a single locality (for example, London). Unless tests involve assets issued in different countries, they can tell us little about the ease with which residents of those countries can engage in intertemporal trades. This point would be irrelevant if nominal yields on assets denominated in the same currency but issued in different political jurisdictions were equal. But casual observation reveals discrepancies, for reasons that may involve heterogeneity in terms of default risk, sovereign risk, and tax treatment, as well as existing capital controls and other financial regulations [see Aliber (1973) and Dooley and Isard (1980)].[8]

Indeed, any attempt to measure capital mobility using rates of return must be based, not on a comparison of Eurocurrency rates, but on a comparison of nominal yields on "onshore" and "offshore" assets denominated in the <u>same</u> currency--for example, large dollar certificates of deposit issued by New York banks and those issued by London banks. These rates generally do differ, as noted above, but for many currencies they have tended to move together in recent years [see Fieleke (1982), chart 1].

Johnston (1979) finds that after correction for differential financial regulations, Eurodollar and Eurodeutschemark rates are always quite close to the interest rates paid on comparable liabilities of onshore banks (at least after 1975 for dollar rates and after mid-1973 for DM rates). In a very careful study accounting for bid-ask spreads and the cost of deposit insurance as well as differential reserve requirements, Kreicher (1982) finds that over the 1975-1980 period, the difference between Eurodollar and U.S. certificate-of-deposit rates afforded banks little or no opportunity for arbitrage.[9] Hartman (1984) presents evidence of significant two-way feedback between Eurodollar deposit rates and interest rates on commercial paper issued in the U.S.

When capital controls are known to have been important, there are still links between onshore and offshore interest rates, but also some important discrepancies. Giavazzi and Pagano (1984) show that for France and Italy, these discrepancies have been largest around the time of exchange-rate realignments within the European Monetary System (EMS). In contrast, these authors find a close connection between onshore and offshore rates for Germany and the Netherlands, two EMS countries with essentially open capital markets. Rogoff (1985) also presents evidence that capital controls have helped the French and Italian authorities maintain EMS-linked exchange rates. Ito (1983) documents the existence of apparent arbitrage opportunities between Japanese Gensaki repurchase agreements and Eurocurrency deposits during the 1970s, when Japanese capital controls were stringent. However, he shows that these opportunities became very infrequent once Japanese capital markets were effectively opened in December 1980.[10]

On the whole, therefore, data on onshore-offshore interest differentials imply a substantial degree of capital mobility among OECD countries. In the face of this strong evidence of efficient international portfolio allocation at each point in time, it is difficult to understand assertions that the allocation of portfolios <u>over</u> time is somehow consistent with substantial arbitrage opportunities.

No explicit mention has been made of the international linkage among expected <u>real</u> rates of interest, defined as nominal rates corrected for expected local price-level inflation. The reason is that the theory outlined above makes no strong predictions about real interest rates so defined. This point is illustrated through the assumption that the interest parity condition (4) holds. Define the domestic inflation rate as $\Pi_{t+1} = (P_{t+1}/P_t) - 1$ and the foreign inflation rate as $\Pi^*_{t+1} = (P^*_{t+1}/P^*_t) - 1$. If τ_t denotes the terms of trade $X_t P^*_t/P_t$, and if τ_t and P_t/P^*_t are distributed independently, then (4) can be written

$$(6)\quad (R_t - R^*_t)/(1+R^*_t) = [E_t(\tau_{t+1})/\tau_t]E_t[(1+\Pi_{t+1}/1+\Pi^*_{t+1})] - 1.$$

Note that <u>if, in addition, the terms of trade are expected to remain constant over time</u>, (6) assumes the form

$$(7)\quad (R_t - R_t^*)/(1+R_t^*) = E_t[(\Pi_{t+1} - \Pi_{t+1}^*)/(1+\Pi_{t+1}^*)],$$

which explains relative nominal interest rates by expected relative inflation rates. A very crude approximation to (7) is

$$R_t - E_t(\Pi_{t+1}) = R_t^* - E_t(\Pi_{t+1}^*),$$

the usual statement of the international equality of expected real interest rates. But even when (4) holds, the equality (7) leading to this approximation follows only if one makes some exceedingly strong assumptions, including the assumption that the relative price of national outputs follows a martingale process. This last assumption is sometimes called ex ante purchasing power parity, and while there is some support for it in the data, it can be statistically rejected in many cases [see Cumby and Obstfeld (1984)].

The equality of expected real rates has been tested, for both onshore and offshore nominal rates, in a series of papers by Hodrick (1979), Howard (1979), Cumby and Mishkin (1985), Cumby and Obstfeld (1984), and Mishkin (1984a,1984b). In light of the rather strong rejections of uncovered parity and ex ante purchasing power parity, is it is not surprising that most of these tests reject the hypothesis that expected real rates are equal across currencies. Nonetheless, the bilateral correlations computed by Cumby and Mishkin (1985) show that ex ante real rates tend to move together, even when defined using onshore interest rates. Their finding reinforces the impression of significant capital mobility among OECD countries.

III. Saving, Investment, and Capital Mobility

While international comparisons of interest rates yield indirect evidence on the mobility of capital among countries, the connection between a country's income and its expenditure yields a direct measure of the extent of its intertemporal trade with the rest of the world. When a country is completely closed to capital movements, its income necessarily equals its spending on consumption and investment goods. In contrast, countries that are integrated into the world capital market may finance discrepancies between income and spending through international borrowing or lending.

In a pair of stimulating papers, Feldstein and Horioka (1980) and Feldstein (1983) have attempted to use measured discrepancies between national incomes and expenditures to assess the degree of international financial integration. To motivate their approach, let Y denote national income, C private consumption, I domestic investment, and G government consumption. In an economy closed to international capital movements, total national saving $S = Y - C - G$ necessarily equals domestic investment I. The current account of the balance of payments, given by

$$CA = Y - (C + I + G) = S - I,$$

is necesarily zero in this case. For an economy open to external asset trade, S and I need not coincide and therefore can vary independently in equilibrium. For example, when national saving exceeds domestic investment,the economy is running a current-account surplus and accumulating net claims on the rest of the world's future output. The Feldstein-Horioka analysis is predicated on the contention that in a world of perfect capital mobility, movements in domestic investment and movements in national saving will be approximately uncorrelated. As they put it, "With perfect world capital mobility, there should be no relation between domestic saving and domestic investment: saving in each country responds to the worldwide opportunities for investment while investment in that country if financed by the worldwide pool of capital." [Feldstein and Horioka (1980), p. 317.]

The statistical analysis in these papers is based on regression equations of the form

$$(8)\quad (I/GDP)_i = \gamma_0 + \gamma_1 (S/GDP)_i ,$$

where GDP is nominal gross domestic product, the left- and right-hand side variables are averages of annual ratios of gross nominal investment and saving to GDP over periods ranging in length from five to twenty years, and the index i ranges over a cross-section of OECD countries. A finding that γ_1 differs significantly from 0 is viewed as being inconsistent with perfect capital mobility, while a value of $\gamma_1 = 1$ is taken to represent the case of complete capital immobility.[11]

Over the period 1960-1974, for example, the least-squares estimate reported in Feldstein and Horioka (1980), table 2, is

$$\underset{(0.018)}{\gamma_0 = 0.035}, \qquad \underset{(0.074)}{\gamma_1 = 0.887}, \qquad R^2 = 0.91.$$

Regressions using net, rather than gross, saving and investment yield estimates of γ_1 even closer to 1. Because γ_1 is repeatedly estimated to be significantly different from zero but not significantly different from 1, the authors conclude that capital mobility is not perfect and that most of any increment to national saving ends up augmenting the domestic capital stock. The estimated value of γ_1 is interpreted as measuring the effect of a sustained increase in a country's saving rate on its investment rate. The strong policy implication drawn from this interpretation is that policies to encourage domestic saving will have an effect on domestic investment that is essentially one-for-one.[12]

The balance of this section argues that the results reported in Feldstein and Horioka (1980) and in Feldstein (1983) do not necessarily have any implications regarding the extent of capital mobility. Common factors affecting both saving and investment rates may cause these variables to be highly correlated in cross-sectional data. But such high measured correlations do not imply that any shift in national saving, regardless of its source, affects domestic investment, as would be the case under capital immobility. A corollary of this argument is that policies that increase domestic saving rates may have no effect on domestic investment rates even if regressions like (8) yield large and statistically significant least-squares estimates of γ_1.[13]

These points are established within the context of a life-cycle model of saving and growth in the world economy. The model is designed to capture forces influencing saving and investment over the longer term. First, the theoretical predictions of the model are established. These include a possibly positive cross-sectional correlation between investment and saving rates, but a zero effect on investment of policies that encourage saving within an individual country. Second, it is demonstrated through simulated regression analysis that the theoretical model is capable of producing empirical results similar to those reported in the Feldstein-Horioka studies.[14]

Consider a small open economy which produces and consumes the single consumption good available in the world. Individuals live for two periods and are endowed with a unit of labor which is sold in the first period of life at a real wage w. The labor endowment of an old individual is zero, so all old-age consumption is financed through wealth accumulated while young. Wealth may be held in the form of domestic capital or in the form of an internationally-traded bond which costs one unit of the consumption good and pays its owner ρ units of consumption after a period. ρ is just the world rate of interest, and it is a parameter from the standpoint of the small economy.

Output y_t is a function $f(k_t,n_t)$ of domestic capital and labor. $f(.,.)$ exhibits standard properties, including constant returns. The labor force is assumed to equal $(1+g)^t$, and therefore grows at rate g. Labor cannot migrate across national boundaries. A unit of saving may be costlessly transformed into a unit of installed capital a period later, and capital depreciates in use at rate δ. Equilibrium is characterized by the conditions $\rho + \delta = f_k(k_t,n_t)$, $w_t = f_n(k_t,n_t)$, and $n_t = (1+g)^t$. If the production function is taken to be of the form $k^\alpha n^{1-\alpha}$, these equalities imply that for all t

(9) $k_t = (1+g)^t(\alpha/\rho+\delta)^{1/1-\alpha}$,

(10) $w_t = w = (1-\alpha)(\alpha/\rho+\delta)^{\alpha/1-\alpha}$,

(11) $y_t = (1+g)^t(\alpha/\rho+\delta)^{\alpha/1-\alpha}$.

Let c_t denote an individual's consumption in period t. Then the lifetime problem of an individual young at time t is to maximize

(12) $u(c_t) + \beta u(c_{t+1})$

subject to the constraint

(13) $c_t + c_{t+1}/(1+\rho) = w$.

If it is assumed that the subjective time preference factor β equals $1/1+\rho$, maximization of (12) subject to (13) results in a preferred individual consumption path that is flat at the level

(14) $c = (1+\rho)w/(2+\rho)$

and the same for each member of each generation.

Aggregate net saving in this economy, S_t, consists of the saving of the young plus the (negative) saving of the old:

(15) $S_t = (1+g)^t(w - c) + (1+g)^{t-1}[\rho(w - c) - c]$.

Equations (14) and (15) imply that

(16) $S_t = g(1+g)^{t-1}w/(2+\rho)$,

and equations (10) and (11) may be combined with (16) to obtain the ratio of net saving to gross domestic product y_t (= GDP_t),

(17) $S_t/GDP_t = (g/1+g)[(1-\alpha)/(2+\rho)]$.

Net investment I_t is given by

(18) $I_t = k_{t+1} - k_t = g(1+g)^t(\alpha/\rho+\delta)^{1/1-\alpha}$

according to (9). By (11),

(19) $I_t/GDP_t = g(\alpha/\rho+\delta)$.

The most important fact to note is that because a rise in the population growth rate g causes both the saving rate given in (17) and the investment rate given in (19) to rise, these variables can be correlated in a cross-section of countries, in spite of the perfect mobility of capital.[15] Saving rates are increasing functions of population growth rates for the standard life-cycle reasons [as set forth in Modigliani (1970), for example]: the more quickly the economy grows, the lower the weight in the aggregate saving ratio of dissaving by the old. Investment, however, depends on population growth for reasons that are unconnected with saving behavior: as the effective labor force increases, the capital stock must increase in proportion to maintain the equality between the net marginal product of capital and the world rate of return. It is really the international immobility of <u>labor</u> that is behind the saving-investment correlation in this model.

Note, however, that saving and investment rates will be negatively correlated in a cross-sectional sample if growth rates are fairly uniform across countries but there are wide disparities in the values of capital's share α.

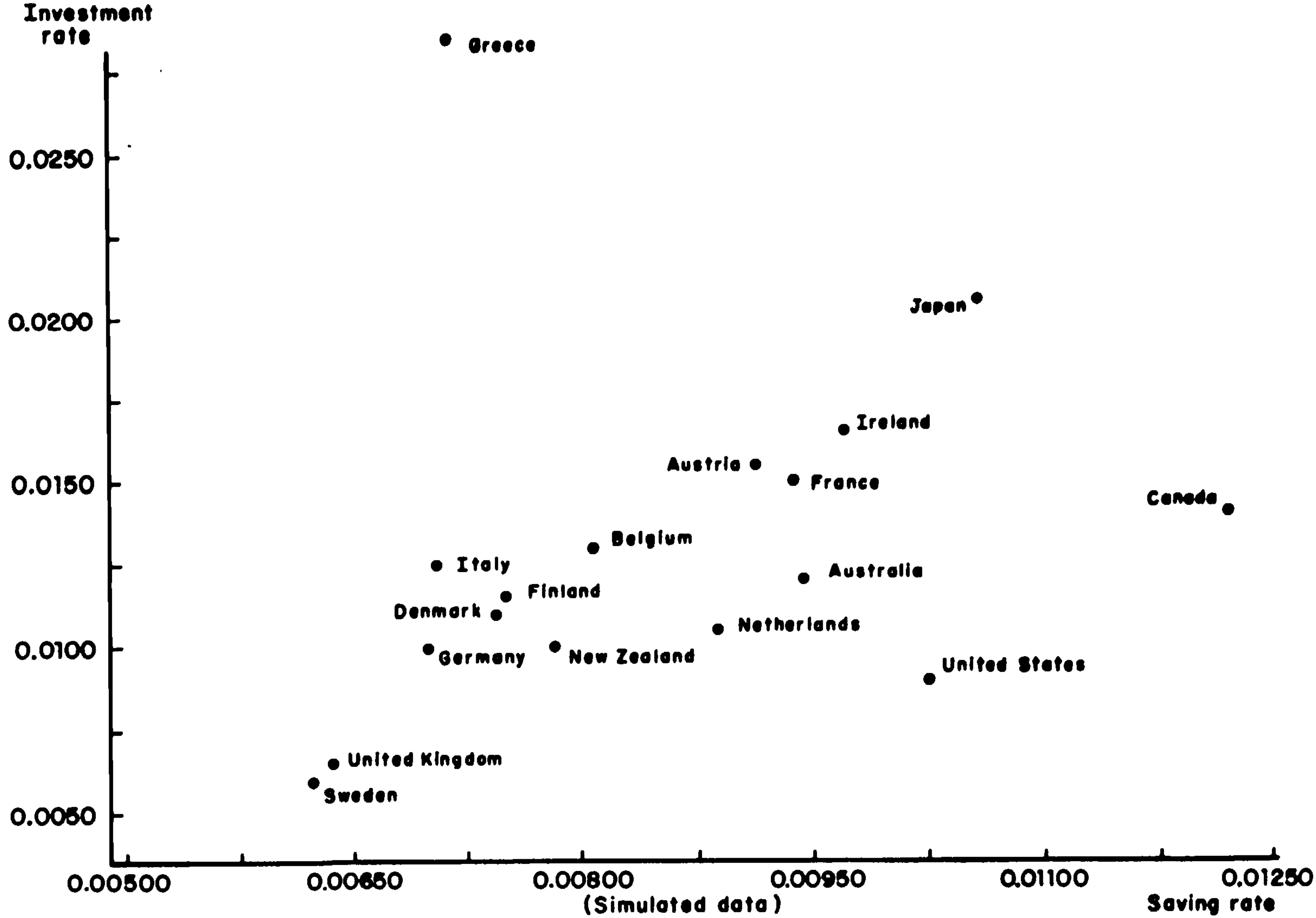
Can the theoretical model developed here yield regression results similar to those found by Feldstein and Horioka (1980) and Feldstein (1983)? To answer this question the model was calibrated using data on growth rates and the functional distribution of income for the seventeen OECD countries listed in table 1 of Feldstein (1983). In this model world economy, the lifespan of a generation was taken to be a year, ρ was set at .1, and δ was set at 1 (implying that capital is used up completely in production). A scatter diagram for the saving and investment rates generated by (17) and (19) is shown in figure 1.[16]

Estimation of (8) by ordinary least squares using the simulated data set yields

$$\gamma_0 = \underset{(0.001)}{0.006}, \qquad \gamma_1 = \underset{(0.806)}{0.858}, \qquad R^2 = 0.07.$$

While the estimate of the slope coefficient γ_1 is very close to those obtained in the literature, this parameter is imprecisely estimated, and does not differ significantly from 0 or 1. However, figure 1 indicates that "Greece" is an extreme outlier in this sample (largely because of

Figure 1


Investment rate
0.0250
0.0200
0.0150
0.0100
0.0050
0.00500
0.00650
0.00800
0.00950
0.01100
0.01250
(Simulated data)
Saving rate
Greece
Japan
Ireland
Austria
France
Canada
Belgium
Italy
Australia
Finland
Denmark
Netherlands
Germany
New Zealand
United States
United Kingdom
Sweden

the unusually low share of employee compensation in national income, an artifact of severely distorted data). Omitting that observation yields

$$\gamma_0 = \underset{(0.004)}{0.000}, \qquad \gamma_1 = \underset{(0.456)}{1.422}, \qquad R^2 = 0.41.$$

In this equation the estimated slope coefficient is significantly different from 0 and insignificantly different from 1. The equation is therefore quite close to the type of result found in the Feldstein-Horioka literature, although the R^2 is only about half as large as those typically reported there.

The preceding simulated regressions show that the Feldstein-Horioka findings are consistent with perfect capital mobility. They also show that it is hazardous to make predictions on the basis of such regressions without knowledge of the economic model underlying the measured correlation. It is true, in the theoretical model, that an increase in the saving rate caused by an increase in the economy's growth rate will be associated with a rise in the domestic investment rate. This fact lies behind the large and significant slope coefficient in the regressions. But it does not follow that <u>any</u> rise in saving will be accompanied by an increase in investment. For example, a rise in the saving rate induced by tax policies that do not affect firms will leave the investment rate unchanged: any increment to saving will indeed flow abroad in that case. The example warns us that the regression results, taken by themselves, are an insufficient basis for policy formulation.

While the foregoing counter-example is driven entirely by economic growth, it is not clear that growth alone can account for the saving and investment rates seen in the real-world data. Modigliani (1970), in a cross-country study, finds that growth rates are an important determinant of saving rates. However, there is an increasing body of evidence that life-cycle considerations alone are insufficient to explain national saving behavior in the U.S. and elsewhere [see, for example, Kotlikoff and Summers (1981)]. Feldstein and Horioka (1980) test for the importance of growth by adding the rate income growth to their basic equation (8). But while the t-statistic for the new regressor is 1.45, a high correlation between saving and investment rates remains. Summers (1985) finds a highly significant coefficient on population growth when that variable and the rate of income growth are added as regressors. An investment-saving correlation of 0.81 remains, but the Summers result contradicts the hypothesis that domestic investment depends only on domestic saving in the long run. It is an open question whether more realistic intergenerational models, incorporating bequests as well as country-specific demographic and institutional factors, can explain the observed behavior of current accounts over long periods. The preceding simulation example should not be taken as an explanation of the Feldstein-Horioka results. It should be taken as evidence that explanations other than capital immobility are quite possible. Future research should aim at identifying and testing the potential alternative explanations.[17]

Another question that has not been answered is why OECD current accounts have been so small relative to saving over most of the post-1960 period [see Feldstein and Horioka (1980) and Fieleke (1982)]. Recall that the current account measures the net flow of capital between a country and the rest of the world. Both the results of this section and the fact that gross capital flows have been large suggest that small current-account imbalances are not evidence of capital immobility. A further reason why small current accounts need not imply capital immobility is that a country's bilateral current account with respect to an individual trading partner not infrequently exceeds the difference between its total saving and investment.[18] Section V, below, points out that definitions used in national income statistics may artificially reduce the measured variability of current accounts. However, the empirical importance of this distortion is unknown at present. Tobin (1983), Westphal (1983), Summers (1985), and others have suggested that governments may target the current account over the long run through fiscal measures designed to offset changes in private spending. The extent to which endogenous fiscal policy reaction is responsible for the small size of current-account imbalances is, again, an open question; Summers (1985) presents some instrumental-variable estimates that appear to support this explanation. It should be reiterated, however, that the simulation results reported above show that a strong cross-sectional saving-investment covariation is consistent with perfect capital mobility even in the absence of such current-account targeting.

IV. Time-Series Covariation between Saving and Investment: An Example

Section III explored the interpretation of cross-sectional correlations between long-run average saving and investment rates. The Feldstein-Horioka reasoning implies also that the time-series correlation between changes in saving rates and changes in investment rates should be zero as well if capital mobility is perfect. This section discusses this proposition at a theoretical level, showing that its validity will depend on the nature of the shocks impinging on the economy. The discussion serves as a background for the estimation of time-series saving-investment correlations in section VI, below.

A simple intertemporal model of a small open economy illustrates one channel leading to a positive time-series correlation between innovations in saving and innovations in investment. That channel is the response of both saving and investment to temporary shifts in the productivity of domestic capital and labor. Saving and investment may move together in the short run even if domestic firms are entirely foreign owned. The essential reason for this comovement is again the fact that labor is not mobile across national boundaries. An increase in domestic factor productivity therefore entails an increase in the domestic wage; and if this increase is sufficiently transient, saving will rise as suppliers of labor spread it over all future periods.

The model is deliberately kept as simple as possible; in particular, a nonstochastic environment is assumed. While a stochastic setup would of course be necessary to develop rigorously the model's empirical implications, my goal here is merely to illustrate an aspect of the saving-investment link in open economies.[19] The possibly different identities of the agents who make saving decisions and those who make investment decisions is highlighted below by the presence of a stock market and value-maximizing firms. However, the competitive equilibrium naturally leads to the same allocation of resources that a central planner would choose.

A small open economy faces a perfect world capital market. Individuals consume a single good which may also be transformed into a unit of capital or lent abroad at the interest rate ρ. The world capital market is perfect in the sense that individuals may lend or borrow any amount they wish at the rate ρ, subject to a lifetime budget constraint to be discussed below. All loans are again denominated in units of the single consumption good.

The representative immortal consumer has a fixed labor endowment (normalized at unity) which he sells domestically at the wage rate w_t at time t. He holds his nonhuman wealth at time t in the form of claims on foreigners (possibly negative) and shares h_t $(0 \leq h_t \leq 1)$ in the profits of the single domestic firm. Shares pay dividends (and bonds pay interest) after a period. Let d_t denote the dividends the domestic firm pays out in period t and q_t the firm's ex-dividend (or end-of-period) market value. Necessary conditions for the optimal individual consumption plan under perfect foresight may be derived by maximizing the consumer's objective function

(20) $\Sigma_{t=1}^{\infty}\beta^{t-1}u(c_t)$

subject to

(21) $q_t h_t + b_t = w_t + (q_t + d_t)h_{t-1} + (1+\rho)b_{t-1} - c_t \qquad (t \geq 1).$

An implication of the necessary conditions is that in a perfect-foresight equilibrium, shares in the domestic firm offer a rate of return equal to the world interest rate:

(22) $(q_{t+1} - q_t + d_{t+1})/q_t = \rho.$

The simplifying assumption $\beta = 1/(1+\rho)$ yields the further implication that individuals choose a perfectly flat consumption path.

Consumption is flat at the highest constant level that allows the lifetime budget constraint

(23) $\Sigma_{t=1}^{\infty}(1+\rho)^{-(t-1)}(c_t - w_t) \leq (q_1+d_1)h_0 + (1+\rho)b_0$

to hold as an equality. The implied consumption function is

(24) $c_t = (\rho/1+\rho)[(q_t+d_t)h_{t-1} + (1+\rho)b_{t-1} + \Sigma_{j=0}^{\infty}(1+\rho)^{-j}w_{t+j}],$

for all $t \geq 1$.

Consider next the behavior of the representative domestic firm. The firm is labelled "domestic" not because it is owned entirely or even in part by domestic residents, but because its capital cooperates with domestic labor in the production of output. The firm chooses a program of production and investment that maximizes its beginning-of-period value v, equal to the discounted present value of current and future dividends. In the Modigliani-Miller environment that has been assumed, it makes no difference how the firm finances its investment. It is convenient to assume that the firm does so entirely through retained earnings.[20]

Output at time t, y_t, is a constant-returns function $\theta_t f(k_t, n_t)$ of domestic capital k_t, labor n_t, and a factor-productivity disturbance θ_t. Capital may be installed costlessly, and it depreciates in use at rate δ. Installation takes a period, however, and installed capital may not be removed from production until the following period. (In other words, the stock of capital, unlike the labor input, is a predetermined variable.) The firm's maximand, the present discounted value of its stream of dividend payments $\{d_j\}_{j=t}^{\infty}$, may therefore be written:

$$(25)\quad v_t = \Sigma_{j=0}^{\infty}(1+\rho)^{-j}d_{t+j}$$

$$= \Sigma_{j=0}^{\infty}(1+\rho)^{-j}[\theta_{t+j}f(k_{t+j},n_{t+j}) - w_{t+j}n_{t+j} - k_{t+j+1} + (1-\delta)k_{t+j}].$$

Equation (22) implies that $v_t = q_t + d_t$.

The problem's solution calls for investment and employment paths such that

$$(26)\quad \theta_t f_k(k_t,n_t) = \rho + \delta,$$

$$(27)\quad \theta_t f_n(k_t,n_t) = w_t,$$

for all t (although the initial capital stock is not subject to choice). Notice that when rules (26) and (27) are followed, the ex-dividend value of the firm is given by

(28) $q_t = k_{t+1}$.

At the end of the market period, the firm's value must equal the stock of capital that has been put in place to participate in next period's production.

In equilibrium, the firm's demand for labor equals the available domestic labor force:

(29) $n_t = 1$.

To be concrete, take once again the Cobb-Douglas case $f(k,n) = k^{\alpha}n^{1-\alpha}$. Then the equilibrium capital stock and wage in each period are given by

(30) $k_t = [\alpha\theta_t/\rho+\delta]^{1/1-\alpha}$,

(31) $w_t = (1-\alpha)[\alpha/\rho+\delta]^{\alpha/1-\alpha}(\theta_t)^{1/1-\alpha}$.

Net saving in period t, denoted S_t, is given by

(32) $S_t = w_t + (q_t + d_t - q_{t-1})h_{t-1} + \rho b_{t-1} - c_t$.

Let $v = \theta^{1/1-\alpha}$. Equations (22), (24), and (32) imply that along a perfect-foresight equilibrium path,

(33) $S_t = w_t - \rho\Sigma_{j=0}^{\infty}(1+\rho)^{-(j+1)}w_{t+j}$

$= (1-\alpha)[\alpha/\rho+\delta]^{\alpha/1-\alpha}[v_t - \rho\Sigma_{j=0}^{\infty}(1+\rho)^{-(j+1)}v_{t+j}]$.

Equation (30) implies that the perfect-foresight level of net investment in period t, I_t, is

$$(34)\quad I_t = k_{t+1} - k_t = [\alpha/\rho+\delta]^{1/1-\alpha}(v_{t+1} - v_t).$$

Consider now an unanticipated rise in the productivity parameter, which had previously been expected to be constant at the level v. The shock occurs in period 1, and, as will be shown, it generally causes both national saving and domestic investment to causes in that period. Equations (33) and (34), which presuppose perfect foresight, are applicable after period 1 provided no further unanticipated disturbances occur. But because k_1 is predetermined and was chosen on the basis of mistaken expectations, S_1 and I_1 must be calculated from first principles. I will assume that from period 1 onward, the productivity disturbance follows the path

$$(35)\quad v_t = v + \lambda^{t-1}(v' - v) \qquad (0 < \lambda \leq 1).$$

For $\lambda < 1$, (35) represents a transitory increase in productivity from v to v' that decays at rate λ. For $\lambda = 1$, the productivity increase is permanent.

In period 0, firms choose k_1 so that the expected net marginal product of capital equals the world interest rate, $v^{1-\alpha}f_k(k_1,1) = \rho + \delta$. This leads to $k_1 = v[\alpha/\rho+\delta]^{1/1-\alpha}$. After v rises to v' in period 1, however, the capital stock must remain fixed at k_1 even though the the capital stock desired for period 2 rises. Net investment in period 1, equal to $k_2 - k_1$, is therefore given by

$$I_1 = [\alpha/\rho+\delta]^{1/1-\alpha}\lambda(v' - v) > 0.$$

Investment in all future periods is negative (when $\lambda < 1$) or zero (when $\lambda = 1$) if there are no further shocks. According to (34) and (35), the time path of investment from period 2 on is

$$I_t = [\alpha/\rho+\delta]^{1/1-\alpha}[(\lambda-1)\lambda^{t-1}(v'-v)] \leq 0 \qquad (t \geq 2).$$

Figure 2 illustrates the response of domestic investment to a temporary productivity increase.

What about the behavior of national saving? First-period consumption jumps to a level fully incorporating the information embodied in (35), while k_1 (as noted earlier) remains at its predetermined level. Period 1 saving S_1 is therefore equal to $w_1 + (q_1 + d_1 - q_0)h_0 + \rho b_0 - c_1$, or, using (24), (26), and (28),

$$(36)\quad S_1 = (1/1+\rho)\{[w_1 - \rho\Sigma_{j=1}^{\infty}(1+\rho)^{-j}w_{j+1}] + [q_1+d_1-(1+\rho)q_0]h_0\}$$

$$= (1/1+\rho)\{[w_1 - \rho\Sigma_{j=1}^{\infty}(1+\rho)^{-j}w_{j+1}] + (\rho+\delta)[(v'/v)^{1-\alpha}-1]k_1h_0\}.$$

The first term in the braces in (36) is the component of saving due to deviations between the current real wage and the discount-rate weighted average of future wages. When the current wage exceeds the "permanent" wage, for example, households will tend to accumulate wealth in order to smooth their consumption over time. The second term in the braces in (36) reflects the windfall gain to stockholders caused by a temporary deviation between the net marginal product of capital and the world rate of return ρ. Because k_1 cannot be adjusted until period 2, an unanticipated productivity shock in period 1 leads to a deviation from the perfect-foresight arbitrage condition (22). The resulting abnormal profits are expected to disappear next period, so only a fraction $\rho/1+\rho$ of the windfall is consumed in period 1.

To understand the response of aggregate saving, it is useful to consider each of the terms in (36) separately. The effect on saving of temporarily abnormal profits is unambiguously positive, and its mag-

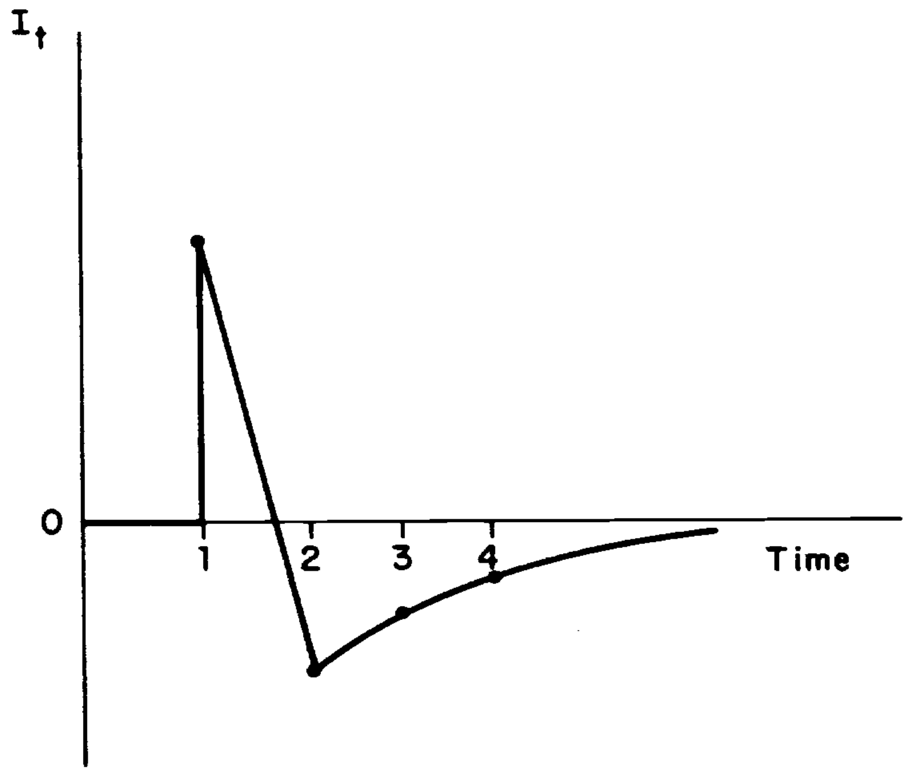


Figure 2

nitude is independent of the persistence parameter λ. Equation (30) shows that this effect is given by $(1/1+\rho)(\rho+\delta)[(v'/v)^{1-\alpha}-1]k_1h_0\} = (1/1+\rho)\alpha[\alpha/\rho+\delta]^{\alpha/1-\alpha}[(v')^{(1-\alpha)}v^{\alpha} - v)]h_0$.

However, the persistence parameter λ plays a key role in determining the impact of wage movements on saving. When $\lambda = 1$, so that the productivity shock is permanent, the period-1 wage rises to the level $(1-\alpha)(v')^{1-\alpha}k_1^{\alpha} = (1-\alpha)[\alpha/\rho+\delta]^{\alpha/1-\alpha}(v')^{1-\alpha}v^{\alpha}$, which lies between the pre-shock wage and the wage $(1-\alpha)[\alpha/\rho+\delta]^{\alpha/1-\alpha}v'$ expected to prevail in all future periods [see equation (31)]. Since the wage in period 1 is therefore below its permanent level, the first term in (36) is negative and equal to $(1/1+\rho)(1-\alpha)[\alpha/\rho+\delta]^{\alpha/1-\alpha}[(v')^{(1-\alpha)}v^{\alpha} - v')]$. If $h_0 = 1$, so that all shares in the domestic firm are domestically owned, net first-period saving when $\lambda = 1$ is

$$S_1 = (1/1+\rho)[\alpha/\rho+\delta]^{\alpha/1-\alpha}[(v')^{1-\alpha}v^{\alpha} - (1-\alpha)v' - \alpha v],$$

a negative (and probably small) number. Period-1 saving is even lower if $h_0 < 1$; and saving is zero from period 2 on [see (33)]. If the only shocks hitting the economy are productivity shocks which are perceived as permanent, the time-series correlation between saving and investment changes is likely to be negigible.

In the general case the time path of saving is

$$S_1 =$$
$$(1/1+\rho)[\alpha/\rho+\delta]^{\alpha/1-\alpha}\{[1-(1-h_0)\alpha][(v')^{1-\alpha}v^{\alpha}-v]-(1-\alpha)[\rho\lambda/(1+\rho-\lambda)](v'-v)\},$$

$$S_t = (1/1+\rho)[\alpha/\rho+\delta]^{\alpha/1-\alpha}(v' - v)[(1-\lambda)\lambda^{t-1}/(1+\rho-\lambda)] > 0 \qquad (t \geq 2),$$

where the second equality follows from (33). Notice that if λ is small enough (so that the disturbance is sufficiently transitory), S_1 may now be positive. Since wages are expected to decline over time, the increase in w_1 over w_0 may be sufficiently large to induce saving even though w_1 is lower than it would have been if the firm had correctly foreseen the period-1 productivity increase in period 0. Figure 3 depicts a saving path in which first-period saving is positive. This may occur even if all shares are owned by foreigners ($h_0 = 0$), although S_1 is increasing in h_0.

Figures 2 and 3 together make the point that investment and saving innovations can be positively correlated when both are caused by temporary shifts in the domestic production function. Shifts in productivity alter saving as well as investment incentives by conferring a windfall gain or loss on domestic shareholders and changing the path of real wages. When shocks to the production function are sufficently transient, saving and investment will move together in the short run.

The purpose of this section has been to provide a single illustrative example, but it is clear that factors other than productivity shocks can induce a positive correlation between saving and investment innovations. Suppose, for example, that production requires as an input an imported good that is distinct from the output of the domestic firm. If imports and capital are complements in production, a temporary fall in the relative price of imports will spur investment and also encourage saving as households spread the temporary increase in their real incomes over all future periods. Temporary changes in the world interest rate ρ (the intertemporal terms of trade) also cause simultaneous movements in saving and investment.[21]

V. A Problem with National Income Account Data

National income account (NIA) data provide notoriously poor proxies for the economic concepts of saving and investment. For example,

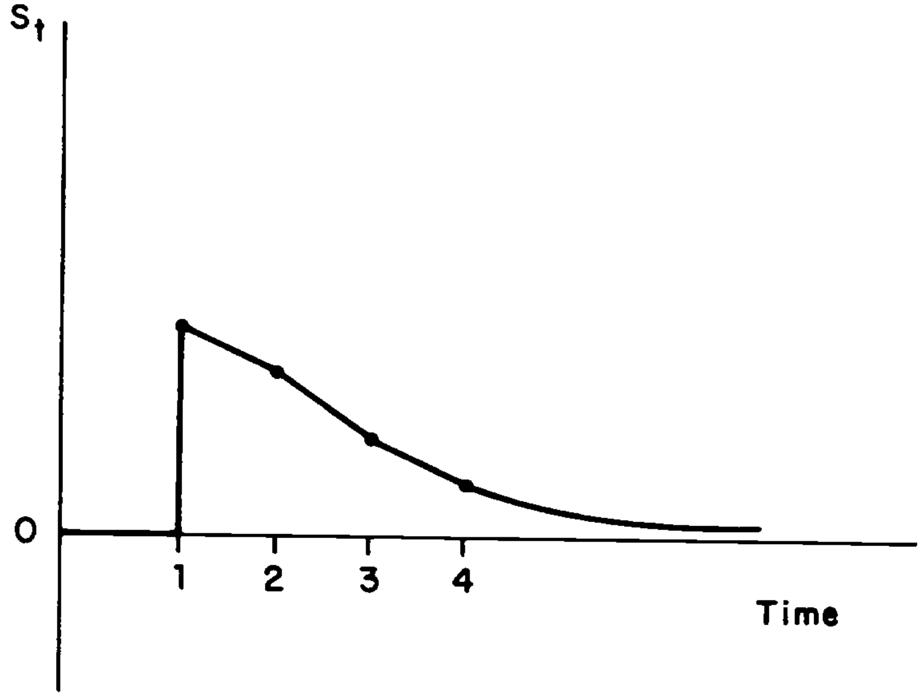


Figure 3

purchases of consumer durables, which really represent investment, are treated in the accounts as current consumption. Since national product figures represent the nominal value of goods and services produced by a country's factors, as measured by realized financial flows, exchange-rate induced redistributions of wealth between nations do not enter into the NIA definition of national income or saving. Also ignored are the changes in the real value of net external debts due to inflation [see, for example, Freedman (1979)].

The previous section's theoretical model suggests an additional data problem which is related to those associated with exchange-rate and price-level variation. This problem is most acute for economies in which a substantial share of domestic industry is foreign owned, or in which much of domestic wealth is held as shares in foreign firms.[22] In the former case, that in which foreigners own domestic shares, the correlation between the NIA measure of saving and investment will tend to be higher than that between the true value of saving and investment.

Continue to assume there is no government, as in section IV, and recall the definition of net saving in that section's model [equation (32)]:

$$S_t = w_t + (q_t + d_t - q_{t-1})h_{t-1} + \rho b_{t-1} - c_t.$$

The definition of dividends d_t and the fact that $q_t = k_{t+1}$ [equation (28)] imply that aggregate net saving may be written as

$$(37)\quad S_t = y_t - \delta k_t - (q_t + d_t - q_{t-1})(1 - h_{t-1}) + \rho b_{t-1} - c_t.$$

Since $q_t + d_t - q_{t-1} = f_k(k_t,1)k_t - \delta k_t$, (37) states that net saving equals net output plus net factor payments from abroad minus consumption.

In contrast to (37), the NIA definition of net saving, $NIAS_t$, ignores the capital gains on foreign securities accounted for by (37) and instead sets

$$(38)\quad NIAS_t = y_t - \delta k_t - d_t(1-h_{t-1}) + \rho b_{t-1} - c_t$$

$$= (w_t + d_t h_{t-1} + \rho b_{t-1} - c_t) + (k_{t+1} - k_t).$$

The second line of (38) shows that NIAS is the sum of two components, the NIA concept of personal saving (which also ignores capital gains) plus what is usually defined as corporate saving, i.e., retained earnings. Regrouping the terms on the second line of (38) shows that in the model of section IV,

$$(39)\quad NIAS_t = S_t + (1-h_{t-1})(k_{t+1} - k_t),$$

implying that the NIA definition of saving equals actual saving plus a term proportional to net investment.

When $h = 1$, so that all shares are domestically owned,the NIA concept of saving and true saving coincide in this model. The reason is that corporate saving just equals the increase in the firm's ex-dividend market value, so that when no shares are owned by foreigners, the addition of corporate saving to personal saving corrects the latter measure for the omission of capital gains from personal income. But when $h < 1$, the addition of corporate saving to personal saving inflates aggregate saving by incorrectly counting as part of domestic income capital gains that actually accrue to foreigners. The error equals the fraction of foreign-owned shares times the firm's net investment.

Equation (39) makes clear that NIA conventions may artficially increase the correlation between measured national saving and domestic investment. Paradoxically, the magnitude of this distortion is greater the larger the share of domestic firms owned by foreigners, that is, the more open is the economy to foreign portfolio investment. Indeed, in an integrated world economy with full international portfolio diversification, we would expect domestic residents to own a negligible share of the domestic firm when human-capital risk is approximately uncorrelated with the firm's profitability. But if $h \approx 0$, national income data for the economy of section IV would nonetheless show NIA net saving and investment as being perfectly correlated precisely when investment is totally uncorrelated with the economically relevant measure of saving.

The prevalence of earnings retention as a means of financing corporate investment lends empirical significance to this problem.[23] But the magnitude of the errors involved is unknown. Gross capital flows between countries are very large even though net flows, as measured by current account imbalances, have been small (see section III). So while the problem may be of minor importance for the U.S., where the ratio of foreign-owned capital to total capital is low, it may be of greater importance in other economies. It should also be remembered that in reality, NIA saving differs from true saving not only because of capital gains on foreign-owned shares but because of unobserved capital gains on foreign shares owned by domestic residents. The effect of this additional discrepancy on the correlation between NIA saving and investment is theoretically ambiguous.

VI. Saving and Investment in the Short Run: Time-Series Evidence

This section presents estimated correlations between quarterly changes in saving and investment rates, for seven OECD countries, over the period since the restoration of currency convertibility in late 1958. Confidence intervals for these estimates are also calculated. The empirical results are consistent with a significant and increasing degree of capital mobility over the sample period.

There are at least four reasons why short-run time-series correlation coefficients between changes in saving and investment rates are of interest. First, and most important, they provide a set of empirical regularities with which theoretical open-economy models must be consistent. These empirical regularities also suggest hypotheses that may inspire more powerful tests in the future. Second, estimation of the coefficients and their asymptotic distributions permits an assessment of the significance of their difference from the value of 1 that would obtain under complete capital immobility. Third, the results can provide some guidance on the appropriateness of pooling time-series observations on different countries, as in Feldstein (1983). In fact, the data give a strong indication that such pooling is not appropriate. Fourth, even though (as was shown in section IV) short-run saving and investment changes need not be uncorrelated under perfect capital mobility, measures of their correlation are likely to be unaffected by some of the the forces that may limit protracted current-account imbalances over longer periods. This is still insufficient to allow rigorous inference concerning a country's openness to capital movements. But once the saving and investment rate data have been purged of movements caused by known common factors, such as effective labor-force growth, the identifying assumptions needed to permit such inference become more plausible. Of course, additional tests may ultimately lead to the rejection of some or all of these identfying assumptions.

The data used in estimating the correlations are nominal quarterly national-account data from the International Monetary Fund's <u>International Financial Statistics</u> data tape. The sample of countries was dictated by the availability of quarterly data over a reasonably long sample period; it consists of Australia, Austria, Canada, the Federal Republic of Germany, Japan, the United Kingdom, and the United States.[24] For the sake of comparability with the Feldstein-Horioka results, no attempt was made to adjust the data to account for any of the potential problems discussed in section V. In addition, gross rather than net saving and investment series were utilized. Saving S was defined as gross national product (GNP) minus private plus government consumption.[25] Investment I was defined as gross fixed capital formation plus the change in stocks. The correlations that were computed were between $\Delta(S/GNP)$ and $\Delta(I/GNP)$, where Δ denotes a quarterly first difference. The population value of this correlation will be labelled ρ_{SI}.

Obtaining point estimates of the contemporaneous correlations ρ_{SI} presents no difficulties. Under conditions spelled out in Fuller (1976), chapter 6, which imply joint covariance stationarity of the $\Delta(S/GNP)$ and $\Delta(I/GNP)$ series, the sample correlations r_{SI} provide consistent estimates of the population correlations ρ_{SI}.

Statistical inference based on the estimated correlations requires an asymptotic distribution theory, however. Assume that the $\Delta(S/GNP)$ and $\Delta(I/GNP)$ series are jointly normal, let $\sigma_{SI}(j) = \sigma_{IS}(-j)$ denote the unconditional population covariance $Cov[\Delta(S/GNP)_t, \Delta(I/GNP)_{t+j}]$, and let $c_{SI}(j)$ denote the corresponding sample covariance based on a sample of T observations. Denote the population autocovariances for the series by $\sigma_{SS}(j)$ and $\sigma_{II}(j)$; of course, $\sigma_{SS}(0) = Var[\Delta(S/GNP)]$, $\sigma_{II}(0) = Var[\Delta(I/GNP)]$, and $\rho_{SI} = \sigma_{SI}(0)/[\sqrt{\sigma_{SS}(0)}\sqrt{\sigma_{II}(0)}]$. If the autocovariance functions of the two series are absolutely summable, then

$$(40)\quad \lim_{T\to\infty} T\, Var[c_{SI}(0)] = \Sigma_{j=-\infty}^{\infty}\sigma_{SS}(j)\sigma_{II}(j) + \Sigma_{j=-\infty}^{\infty}\sigma_{SI}(j)\sigma_{IS}(j) = M$$

[Fuller (1976), theorem 6.5.1]. It can be shown that the random variable $\sqrt{T}[c_{SI}(0) - \sigma_{SI}(0)]$ has a limiting normal distribution with mean 0 and variance equal to M [Hannan (1970), theorem 14, chapter IV]. Therefore

$$(41) \quad \sqrt{T}(r_{SI} - \rho_{SI}) \rightarrow N[0, M/\sigma_{SS}(0)\sigma_{II}(0)]$$

in distribution. From (41), the asymptotic standard error of r_{SI} is just

$$(42) \quad \sqrt{[M/T\sigma_{SS}(0)\sigma_{II}(0)]}.$$

The variances $\sigma_{SS}(0)$ and $\sigma_{II}(0)$ in (42) can be consistently estimated by sample variances. It is also possible to estimate M consistently in the time domain by truncating the infinite sums in (40) at some j that increases sufficiently quickly with sample size and substituting sample covariances for their population counterparts. However, Singleton (1980) and Hodrick and Srivastava (1985) have suggested a frequency-domain procedure for estimating M that is more convenient from a computational point of view. That procedure is implemented in obtaining the standard error estimates reported below.

Define the autocovariance matrix

$$(43) \quad \sigma(j) = \begin{bmatrix} \sigma_{SS}(j) & \sigma_{SI}(j) \\ \sigma_{IS}(j) & \sigma_{II}(j) \end{bmatrix} .$$

Then the spectral density matrix for the vector process $\{\Delta(S/GNP)_t, \Delta(I/GNP)_t\}$ at frequency ω is given by

$$(44) \quad s(\omega) = (1/2\pi) \Sigma_{j=-\infty}^{\infty} \sigma(u) e^{-i\omega j} = \begin{bmatrix} s_{SS}(\omega) & s_{SI}(\omega) \\ s_{IS}(\omega) & s_{II}(\omega) \end{bmatrix} ,$$

where $i = \sqrt{-1}$. Direct computation using (43) and (44) shows that M can be written in the form

$$(45)\quad M = 2\pi\int_{-\pi}^{\pi}[s_{SS}(\omega)s_{II}(\omega) + s_{SI}(\omega)^2]d\omega.$$

Consistent estimates of the spectral density matrix $s(\omega)$ may be used in formula (45) to obtain a consistent estimate of M.[26]

The results, for the entire sample available since the return to convertibility, are presented in table 1.

A pronounced pattern emerges from these estimates. For the smallest countries, Australia and Austria, the contemporaneous correlation between Δ(S/GNP) and Δ(I/GNP) is low. In the case of Austria, r_{SI} is statistically insignificant. For Canada, Germany, and the United Kingdom, the correlation coefficients are statistically significant but lower than the cross-sectional coefficients reported in the Feldstein-Horioka papers. Only in the cases of Japan and the United States, with r_{SI} values of 0.846 and 0.908 respectively, are the correlations of the same order of magnitude as the coefficients estimated by Feldstein and Horioka. Also, it is only in the cases of Japan and the U.S. that the estimated coefficients do not differ significantly from 1, the theoretical value under complete capital immobility. However, the U.S. is the largest country in the world economy, while Japan has had extensive capital-account controls until very recently.

The results of table 1 therefore suggest that the measured saving-investment correlation is an increasing function of country size. Except where capital controls were an important factor, the correlation is low for small countries, moderate for medium-sized countries, and high for the largest country. Harberger (1980) and Murphy (1984) have argued that the link between saving and investment will increase with country size

Table 1

Estimated Correlations between Changes in Saving and Investment Rates
(Quarterly Data)

Country	Sample Period	r_{SI}	Standard Error
Australia	60:I - 83:IV	0.194	0.106
Austria	70:II - 84.I	0.132	0.195
Canada	59:I - 84:II	0.550	0.125
Germany	60:III - 84:II	0.649	0.133
Japan	59:I - 83:IV	0.846	0.140
United Kingdom	59:I - 84:II	0.604	0.166
United States	59:I - 84:II	0.908	0.143

because a country's ability to influence the world interest rate and other world prices grows as its share in world output grows. The estimates presented here are consistent with this interpretation, and certainly cannot be interpreted as evidence <u>against</u> perfect capital mobility. Indeed, the evidence is fully consistent with a world in which capital mobility is substantial, but in which saving and investment changes can be significantly correlated for reasons like those discussed in section IV and because of country size.[27]

It is interesting to compare the results of table 1 to a pooled time-series cross-section regression in Feldstein (1983), p. 136, which correlates year-to-year changes in the investment rate with year-to-year changes in the saving rate. The slope coefficient in that regression is 0.863 (with a standard error of 0.040), from which it is concluded that "even year to year increases in saving tend to be associated with increases in domestic investment in the saving country by approximately equal amounts." The evidence in table 1 shows that on a quarterly basis there is considerable heterogeneity across countries with respect to the magnitude of this association. The assumption of uniformity implicit in the pooling procedure is therefore implausible. It is also difficult to interpret the reported standard error of estimation without a discussion of the serial-correlation properties of the regression's error terms.

Since the breakdown of the postwar system of fixed exchange rates in 1973, there has been an apparent increase in the integration of world capital markets. Four sets of reasons are usually given for this development. The first involves the dismantling of the widespread barriers to capital movement that had impeded international money flows under fixed exchange rates but appeared superfluous under flexible rates. The second centers on the emergence of the OPEC surpluses after

1973 and the growth of world trade generally, developments that raised demand for the services of international financial intermediaries. The third set of reasons is related to technological change in the communications and data-processing areas. The fourth concerns increased multinational corporate activity.[28]

These considerations suggest that the stochastic properties of the saving-investment process may have changed over time. To investigate this possibility the samples were split at 1972:IV and the correlation coefficients were estimated separately over the sub-samples. (The procedure was not carried out for Austria because the data on that country are available only from 1970.) Table 2 reports the results. In all cases except that of Australia, r_{SI} drops--sometimes dramatically--between the earlier and later periods. This evidence is consistent with the widespread belief that the degree of international capital mobility increased after 1972:IV. Note that for the second sub-sample r_{SI} remains more than two standard deviations below 1 for all countries other than Japan and the U.S. But once again, the high estimated correlations for these two countries can be ascribed to capital controls in the Japanese case and country size in the U.S. case. Because the estimated correlations are higher before 1973:I and because smaller sample size results in less precise estimates, r_{SI} lies within two standard errors of 1 more frequently in the first sub-sample than over the complete sample.

One further test can be conducted to help evaluate the argument that high values of r_{SI} for the United States are a consequence of its size rather than capital immobility. The United Kingdom occupied a similarly dominant position in the world economy during the pre-World War I gold-standard era, particularly from 1870 onward, and its experience then is often cited as the prime example of unfettered capital

Table 2
Estimated Saving-Investment Correlations up to and after 1972:IV
(Quarterly Data)

Country	r_{SI} up to 72:IV		r_{SI} after 72:IV	
Australia	0.095	(0.147)	0.331	(0.155)
Canada	0.716	(0.193)	0.399	(0.143)
Germany	0.747	(0.198)	0.536	(0.168)
Japan	0.885	(0.184)	0.723	(0.190)
United Kingdom	0.622	(0.196)	0.593	(0.235)
United States	0.962	(0.191)	0.870	(0.207)

<u>Note</u>: Standard errors appear in parentheses.

mobility. A high correlation between changes in U.K. saving and investment rates over the gold-standard period would therefore provide indirect evidence that the U.S. results are consistent with substantial capital mobility.[25]

Annual data for the U.K. covering the period 1871-1912 were taken from Feinstein (1972), table 2. Saving and investment were defined as in the postwar tests, and r_{SI} and its asymptotic standard error were calculated. The estimated correlation coefficient is 0.722, with a standard error of 0.199. This coefficient is not quite as high as that for the U.S. over the floating exchange rate period, but it exceeds many of those reported in tables 1 and 2. In addition, the coefficent does not differ significantly from 1, in spite of the undeniable mobility of capital during the gold-standard period. It follows that the high value of r_{SI} for the postwar U.S. provides no evidence that it is closed to international capital movement.

The picture that emerges from these time series tests is consistent with substantial and increasing capital mobility among OECD countries. In most cases saving-investment correlations are quite far from the value of 1 implied by complete capital immobility. When they are not, high correlation can be ascribed either to large-country effects or to known official restrictions on international asset trade.

VII. Conclusions

Capital mobility in the world economy has been measured by comparing asset yields across countries and, more recently, by studying comovements between saving and investment. The second approach, introduced by Feldstein and Horioka (1980) and by Feldstein (1983), may encounter severe identification problems. But the approach has the considerable merit of focusing attention directly on the determinants of intertemporal trade patterns.

Both international interest-rate data and data on national saving and investment patterns are consistent with a world in which capital mobility is substantial, at least among OECD countries. In particular, quarterly time-series correlations between changes in saving rates and changes in investment rates are in most cases significantly distant from the value of 1 that would prevail were capital entirely immobile across national boundaries. The data are also consistent with the hypothesis that capital mobility has increased in recent years. Future research should aim to sharpen our knowledge by explaining both the time-series correlations reported above and the cross-sectional correlations emphasized in the Feldstein-Horioka studies.

Notes

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1. The synchronized nature of the rise in world real interest rates is documented, for various measures of expected domestic inflation, by Blanchard and Summers (1984) and by Cumby and Mishkin (1985).

2. As noted by Kotlikoff (1984), there are special circumstances (such as those assumed in the static Heckscher-Ohlin trade model), in which

the international allocation of a given stock of productive factors can be efficient even in the absence of capital mobility. In the Heckscher-Ohlin model, this occurs when no country is specialized in production, so that factor prices are equal everywhere. But when capital is immobile, factor-price equalization at a point in time does not imply that the world allocation of resources is intertemporally efficient. In addition, dynamic Heckscher-Ohlin models may entail optimal capital-accumulation paths leading to a steady state in which one of the countries is specialized (or both are) and factor prices differ internationally.

3. Some policy implications of this line of empirical research are discussed in Obstfeld (1982). Problems connected with the taxation of interest payments remain relevant even when the group of assets studied is narrowed; see Howard and Johnson (1982,1983).

4. Similar analyses appear in Hansen and Hodrick (1983), Hodrick and Srivastava (1984, 1985), Kouri (1983), Lucas (1982), and Stockman and Svensson (1984). Stulz (1984) provides a useful survey of the theory of asset pricing from an international perspective.

5. In models with cash-in-advance constraints, (1) and (2) will not hold in general if nominal consumption expenditures cannot be predicted with certainty a period in advance. Stockman and Svensson (1984) analyze a model of that type. In contrast, (1) and (2) always hold in Lucas's (1982) cash-in-advance model. Because the present discussion is illustrative, I make no attempt to motivate the existence of national monies.

6. Uncovered interest parity follows from (3) if the marginal consumption value of domestic currency is distributed independently of the exchange rate. While it is difficult to assess this possibility in the present, partial-equilibrium setting, general-equilibrium models of Lucas (1982) and Stockman and Svensson (1984) suggest that (4) is unlikely to hold when there are output shocks or domestic monetary shocks. Hansen and Hodrick (1983) show that (3) leads to a log-linear approximation to (4) involving a time-invariant risk premium when all relevant variables are jointly lognormally distributed. (They reject this model empirically.) If agents are risk neutral, (4) holds if the price level and exchange rate are independently distributed [see Engel (1984) and Frenkel and Razin (1980)]. The assumption of risk neutrality may have implausible consequences in general equilibrium, however. If the instantaneous utility function is linear and the same in each period, for example, marginal rates of substitution in consumption, and hence the terms of trade, must be fixed.

7. There is relatively little empirical work that attempts to model the risk premium explicitly. Hansen and Hodrick (1983) test, and reject, some simple models of intertemporal equilibrium (see the previous footnote). Frankel (1982) is unable to reject a two-period mean-variance model based on a portfolio of six currencies. Hodrick and Srivastava (1984,1985) discuss emprical aspects of Lucas's (1982) model.

8. The argument made above to justify ignoring default risk on Eurocurrency deposits is inapplicable here because the deposits being compared are not issued by a single bank. Even when there is no currency risk, nominal interest rates can therefore differ across national boundaries.

9. However, he detected an increase in potential arbitrage profits over the period from the end of 1980 to early 1982. He attributes this in part to increased concern about default risk on the part of banks and their regulators.

10. Frankel (1984) discusses recent measures opening Japanese capital markets, and also presents evidence on interest differentials. Both the Giavazzi-Pagano and Ito papers, like Kreicher's, account for bid-ask spreads in calculating potential arbitrage profits. Ito also accounts for domestic transaction taxes.

11. Since the least-squares estimate of γ_1 is not, strictly speaking, a correlation coefficient, there is no reason for it to be less than 1. This is borne out by the simulated regressions reported later in this section. In what follows I sometimes refer to γ_1 as a "correlation," but it should be understood that this is an informal usage of the word.

12. Feldstein and Horioka (1980) also present instrumental-variable estimates based on an explicit model of aggregate saving. They regard those results as supporting the conclusions reached earlier in their paper. However, interpreting (8) as a structural investment equation involves some potential specification errors. A number of studies have pursued the approach outlined in the text. Penati and Dooley (1984) and Fieleke (1982) obtain results consistent with those reported by Feldstein and Horioka. Caprio and Howard (1984) find that the results are quite sensitive to the period over which saving and investment rates are averaged, while Summers (1985) finds that the correlation between saving and investment rates falls dramatically when less-developed

countries are included in the sample. Sachs (1981,1983) carries out cross-sectional regressions involving CA/Y and I/Y, concluding that changes in domestic investment have had large, negative effects on OECD current accounts, in apparent contradiction of the Feldstein-Horioka findings of limited capital mobility. However, Sachs's empirical results are subject to the difficulties of interpretation outlined below in connection with the Feldstein-Horioka findings. On the basis of an empirical simultaneous-equation model of saving and investment, von Furstenberg (1980) concludes that the United States is quite open to international capital movement. Another related approach is that taken by Milne (1977), who performs time-series regressions of trade balances on fiscal deficits for a large sample of countries. Several papers in the development literature attempt to measure the impact of capital inflow on saving and investment by regressing those variables on the current account. Leff and Sato (1984) discuss some econometric biases that may arise.

13. Feldstein and Horioka (1980) recognize the potential importance of common factors affecting both saving and investment, but assert (p. 319) that their strong results place "the burden of identifying such common causal factors" on proponents of the hypothesis that capital is internationally mobile. The demonstration in this section that equally strong results can emerge in a world with perfect capital mobility hopefully redistributes the burden more equitably. The empirical relevance of the forces driving this section's simulation example is discussed below. Summers (1985) points out that least-squares estimates of γ_1 do not measure the effect of aggregate saving on investment when fiscal policy systematically counteracts shifts in private spending. The theoretical

possibility that γ_1 exceeds 1, noted above, seems inconsistent with the interpretation of this coefficient as the fraction of any increase in saving that is reflected in domestic investment.

14. Buiter (1981) has studied a two-country version of the model employed here.

15. Labor-augmenting technical change would have a similar effect in the model. I concentrate here (and in the theoretical model of section IV) on net saving and investment, rather than on the gross concepts emphasized by Feldstein and Horioka (1980) and Feldstein (1983), because net concepts are the economically meaningful ones. As remarked above, those authors found even higher correlations between saving and investment ratios constructed from net measures. They ascribed the higher correlation to a common error in measuring depreciation.

16. Growth rates g were taken to be average annual real GDP growth rates over 1970-1979, as reported in the United Nations Statistical Yearbook, 1981, table 30. (The GDP growth rate for New Zealand was calculated from data reported in the International Monetary Fund's International Financial Statistics.) Labor's share, $1-\alpha$, was calculated as the ratio of employee compensation to national income in 1970. These data were taken from OECD, National Accounts of OECD Countries, vol. II, 1974. No attempt was made to correct for the labor income of the self-employed, so the estimate of $1-\alpha$ used is an underestimate of labor's share. This bias reduces saving rates relative to investment rates in the simulated economy.

17. One alternative explanation involves the economy's intertemporal budget constraint, which states that current accounts must sum over time to the change in the economy's net external assets. If there is a tendency for the economy's external assets to approach some steady-state level, as a result of residents' consumption preferences [as in Obstfeld (1981)] or of the pattern of shocks disturbing the economy, saving and investment will necessarily tend toward equality over long periods. Features of the tax system simultaneously affecting saving and investment rates could also be part of an explanation.

18. For example, Germany's current account balance in 1982 was DM 8.6 billion, but it ran a bilateral current-account surplus of DM 14.7 billion against France alone in that year. In all of the three years 1979-1981, Germany ran historically large current-account deficits, yet it was a net lender to France and other countries. [See Deutsche Bundesbank (1983).] This type of current-account behavior is inconsistent with the idea that overall current-account imbalances are limited by considerations of sovereign-risk exposure. I am indebted to Larry Kotlikoff for this observation.

19. Stockman and Svensson (1984) analyze a stochastic two-country monetary model in which the investment decision in one of the countries is explicitly modelled. They also find that saving and investment may be positively correlated, but the mechanisms operating in their model stem from terms-of-trade effects and are different from the one emphasized here.

20. Taken literally, this assumption may require that dividends be

negative in some periods. The possibility of negative dividends raises no conceptual difficulties, but for the sake of realism one might want to assume that shocks to technology, and hence period-to-period changes in the capital stock, are "small."

21. Persson and Svensson (1985) use an overlapping-generations framework to study the effects of various terms-of-trade shocks on saving and investment.

22. The problem is also discussed by Stockman and Svensson (1984), who show how it distorts reported current-account data.

23. The analysis would be modified if the firm financed some investment through debt issue. In this case the difference betweem NIAS and S would be proportional to net investment minus corporate borrowing. The problem does not arise here when investment is financed exclusively through the issuance of new shares.

24. These data, with the exception of the Austrian data, were available only in seasonally-adjusted form. The estimates for Austria reported below are based on the theoretically preferable seasonally-unadjusted data.

25. In the U.S. data, the government consumption variable includes government investment. This is not the case for the other countries, whose national-income data are compiled according to the United Nations System of National Accounts.

26. Formula (45) appears in Fishman (1969), p. 121. In the present application, the spectral density matrix was estimated at T equally spaced frequencies between $-\pi$ and π, where T is the number of observations. A triangular smoothing window of width seven was used. An estimate of M was then calculated by summing the integrand in (45) over the T frequencies and multiplying the result by $4\pi^2/T$.

27. Summers (1985) performs a cross-sectional regression on a sample including small, less-developed countries in addition to the OECD countries included in the Feldstein-Horioka studies. His estimate of the parameter γ_1 is only 0.311. This evidence lends support to the view that large-country effects are in part responsible for the Feldstein-Horioka findings.

28. Bryant (1985) reviews the postwar growth of international financial intermediation.

29. Between 1870 and 1913, U.K. net foreign lending averaged 5.2 percent of GNP, a figure that is enormous by postwar standards [Edelstein (1982)]. The temptation to quote Keynes's description of the period is irresistible: "The inhabitant of London could order by telephone, sipping his morning tea in bed, the various products of the whole earth, and in such quantity as he might see fit, and reasonably expect their early delivery upon his doorstep; he could at the same moment and by the same means adventure his wealth in the natural resources and new enterprises of any quarter of the world, and share, without exertion or even trouble, in their prospective fruits and advantages; or he could decide to couple the security of his fortunes with the good faith of the

townspeople of any substantial municipality in any continent that fancy or information might recommend. He could secure forthwith, if he wished it, cheap and comfortable means of transit to any country or climate without passport or other formality, could despatch his servant to the neighbouring office of a bank for such supply of the precious metals as might seem convenient, and could then proceed abroad to foreign quarters, without knowledge of their religion, language, or customs, bearing coined wealth upon his person, and would consider himself greatly aggrieved and much surprised at the least interference. But, most important of all, he regarded this state of affairs as normal, certain, and permanent, except in the direction of further improvement, and any deviation from it as aberrant, scandalous, and avoidable." [Keynes (1919), pp. 9-10.]

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