Slides for Chapter 11: International Capital Market Integration

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These are the slides for the textbook, "International Macroeconomics: A Modern Approach," by Stephanie Schmitt-Grohé, Martín Uribe, and Michael Woodford, Princeton University Press, 2022, ISBN: 9780691170640.

Introduction

• In Chapter 9, we studied whether world goods markets are integrated and whether under free trade there is a tendency for the prices of goods and services to equalize across countries. In this chapter, we study whether international capital markets are integrated and investigate whether under free capital mobility there is a tendency for interest rates to equalize across countries.

• Overall, the world has become more financially globalized. For example, between the mid 1970s and 2018 U.S. gross international liabilities grew from 15 to over 170 percent of GDP and U.S. gross international assets jumped from 20 to over 130 percent of GDP. A similar pattern of growth in gross international asset and liability positions has been observed in many countries.

• A number of events have contributed to this phenomenon: capital controls were dismantled after the breakdown of the Bretton-Woods fixed-exchange rate system in the early 1970s, the creation of the European monetary union led to the removal of all capital controls within the euro area by 1986, and following accession to the WTO in the early 2000s, China has emerged as a major supplier of funds to world capital markets.

Covered Interest-Rate Parity

• Under free capital mobility, rates of return on risk-free investments should be equal across countries.

• One difficulty in measuring cross-country return differentials is that interest rates across countries are not directly comparable if they relate to investments in different currencies.

Example:
i_t = domestic interest rate (dollar); i_t^* = foreign interest rate
Dollar payoff in period $t+1$ of a 1-US dollar investment made in t:
$1 + i_t$ dollars when invested in the US
$(1 + i_t^*)\mathcal{E}_{t+1}/\mathcal{E}_t$ dollars when invested abroad
$\Rightarrow$ payoffs in the same currency depend not only on i_t and i_t^*, but also on $\mathcal{E}_{t+1}/\mathcal{E}_t$.
One might be tempted to conclude that:
—If $1 + i_t > (1 + i_t^*)\mathcal{E}_{t+1}/\mathcal{E}_t$, borrow abroad and invest in US, and make unbounded profits.
—If $1 + i_t < (1 + i_t^*)\mathcal{E}_{t+1}/\mathcal{E}_t$, borrow in US, invest abroad, and make unbounded profits.

This investment strategy suffers, however, from a fundamental problem.

At time t, $\mathcal{E}_{t+1}$ is not known with certainty.

In period t, the return associated with investing in US, $1+i_t$, is known with certainty, but the return associated with investing abroad, $(1+i_t^*)\mathcal{E}_{t+1}/\mathcal{E}_t$, is uncertain.

Even under free capital mobility, returns knewn with certainty need not be equal to uncertain returns.

Thus, we cannot deduce from $1+i_t \neq (1+i_t^*)\mathcal{E}_{t+1}/\mathcal{E}_t$ that there is a no free capital mobility.

Forward exchange markets allow investors to cover themselves against exchange rate risk.

Let $F_t =$ the forward rate, which is the dollar price at time t of 1 euro delivered and paid for at time $t+1$.

The dollar return of a one-dollar investment in Germany using the forward exchange market is:

$$(1+i_t^*)\frac{F_t}{\mathcal{E}_t}$$

This return is known with certainty at time t and thus comparable to the return of a 1-dollar US investment.

The difference between the domestic return and the foreign return expressed in domestic currency by use of the forward exchange rate is known as the *covered interest rate differential:*

$$\text{Covered Interest Rate Differential } = (1+i_t) - (1+i_t^*)\frac{F_t}{\mathcal{E}_t}. \tag{1}$$

When the covered interest rate differential is zero, we say that *covered interest rate parity* (CIP) holds.

In the absence of barriers to capital mobility and for interest rates and forward rates that are free of default risk, a violation of CIP implies the existence of arbitrage opportunities. When an arbitrage opportunity exists there is the possibility of making unbounded profits without taking on any risk.

Example of how to exploit violatations of CIP

$i_t = 0.07$ (US rate); $i_t^* = 0.03$(Euro rate);
$\mathcal{E}_t = 0.50$ dollars per euro; $F_t = 0.51$ dollars per euro
The covered interest rate differential is:
$1 + i_t - (1 + i_t^*)F_t/\mathcal{E}_t = 1.07 - 1.03 \times 1.02 = 0.0194 \Rightarrow$ CIP is violated.

How to profit from this violation of CIP?
(1) borrow 1 euro in Germany.
(2) exchange your euro in the spot market for \$0.50.
(3) invest the \$0.50 in a U.S. deposit.
(4) buy 1.03 euros in the forward market
(5) after 1 year, your U.S. investment yields $1.07 \times \$0.5 = \$0.535$.
(6) execute your forward contract, that is, purchase 1.03 euros for $0.51 \times 1.03 = 0.5253$ dollars and repay your German loan.
• receipts - payments, (5)-(6), $= \$0.535 - \$0.5253 = \$0.0097 > 0$.

Note that this operation involved no exchange-rate risk (because you used the forward market), needed no initial capital, and yielded a pure profit of \$0.0097— which makes it a pure arbitrage opportunity.

Takeaway: for interest rates and forward rates that are free of default risk, the covered interest rate differential should be zero if there are no barriers to international capital flows. Therefore, the existence of nonzero covered interest-rate differentials is an indication of lack of free capital mobility.

Empirical Evidence

on

Covered Interest-Rate Differentials

Covered Interest Rate Differentials in China: 1998-2021

• In 2001 China became a member of the World Trade Organization. This required lowering barriers to trade in goods and services (tariffs and quotas). In this way, China became more integrated to the rest of the world in markets for goods and services.

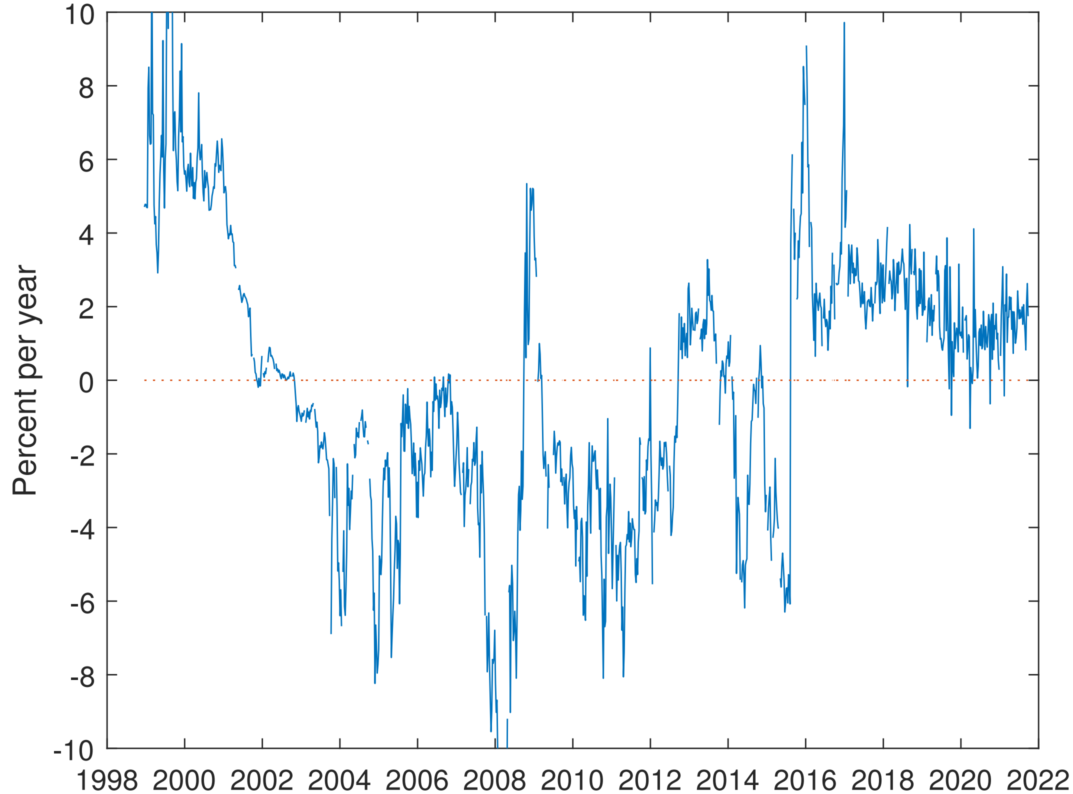
• Did China also become more integrated in world financial markets?

• Let's look at the observed behavior of the dollar-renminbi covered interest rate differential (equation (1)):

$$(1+i_t)-(1+i_t^*)\frac{F_t}{\mathcal{E}_t}$$

where
i_t = dollar interest rate in the United States,
i_t^* = renminbi interest rate in China
$\mathcal{E}_t$ = spot exchange rate (dollars per renminbi), and
F_t = forward exchange rate (dollars per renminbi).

Dollar-Renminbi Covered Interest Rate Differentials, 1998–2021



Notes. The figure plots weekly observations of the dollar-renminbi covered interest rate differential for the period December 11, 1998 to September 24, 2021, in percent per year. Own calculations based on data from Bloomberg.

What Does the Figure Show?

• Observed deviations from covered interest rate parity are large 3.1 percentage points on average.

• In the last five years of the sample, the differential fell by about 1 percentage point but remained sizable, 2.1 percentage points on average.

• Large differentials are a sign of impediments to capital flows.

• The sign of the differential flipped twixe: Mostly positive prior to October 2002 and after August 2015, and mostly negative in the intervening period.

• A negative differential indicates impediments to capital outflows (Chinese wanting to invest abroad, but not being able to do it).

• A positive differential indicates impediments to capital inflows (Chinese wanting to save abroad, but not being able to do it).

Capital Controls and Interest Rate Differentials: Brazil 2009-2012

• Government regulations that impede international capital flows are called capital controls. Examples: taxes on international inflows or outflows of capital, quotas on international borrowing or lending, or requirements to park capital inflows or outflows in nonremunerated domestic accounts for a given period of time.

• During the global financial crisis of 2008, interest rates in developed countries fell to near zero.

• Global investors started to send funds to emerging market economies, where interest rates were higher. Brazil received large inflows.

• Brazilian authorities, concerned that capital inflows would destabilize the economy, enacted capital controls between October 2009 and March 2012, including taxes on portfolio equity inflows, taxes on fixed income inflows, and unremunerated reserve requirements. After March 2012 they were gradually removed.

• To see if capital controls were effective, let's look at the real-dollar covered interest rate differential:

$$(1+i_t)\frac{\mathcal{E}_t}{F_t} - (1+i_t^*)$$

where

$\mathcal{E}_t =$ spot exchange rate (reais price of one U.S. dollar)

$F_t =$ 360-day forward exchange rate of U.S. dollars, and

i_t^* the 360-day U.S. dollar Libor rate.

The cupom cambial

In Brazil, the first term was called cupom cambial, that is

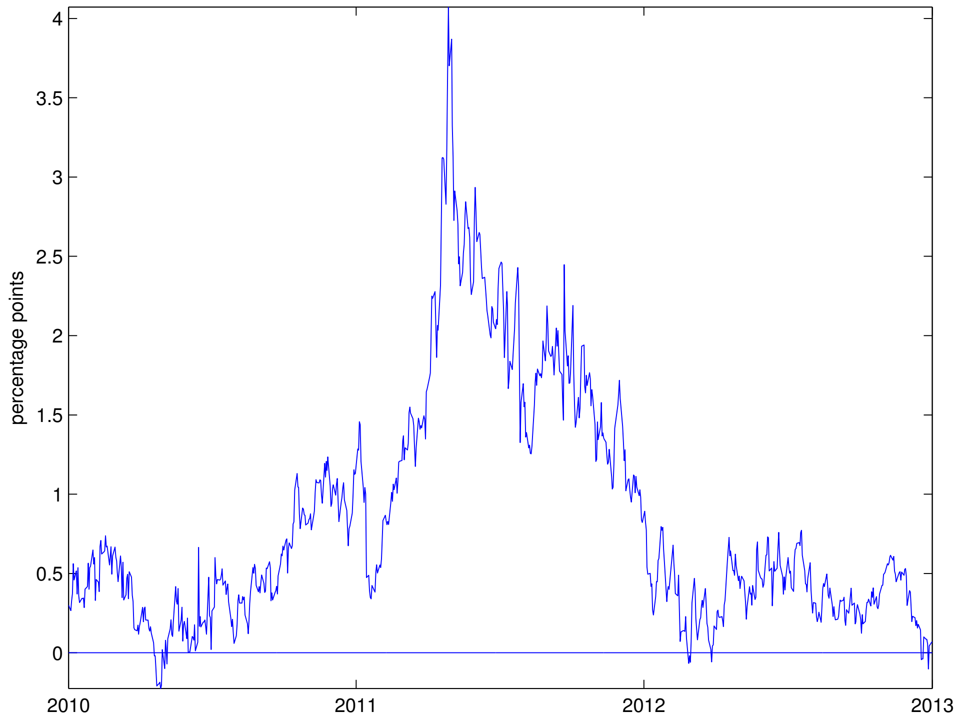
$$1 + i_t^{cupom} = (1 + i_t)\frac{\mathcal{E}_t}{F_t}$$

Thus, the cupom cambial is the dollar interest rate inside Brazil. Then, the covered interest rate differential is

$$\text{covered interest rate differential} \quad = \quad i_t^{cupom} - i_t^*.$$

The next figure plots daily data for the real-dollar covered interest rate differential for the period January 1, 2010 to December 31, 2012.

Brazilian Real-U.S. Dollar Covered Interest Rate Differentials, 2010–2012



Notes. The figure plots daily real-dollar covered interest rate differentials computed as the spread between the cupom cambial and the U.S. dollar Libor rate for the period January 1, 2010 to December 31, 2012. Data Source: Marcos Chamon and Márcio Garcia, 'Capital Controls in Brazil: Effective?', Journal of International Money and Finance 61, 2016, 163-187.

What Does the Figure Show?

• The covered interest rate differential was around half a percentage point until the fall of 2010, suggesting capital controls until then, were not too effective.

starting in the fall of 2010, the Brazilian government intensified capital controls and the differential started rising, reaches 4 percentage points by April 2011. Thus, controls were effective during this periods.

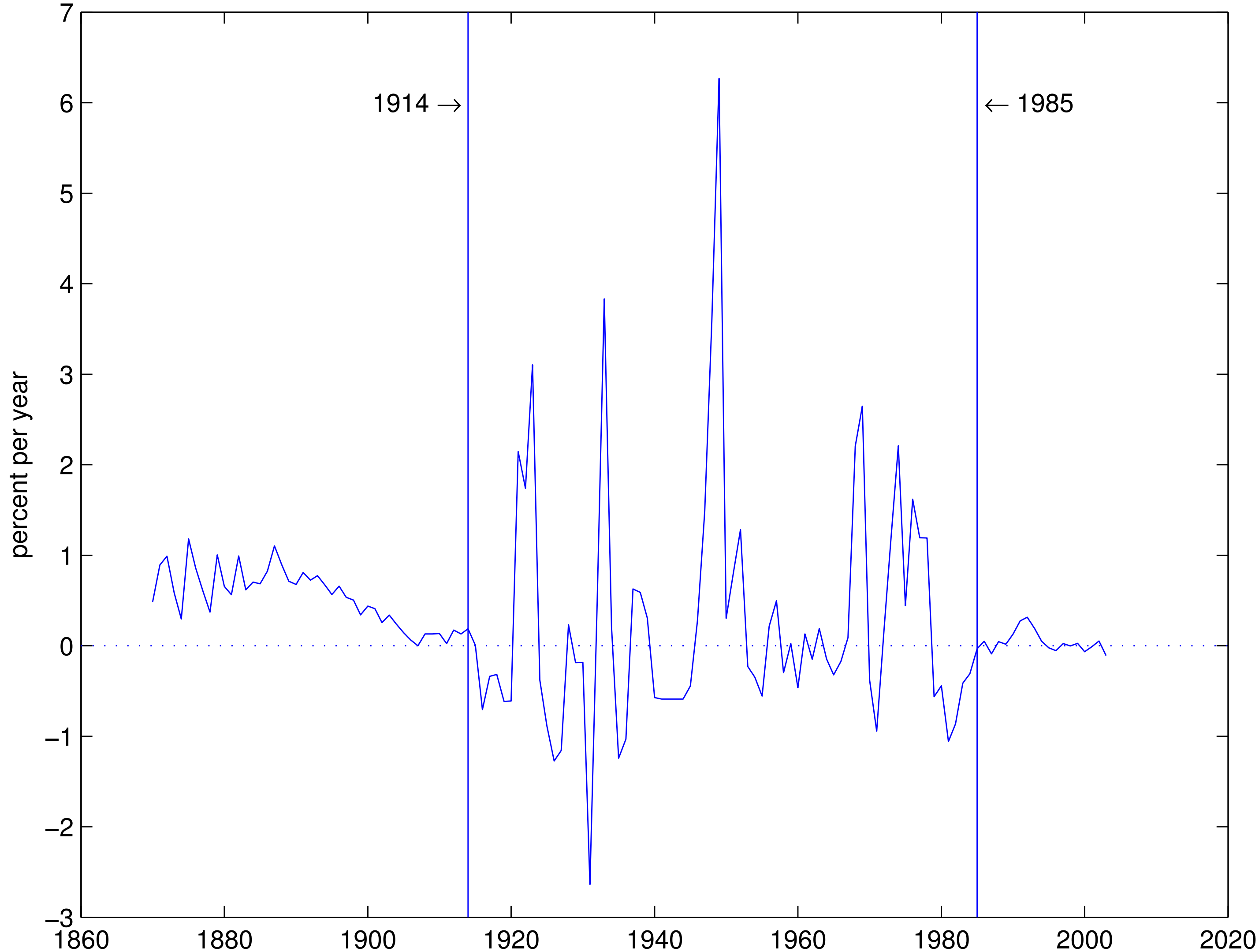
By early 2012, however, arbitragers seem to have found ways to bypass the capital control tax as differentials return to normal levels of around 0.5 percentage points.

Message: Capital controls can be effective.
However, if imposed on a narrowly defined set of international transactions, their effectiveness can be temporary, as financial investors have an incentive to find ways to avoid them.

Empirical Evidence on Covered Interest Rate Differentials:

A Long-Run Perspective

Dollar-Pound Covered Interest Rate Differentials: 1870-2003



Notes: The figure plots annual averages of monthly dollar-pound covered interest rate differentials. Source: Obstfeld, Maurice, and Alan M. Taylor, "Globalization and Capital Markets." In Globalization in Historical Perspective, edited by M. D. Bordo, A. M. Taylor and J. G. Williamson. Chicago: University of Chicago Press, 2003.

Comments on the Figure

What is plotted?: $(1+i_t^{us}) - (1+i_t^{uk})\frac{F_t^{\$/£}}{\mathcal{E}_t^{\$/£}}$ for the period 1870 to 2003.

What does the figure reveal? Small covered interest rate differentials before World War I and after 1985, suggesting a high degree of international capital-market integration in those two subperiods. High covered interest rate differentials after World War I until about 1985, suggesting a low degree of international capital market integration in that period.

Takeaway: free capital mobility is not a modern phenomenon: financial capital flowed in a more or less unfettered fashion before World War I and after 1985.

Empirical Evidence

on

Offshore-Onshore Interest Rate Differentials

• Besides covered interest rate differentials there are other interest rate differentials that are informative about the degree of capital market integration.

• One alternative uses interest rates on instruments denominated in the same currency, for example, the U.S. dollar, issued in financial centers located in different countries. For example, one can compare the interest rate on dollar time deposits in banks located in New York (the onshore rate) and London (the offshore rate).

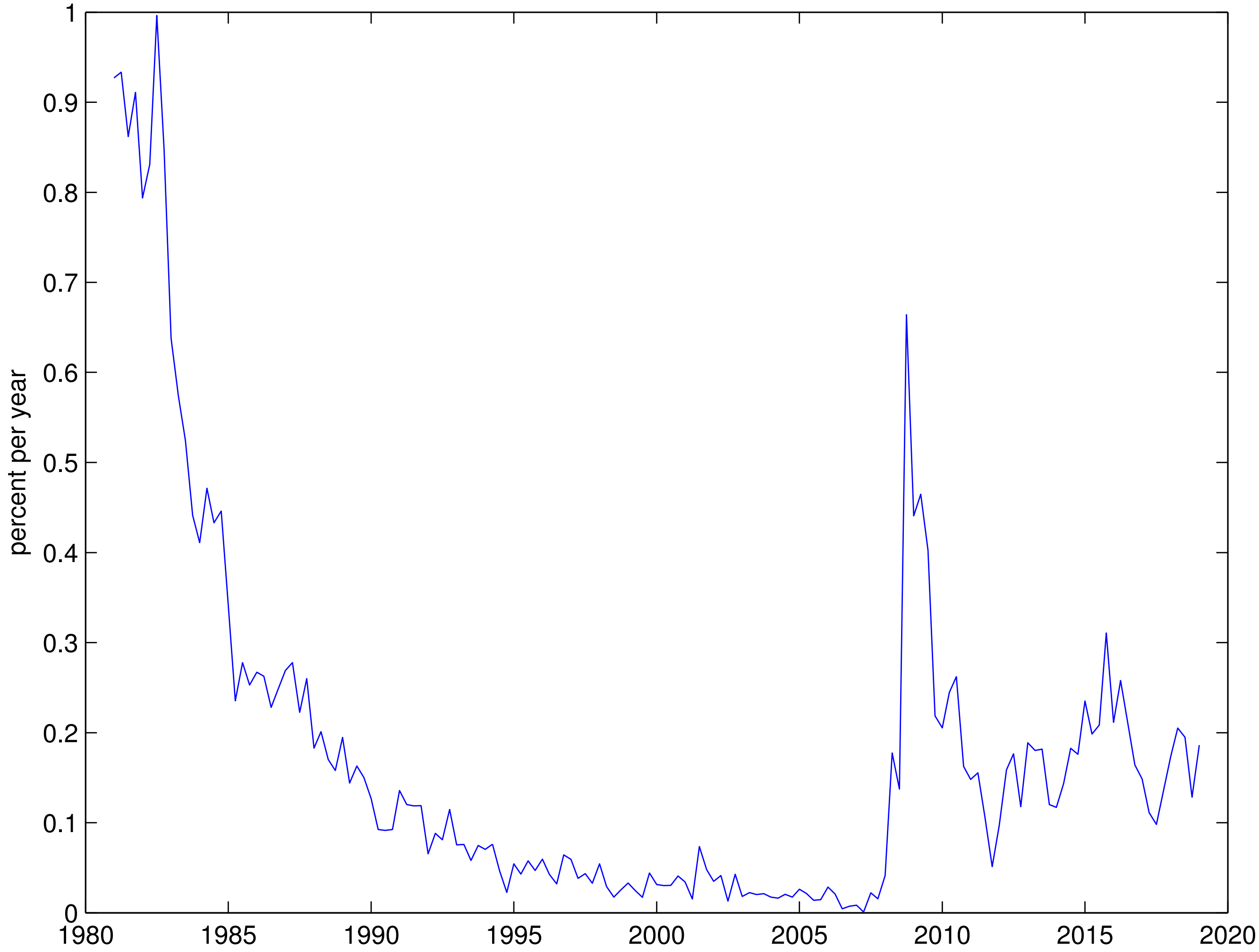
• Letting i_t be the interest rate in period t on a dollar deposit in the United States and i_t^* the interest rate on a dollar deposit in the foreign country, the offshore-onshore interest rate differential is

$$\text{offshore-onshore differential } = i_t^* - i_t.$$

• Both interest rates are on dollar deposits, $\rightarrow$ no exchange rate risk.

• If both deposits are default-risk free, then, under free capital mobility, the offshore-onshore differential should be zero.

Offshore-Onshore Interest Rate Differential of the U.S. Dollar: 1981Q1-2019Q1



Notes: The figure plots the average quarterly offshore-onshore interest rate differential of the U.S. dollar. The offshore rate is the 3-month Euro-Dollar deposit interest rate, Bank of England series: IUQAED3A. The onshore rate is the 3-month certificates of deposit (CD) rate for the United States, OECD MEI series: IR3TIB.

Comments on the Figure

What is plotted?: $i_t^* - i_t$ for 1981Q1-2019Q

What does the figure reveal? Dollar interest rates are higher in the UK than in the US prior to 1985 and after 2008. Near zero offshore-onshore differentials between 1990 and 2008.

Takeaway: free capital mobility between 1990 and 2008, but impediments to free capital mobility in the 1980s (consistent with evidence from CIRD), and to some extend post 2018. The latter is attributed to regulations put into place post financial crisis that prevent financial institutions to exploit the arbitrage opportunities presented by non-zero offshore-onshore interest rate differentials.

Uncovered Interest Rate Parity

• A central concept in international finance is that of *uncovered interest rate parity* (UIP). Uncovered interest rate parity holds if:

$$1 + i_t = (1 + i_t^*) E_t \left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right), \tag{2}$$

where E_t denotes the expectations operator conditional on information available in period t.

• When UIP holds, the gross rate of return of 1 unit of domestic currency invested in domestic assets, $1 + i_t$, is equal to the expected gross rate of return of 1 unit of domestic currency invested in foreign assets, $(1 + i_t^*) E_t \left(\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \right)$.

• In this section we show that when households are risk averse UIP in general does not hold. This suggests that observing sizable uncovered interest rate differentials is not an indication of the existence of impediments to free capital mobility across countries. (We will take up this point first.)

• We also present empirical evidence of violations of UIP.

Asset Pricing in a 2-period Small Open Economy Model

Two important interest rate parity conditions are

- CIP = covered interest rate parity: $(1+i_t) = (1+i_t^*)\frac{F_t}{\mathcal{E}_t}$

- UIP = uncovered interest rate parity: $(1+i_t) = (1+i_t^*)E_t\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$

Do CIP and UIP hold in an eqm asset pricing model under free capital mobility?

Notation:

π = probability economy is in the good state in period 2.
$1 - \pi$ = probability economy is in the bad state in period 2.

Endowments:
Period 1: Q_1
Period 2, good state: Q_2^g
Period 2, bad state: Q_2^b

Consumption:
Period 1: C_1
Period 2, good state: C_2^g
Period 2, bad state: C_2^b

Notation (ctd.):

Exchange rates:
Period 1: $\mathcal{E}_1$, spot exchange rate
Period 1: F_1, forward exchange rate
Period 2, good state: $\mathcal{E}_2^g$, spot exchange rate in good state
Period 2, bad state: $\mathcal{E}_2^b$, spot exchange rate in bad state

Domestic Price Level:
Period 1: P_1
Period 2, good state, P_2^g
Period 2, bad state, P_2^b

Interest Rates:
i_1: interest rate on domestic-currency bond held from period 1 to 2
i_1^*: interest rate on foreign-currency bond held from period 1 to 2

Expectations operator: $E_1 x_2 = \pi x_2^g + (1-\pi) x_2^b$ denotes the expected value of the random variable x_2 given information in period 1.

With this notation, we have:

Covered Interest Rate Parity (CIP):

$$1 + i_1 = (1 + i_1^*) \frac{F_1}{\mathcal{E}_1}$$

Uncovered Interest Rate Parity (UIP):

$$1 + i_1 = (1 + i_1^*) E_1 \frac{\mathcal{E}_2}{\mathcal{E}_1}$$

As we will show next, under free capital mobility, CIP holds in eqm. At the same time, UIP, in general, fails. For UIP to hold it would have to be the case that the forward rate is equal to the expected future spot rate, that is, it would have to be true that

$$F_1 = E_1 \mathcal{E}_2$$

But this condition is not a requirement of eqm.

Is CIP an equilibrium condition of the model economy?

Features of the model

- there is free capital mobility

- Domestic households have access to 3 types of bonds:

– B_1 domestic-currency bonds with interest rate i_1.

– B_1^* foreign-currency bonds with interest rate i_1^* for which HH buys forward cover.

– $\tilde{B}_1^*$ foreign-currency bonds with interest rate i_1^*, for which HH does not buy forward cover.

Households

$$\text{Expected utility } = U(C_1) + \pi U(C_2^g) + (1-\pi)U(C_2^b) \tag{3}$$

Budget Constraints:

Period 1:

$$P_1 C_1 + B_1 + \mathcal{E}_1 B_1^* + \mathcal{E}_1 \tilde{B}_1^* = P_1 Q_1 \tag{4}$$

Period 2, good state:

$$P_2^g C_2^g = P_2^g Q_2^g + (1+i_1)B_1 + (1+i_1^*)F_1 B_1^* + (1+i_1^*)\mathcal{E}_2^g \tilde{B}_1^* \tag{5}$$

Period 2, bad state:

$$P_2^b C_2^b = P_2^b Q_2^b + (1+i_1)B_1 + (1+i_1^*)F_1 B_1^* + (1+i_1^*)\mathcal{E}_2^b \tilde{B}_1^* \tag{6}$$

How to choose B_1, B_1^*, and $\tilde{B}_1^*$? To maximize utility.

Household problem: Pick C_1, C_2^g, C_2^b, B_1, B_1^*, and $\tilde{B}_1^*$ to maximize (3) subject to (14)-(6).

To make the problem easier to characterize solve (14) for C_1, (5) for C_2^g, and (6) for C_2^b and use the resulting expressions to eliminate C_1, C_2^g, and C_2^b from (3). Then we have a single objective function in three unknowns, namely, B_1, B_1^*, and $\tilde{B}_1^*$, which we pick to maximize expected utility.

Solving the period-1 budget constraint for C_1 yields:

$$C_1(B_1, B_1^*, \tilde{B}_1^*) = \frac{P_1 Q_1 - B_1 - \mathcal{E}_1 B_1^* - \mathcal{E}_1 B_1^*}{P_1}.$$

Solving the period-2, good state, budget constraint for C_2^g yields:

$$C_2^g(B_1, B_1^*, \tilde{B}_1^*) = \frac{P_2^g Q_2^g + (1+i_1)B_1 + (1+i_1^*)\left(F_1 B_1^* + \mathcal{E}_2^g B_1^*\right)}{P_2^g}.$$

Solving the period-2, bad state, budget constraint for C_2^b yields:

$$C_2^b(B_1, B_1^*, \tilde{B}_1^*) = \frac{P_1^b Q_2^b + (1+i_1)B_1 + (1+i_1^*)\left(F_1 B_1^* + \mathcal{E}_2^b B_1^*\right)}{P_2^b}.$$

Now take the first order condition w.r.t. B_1, this yields:

$$U'(C_1)\frac{1}{P_1} = \pi U'(C_2^g)\frac{1+i_1}{P_2^g} + (1-\pi)U'(C_2^b)\frac{1+i_1}{P_2^b}$$

Rewrite this expression as:

$$1 = (1+i_1)\left[\pi\frac{U'(C_2^g)}{U'(C_1)}\frac{P_1}{P_2^g} + (1-\pi)\frac{U'(C_2^b)}{U'(C_1)}\frac{P_1}{P_2^b}\right]$$

Letting E_1 denote the expectations operator, we have:

$$1 = (1+i_1)E_1\left\{\frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2}\right\}$$

Finally, let $M_2 \equiv \left\{\frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2}\right\}$ denote the nominal mrs between period 2 and period 1, to arrive at the following asset pricing condition:

$$1 = (1+i_1)E_1\left\{M_2\right\} \tag{7}$$

FOC w.r.t. to B_1^* (for which the HH buys forward cover):

$$U'(C_1)\frac{\mathcal{E}_1}{P_1} = \pi(1+i_1^*)U'(C_2^g)\frac{F_1}{P_2^g} + (1-\pi)(1+i_1^*)U'(C_2^b)\frac{F_1}{P_2^b}$$

Rewrite this expression as

$$1 = (1+i_1^*)\frac{F_1}{\mathcal{E}_1}\left[\pi\frac{U'(C_2^g)}{U'(C_1)}\frac{P_1}{P_2^g} + (1-\pi)\frac{U'(C_2^b)}{U'(C_1)}\frac{P_1}{P_2^b}\right]$$

Using the expectations operator notation we have:

$$1 = (1+i_1^*)\frac{F_1}{\mathcal{E}_1}E_1\left\{\frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2}\right\} = (1+i_1^*)\frac{F_1}{\mathcal{E}_1}E_1\{M_2\} \tag{8}$$

Combining (7) and (8) we obtain:

$$\boxed{(1+i_1) = (1+i_1^*)\frac{F_1}{\mathcal{E}_1}} \tag{9}$$

which is the **covered interest rate parity condition**. Thus, we have the answer to our question, under free capital mobility, in our theoretical model CIP is an equilibrium conditions. If one were to observe deviations from CIP, then one can conclude that there are obstacles to free capital mobility.

What about Uncovered Interest Rate Parity, must it hold in eqm?

Consider the FOC w.r.t $\tilde{B}_1^*$.

$$U'(C_1)\frac{\mathcal{E}_1}{P_1} = \pi(1+i_1^*)U'(C_2^g)\frac{\mathcal{E}_2^g}{P_2^g} + (1-\pi)(1+i_1^*)U'(C_2^b)\frac{\mathcal{E}_2^b}{P_2^b}.$$

Rewrite this expression as

$$1 = (1+i_1^*)\left[\pi\frac{\mathcal{E}_2^g}{\mathcal{E}_1}\frac{U'(C_2^g)}{U'(C_1)}\frac{P_1}{P_2^g} + (1-\pi)\frac{\mathcal{E}_2^b}{\mathcal{E}_1}\frac{U'(C_2^b)}{U'(C_1)}\frac{P_1}{P_2^b}\right]$$

Using the expectations operator notation we have:

$$1 = (1+i_1^*)E_1\left\{\left(\frac{\mathcal{E}_2}{\mathcal{E}_1}\right)\left(\frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2}\right)\right\} = (1+i_1^*)E_1\left\{\left(\frac{\mathcal{E}_2}{\mathcal{E}_1}\right)M_2\right\} \quad (10)$$

Combining the asset pricing equations (8) and (10), we obtain

$$\boxed{F_1 E_1 \{M_2\} = E_1 \{\mathcal{E}_2 M_2\}}$$

but this expression does in general **not** imply that the forward rate, F_1, is equal to the expected future spot rate, $E_1\mathcal{E}_2$. That is, it does **not** follow from here that

$$F_1 = E_1 \{\mathcal{E}_2\}$$

Hence, in general, the model predicts that under free capital mobility uncovered interest rate parity fails.

It follows that observed violations of UIP need not imply lack of free capital mobility.

Next we wish to find conditions under which UIP holds in our model.

Recall that for any pair of random variables a and b their covariance conditional on information available in period 1 is given by

$$\begin{aligned} cov_1(a,b) &= E_1\left(a - E_1(a)\right)\left(b - E_1(b)\right) \\ &= E_1\left(ab\right) - E_1(a)E_1(b) \end{aligned}$$

or $E_1\left(ab\right) = cov_1(a,b) + E_1(a)E_1(b)$

We then can express $E_1\left\{(\mathcal{E}_2/\mathcal{E}_1)M_2\right\}$ as

$$E_1\left\{\frac{\mathcal{E}_2}{\mathcal{E}_1}M_2\right\} = cov_1\left(\frac{\mathcal{E}_2}{\mathcal{E}_1}, M_2\right) + E_1\left\{\frac{\mathcal{E}_2}{\mathcal{E}_1}\right\}E_1\{M_2\}$$

and rewrite (10) as

$$1 = (1 + i_1^*)\left[cov_1\left(\frac{\mathcal{E}_2}{\mathcal{E}_1}, M_2\right) + E_1\left\{\frac{\mathcal{E}_2}{\mathcal{E}_1}\right\}E_1\{M_2\}\right]$$

Suppose now that the depreciation rate, $\mathcal{E}_2/\mathcal{E}_1$, is uncorrelated with the pricing kernel, M_2, that is,

$$cov_1\left(\frac{\mathcal{E}_2}{\mathcal{E}_1}, M_2\right) = 0$$

Then equation (10) becomes

$$1 = (1 + i_1^*)E_1\left\{\frac{\mathcal{E}_2}{\mathcal{E}_1}\right\}E_1\{M_2\}$$

Combine this expression with equation (8) to obtain

$$F_1 = E_1\{\mathcal{E}_2\} \tag{11}$$

which says that, in the model, if the depreciation rate, $\mathcal{E}_2/\mathcal{E}_1$, is uncorrelated with the pricing kernel, M_2, then the forward rate equals the expected future spot rate.

And further if we combine the above expression with (7) we have

$$\boxed{(1 + i_1) = (1 + i_1^*)E_1\left\{\frac{\mathcal{E}_2}{\mathcal{E}_1}\right\}}$$

or UIP holds.

Taking stock. We have shown that

1.) under free capital mobility, CIP holds.

2.) when we observe violations of UIP, we cannot conclude that this is evidence against free capital mobility. For even under free capital mobility UIP need not hold, that is, the forward rate need not equal the expected future spot rate.

Next we will show present some empirical evidence on the failure of UIP.

Carry Trade as a Test of UIP

Suppose UIP holds: $1 + i_t = (1 + i_t^*) E_t[\mathcal{E}_{t+1}/\mathcal{E}_t]$.

$\Rightarrow$ If $i_t > i_t^*$, then $E_t[\mathcal{E}_{t+1}/\mathcal{E}_t] > 1$, that is, the high interest rate currency is expected to depreciate.

If UIP holds, one should not be able to make systematic profits from borrowing at the low interest rate and lending at the high interest-rate, since exchange rate movements would exactly offset the interest rate differential on average.

Yet, this trading strategy, known as *carry trade* is widely used by practitioners, suggesting that it does indeed yield positive payoffs on average.

• When i_t is the high interest rate currency, that is, when $i_t > i_t^*$, the payoff from a carry trade is given by*

$$\text{payoff from carry trade} = (1 + i_t) - (1 + i_t^*)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t},$$

• Empirical studies have shown that carry trade yields positive payoffs on average. For example, average payoffs from carry trade for the pound sterling against 10 currencies over the period 1976:1 to 2005:12 are positive, but low, 0.0029 for 1 pound invested for one month.†

• The fact that the average payoff from carry trade is non-zero means that on average the uncovered interest rate differential is not zero and that UIP fails.

*If i_t^* is the high interest rate currency the payoff is $(1 + i_t^*)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} - (1 + i_t)$.

†See, Burnside, Eichenbaum, Kleshchelski, and Rebelo (2006).

• Carry trade is subject to crash risk. Crashes in carry trade are the result of sudden large movements in exchange rates. For example, on October 6-8, 1998 there was a large surprise appreciation of the Japanese Yen against the U.S. dollar. The Yen appreciated by 14 percent (or equivalently the U.S. dollar depreciated by 14 percent). Suppose that you were a carry trader with 1 billion dollars short in Yen and long in U.S. dollars. The payoff of that carry trade in the span of 2 days was -140 million dollars.

• Because of this crash risk and because of its low payoff relative to the large gross positions it requires, The Economist magazine has likened carry trade to "picking up nickels in front of steamrollers."*

*See, "Carry on speculating," Economic Focus, The Economist, February 24, 2007, page 90.

The Forward Premium Puzzle

• When a foreign currency is 'more expensive' in the forward than in the spot market, that is, when

$$F_t > \mathcal{E}_t,$$

we say that the foreign currency is at a *premium in the forward market*, or, equivalently, that the domestic currency is at a *discount in the forward market*.

• Conditional on CIP holding, UIP holds if and only if

$$E_t \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} = \frac{F_t}{\mathcal{E}_t} \tag{12}$$

That is, UIP holds if and only if the domestic currency is expected to depreciate when the foreign currency trades at a premium in the forward market.

• Consider estimating

$$\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} = a + b\frac{F_t}{\mathcal{E}_t} + \mu_{t+1}$$

• In the data CIP holds pretty well so a testable implication of UIP is that $a = 0$ and $b = 1$.

• Burnside (2018), for example, estimates this regression for the U.S. dollar against the currencies of 10 industrialized economies using monthly observations over the period 1976:1 to 2018:3* and finds cross-country average estimates of a and b of 0.00055 and -0.75. For most countries (7 out of 10), the null hypothesis that $a = 0$ and $b = 1$ is rejected at high significance levels of 1 percent or less.

• This result is known as the *forward premium puzzle.*

• Like the evidence on non-zero average returns to carry trade, the forward premium puzzle indicates that UIP is strongly rejected by the data.

* The countries included in the analysis are Australia, Canada, Denmark, Germany/euro area, Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom.

Real Interest Rate Parity

• Does free capital mobility create a tendency for real interest rates to equalize across countries?

• We will show that the answer to this question is, in general, no.

• Specifically, when purchasing power parity does not hold, which—as shown in Chapter 8—is the case of greatest empirical interest, non-zero real interest rate differentials need not imply the absence of free capital mobility.

We derive this theoretical result next.

Model

• Two-period small open economy with two assets: (i) domestic real bond, b_1, pays $(1+r_1)b_1$ units of the domestic consumption basket in period 2; (ii) foreign real bond, b_1^*, pays $(1+r_1^*)b_1^*$ units of the foreign consumption basket in period 2.

• Real exchange rate, e_t:

$$e_t = \frac{\mathcal{E}_t P_t^*}{P_t}$$

with $P_t =$ nominal price of a domestic basket of goods in domestic currency, $P_t^* =$ nominal price of a foreign basket of goods expressed in foreign currency, and $\mathcal{E}_t$ is the nominal exchange rate, defined as the domestic-currency price of one unit of foreign currency.

The Household Problem

• The utility function of the household:

$$U(C_1) + U(C_2) \tag{13}$$

• Budget constraint in period 1:

$$C_1 + b_1 + e_1 b_1^* = Q_1, \tag{14}$$

• Budget constraint in period 2:

$$C_2 = Q_2 + (1 + r_1) b_1 + (1 + r_1^*) e_2 b_1^* \tag{15}$$

• The household chooses C_1, C_2, b_1, and b_1^* to maximize its utility function, (13), subject to the budget constraints in periods 1 and 2, (14) and (15).

Solve the period-1 budget constraint, (14) for C_1, the period-2 budget constraint, (15) for C_2 and use the resulting expressions to eliminate consumption from the utility function to obtain

$$U(Q_1 - b_1 - e_1 b_1^*) + U(Q_2 + (1 + r_1)b_1 + (1 + r_1^*)b_1^*).$$

FOCs:

$$U'(C_1) = (1 + r_1)U'(C_2)$$

$$U'(C_1) = (1 + r_1^*)U'(C_2)\frac{e_2}{e_1}.$$

These two Euler equations can be combined into:

$$(1 + r_1) = (1 + r_1^*)\frac{e_2}{e_1}. \tag{16}$$

- Real interest rate parity fails as long as $\frac{e_2}{e_1} \neq 1$.

- **Takeaway:** observing nonzero real interest-rate differentials need not be indicative of restrictions to capital mobility.

Saving-Investment Correlations

• In an influential paper Feldstein and Horioka (1980) examined data on average investment-to-GDP and saving-to-GDP ratios from 16 OECD countries over the period 1960-1974 and estimate by OLS:

$$\left(\frac{I}{GDP}\right)_i = 0.035 + 0.887\left(\frac{S}{GDP}\right)_i + \nu_i; \qquad R^2 = 0.91,$$

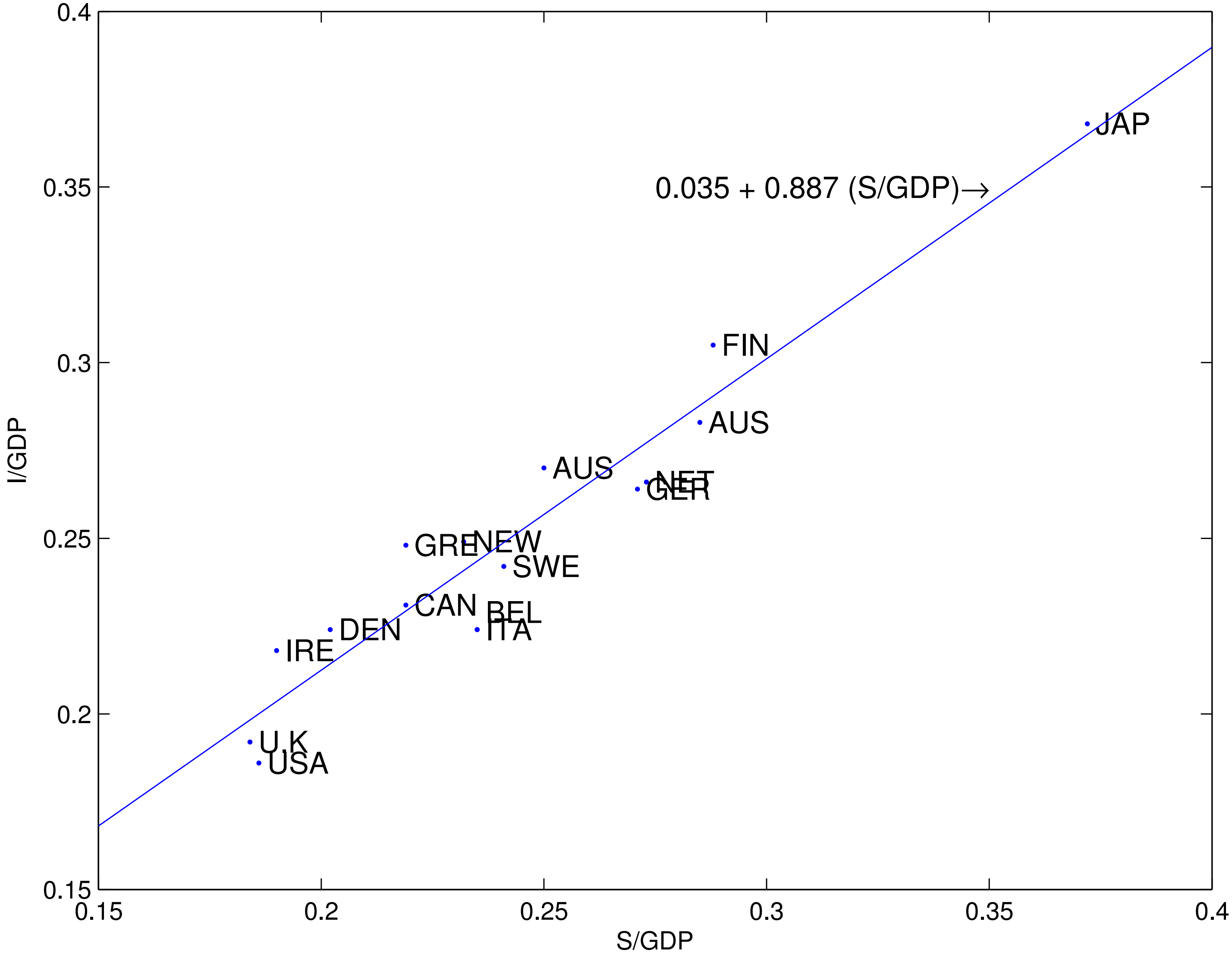
where $(I/GDP)_i$ and $(S/GDP)_i$ denote the average investment-to-GDP and saving-to-GDP ratios in country i for $i = 1, 2, \ldots, 16$, over the period 1960-1974.

• The estimated coefficient of 0.887 means that there is almost a one-to-one positive association between average saving rates and average investment rates.

• The reported R^2 statistic of 0.91 means that the estimated equation fits the data quite well, as 91 percent of the cross-country variation in I/GDP is explained by variations in S/GDP.

• The figure on the next slide plots the raw data and the estimated regression equation.

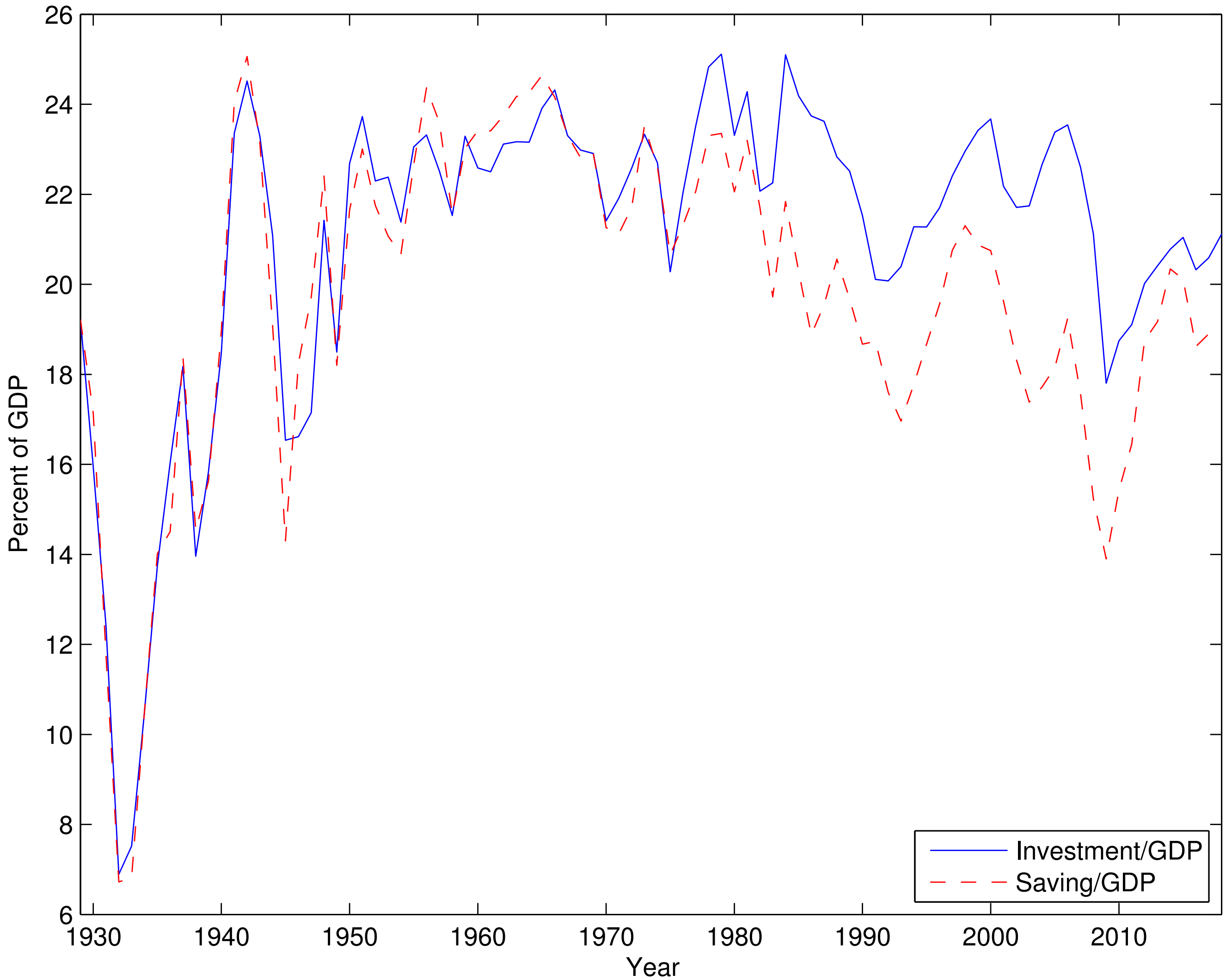
Saving and Investment Rates for 16 Industrialized Countries, 1960-1974 Averages



• A positive relationship between saving and investment rates is observed not only across countries but also across time. For example, the next figure shown on the next slide, plots the U.S. saving and investment rates from 1929 to 2018.

• The two series move closely together, although the comovement has weakened a little since the emergence of large U.S. current account deficits in the 1980s.

U.S. National Saving and Investment Rates, 1929-2018



How to interpret the observed comovements?

• Feldstein and Horioka argued that if capital was highly mobile across countries, then the correlation between saving and investment should be close to zero, and therefore interpreted their findings as evidence of low capital mobility.

• Consider the identity,

$$CA = S - I$$

• In an economy without international capital mobility, the current account must be zero, so that $S = I$ and saving is perfectly correlated with investment. That is, lack of capital mobility implies a high correlation between S and I.

• But what about the other way around? Does a high correlation between S and I necessarily imply that an economy is financially closed? We will show that this is not the case. **Takeaway:** Observing high S-I correlations need not be informative about the degree of international capital market integration.

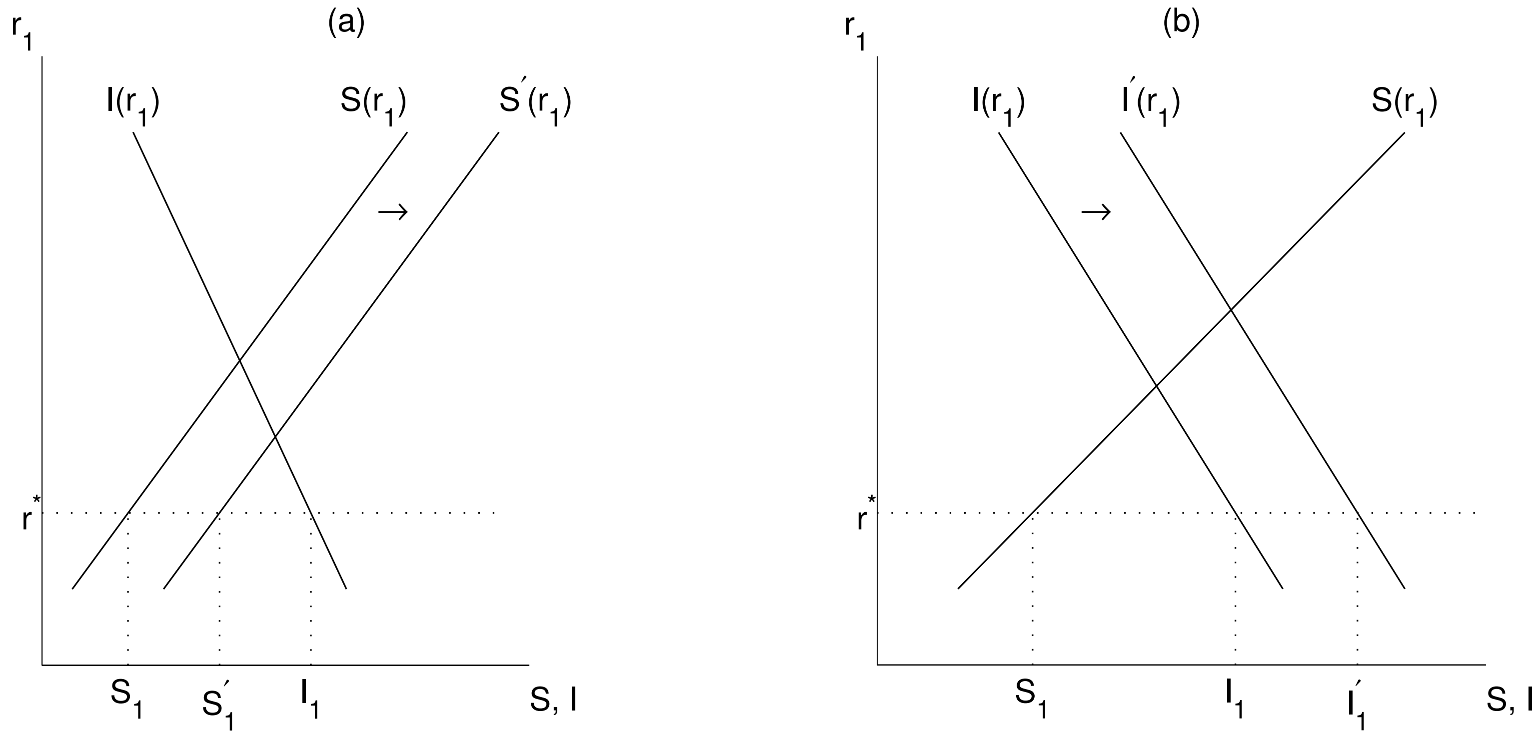
• Consider a small open economy with perfect capital mobility. The comovement of saving and investment will depend on the type of shocks hitting it.

• Let's first consider the case that the saving and investment schedules are affected by independent factors, then the correlation between saving and investment will be zero. And observing high $S-I$ comovements would indicate lack of free capital mobility.

• In particular, shocks that shift only the saving schedule will result in changes in the equilibrium level of saving but will not affect the equilibrium level of investment Similarly, shocks that shift only the investment schedule will result in changes in the equilibrium level of investment but will not affect the equilibrium level of national savings.

• The figure on the next slide illustrates this point.

Response of S and I to independent shifts in (a) the savings schedule and (b) the investment schedule



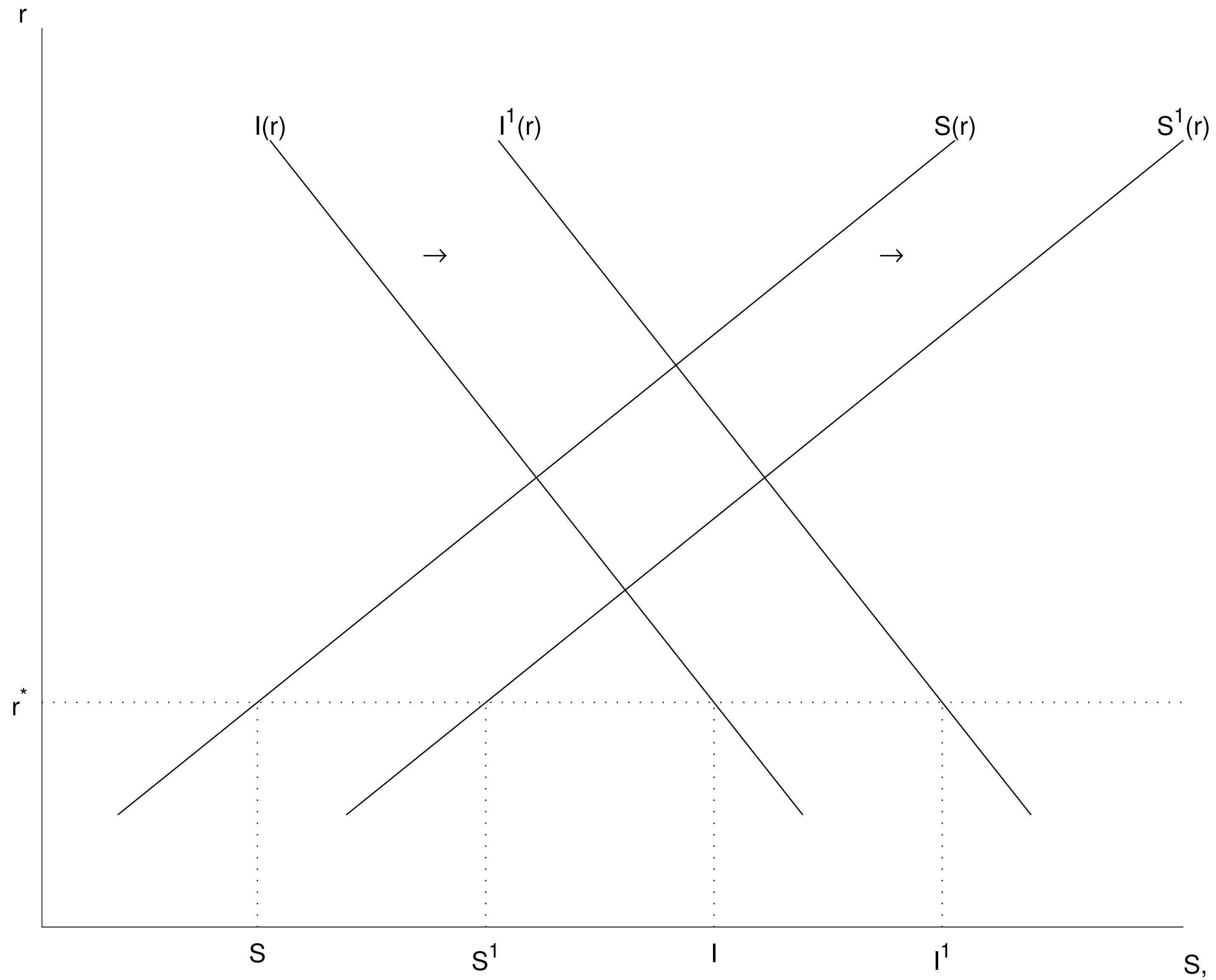
But do the Feldstein-Horioka findings of high savings-investment correlations necessarily imply imperfect capital mobility?

The answer is no.

Here we give 2 counter examples.

Counterexample 1: even under perfect capital mobility, a positive association between S and I can arise when the same shocks shift the savings and investment schedules. Suppose that $Q_1 = A_1 F(I_0)$ and $Q_2 = A_2 F(I_1)$, where A_1 and A_2 denote productivity. Consider a persistent productivity shock. Assume that A_1 and A_2 increase and that A_1 increases by more than A_2. This situation is illustrated in the next slide.

Response of S and I to a persistent productivity shock



Comments on the Figure

- **In response to the increase in A_2, the investment schedule shifts to the right to $I^1(r)$.**

- **The increase in A_2 produces a positive wealth effect, which shifts the saving schedule to the left. The increase in A_1 produces an increase in output in period 1. Consumption-smoothing households will want to save part of the increase in Q_1. Therefore, the effect of an increase in A_1 is a rightward shift in the saving schedule. Because we assumed that A_1 increases by more than A_2, on net the saving schedule is likely to shift to the right. In the figure, the new saving schedule is given by $S^1(r)$.**

- **Because the economy is small, the interest rate is unaffected by the changes in A_1 and A_2. As a result both saving and investment increase (to S^1 and I^1).**

- **Thus, in this economy we would see that saving and investment are positively correlated even though the economy has free capital mobility.**

Counterexample 2: Saving and investment may be positively correlated in spite of free capital mobility in the presence of large country effects.

Consider a shock that shifts the saving schedule to the right from $S(r)$ to $S'(r)$.

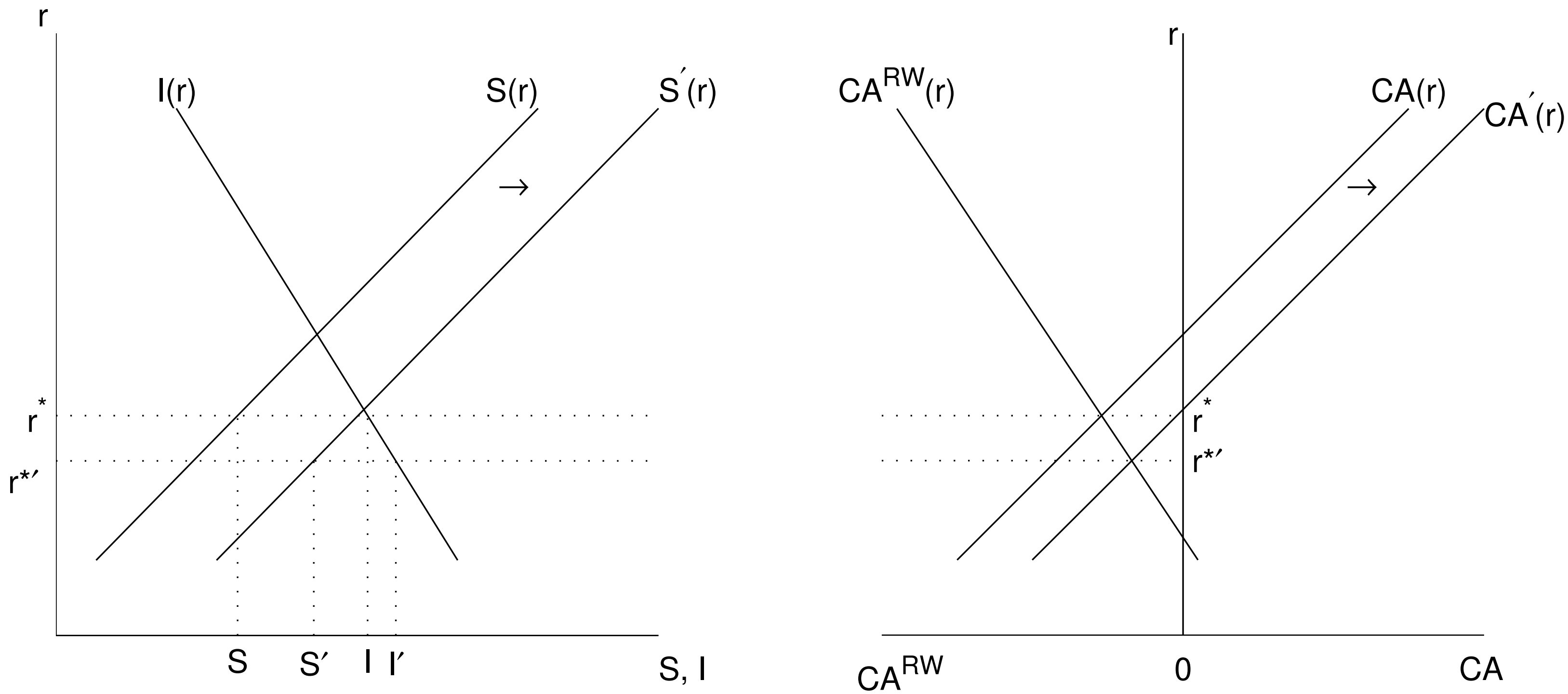
The figure on the next slide illustrates this case.

The current account schedule also shifts to the right from $CA(r)$ to $CA'(r)$. As a result, the world interest rate falls from r^* to $r^{*\prime}$.

The fall in the interest rate leads to an increase in investment from I to I'.

Thus, in a large open economy with free capital mobility, a shock that affects only the saving schedule can result in a positive comovement between saving and investment.

Large open economy: response of S and I to a shift in the savings schedule



Takeaway:

Observing a positive correlation between saving and investment is not necessarily an indication of lack of capital mobility.

Summing Up

• The forward exchange rate, F_t, is the domestic currency price of one unit of foreign currency to be delivered and paid for in a future period.

• The forward discount is the ratio of the forward exchange rate to the spot exchange rate, $F_t/\mathcal{E}_t$. When the forward discount is greater than one, we say that the foreign currency trades at a premium and the domestic currency at a discount in the forward market.

• Covered interest rate parity (CIP) says that the domestic interest rate, i_t, must equal the foreign interest rate, i_t^*, adjusted for the forward discount, $1 + i_t = (1 + i_t^*)F_t/\mathcal{E}_t$.

• The covered interest rate differential is equal to $1+i_t-(1+i_t^*)F_t/\mathcal{E}_t$.

• The cross-currency basis is the same as the covered interest rate differential.

• Under free capital mobility, absent default risk, covered interest rate differentials should be near zero.

Summing Up (ctd.)

- The offshore-onshore interest rate differential is the difference between the domestic nominal interest and the foreign nominal interest on domestic currency denominated assets.

- Under free capital mobility, absent default risk, offshore-onshore interest rate differentials should be near zero.

- Based on observed cross-country interest rate differentials, the developed world displayed a high degree of capital mobility between 1870 and 1914 and again after 1985. The period 1914-1985 was characterized by large disruptions in international capital market integration. This suggests that capital market integration is not a monotonic process.

- As a consequence of new financial regulations, covered interest rate differentials have displayed a slight elevation since the global financial crisis of 2008.

Summing Up (concluded)

• Uncovered interest rate parity (UIP) says that the domestic interest rate must equal the foreign interest rate adjusted for expected depreciation, $1+i_t = (1+i_t^*)E_t\mathcal{E}_{t+1}/\mathcal{E}_t$.

• UIP is in general not implied by an equilibrium asset pricing model.

• UIP is strongly rejected by the data.

• Deviations from real interest rate parity can arise even under free capital mobility.

• Observing a positive correlation between saving and investment is not necessarily an indication of lack of capital mobility.