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# Interest Parity Conditions as Indicators of Financial Integration in East Asia

Gordon de Brouwer

AUSTRALIA–JAPAN RESEARCH CENTRE

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# Interest Parity Conditions as Indicators of Financial Integration in East Asia

*Market participants and policymakers have a growing interest in the development of East Asian financial markets, and to the extent to which these markets are open and influenced by world markets. This paper examines the information contained in interest parity conditions about the international integration of a wide range of economies in East Asia. Legal restrictions on the capital account and tests of covered, uncovered and real interest parity are presented in some detail. Using standard regressions, cointegration analysis and error decompositions, it is argued that uncovered interest parity tests reveal a surprisingly large amount of information about financial openness. For example, McCallum's (1994) model of the interaction of uncovered interest parity and a monetary policy reaction function can be used to explain striking anomalies that arise between countries. Openness and the importance of foreign interest rate shocks appear to have increased in most countries, although Korea remains an important exception. Four policy implications are discussed in the conclusion.*

## Introduction

The integration of markets implies, on the face of it, an increase in transactions and a tendency for prices in those markets to converge. Hence, the international integration of financial markets implies an increase in capital flows and a greater tendency for the common-currency prices and returns on traded financial assets in different countries to converge. The convergence of returns is typically measured by closed, covered, uncovered and real interest parity over a set of traded assets, including money market instruments, long-term securities and equities. This paper examines covered, uncovered and real interest parity for money market instruments in Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand to evaluate the financial integration of these economies with the world market.

First of all, the current state of the laws concerning the capital account of selected countries in East Asia is reviewed, and then some issues concerning data are briefly discussed. In the fourth section, new evidence is presented and assessed on covered interest parity relative to US traded assets for Australia, Hong Kong, Japan, Malaysia, Singapore, Taiwan and Thailand. US assets are the best for comparison since their markets are deep, liberalised and

well-established. Particular attention is paid to whether the 1990s are different from the 1980s — and, if so, why — and the importance of periodic rather than systematic exchange controls is highlighted. In the next section, mean uncovered interest differentials are estimated and standard tests of uncovered interest parity applied, yielding a striking difference in the results between financially open and closed economies. McCallum's (1994) model is used to explain this and the inference is drawn that tests of uncovered interest parity may in fact contain considerable information about financial openness. The time-varying influence of foreign interest rates on domestic nominal interest rates is assessed by examining the cointegration of interest rates and variance decompositions in vector autoregressions. In the sixth section, the real interest differential is decomposed into the uncovered interest differential and relative purchasing power differential in order to explain the wedge between domestic and foreign real interest rates. Finally, the results are comprehensively summarised for the non-technical reader and some policy implications are discussed.

## Legal restrictions on the capital account

Emery (1991) and Cole et al. (1995a, 1995b) discuss the structure of money and foreign exchange markets in East Asia. The development of money markets in the countries examined in this paper has sometimes been stilted, and the principal market is often the interbank market. This section focuses on the recent history of controls in exchange markets, drawing heavily on IMF (1995). While most countries now have relatively open capital accounts, this is only recent for Korea, the Philippines, Taiwan and Thailand, and, to varying degrees, controls still remain in these countries. The development of controls on payments in the current account, capital account and exchange proceeds for countries in the region is summarised in Table 1.[1] In the first column, *o* and *r* indicate, respectively, that the capital account is relatively open (*o*) or restricted (*r*) based on the existence of legal restrictions (in succeeding tables this is included in brackets after each country's name).

Liberalisation has generally been pursued at times of macroeconomic stability in order to minimise possible destabilisation. The catalysts for reform have been recognition of the potential gains to national development from a more sophisticated and open financial system, the need to remain competitive as a location for foreign direct investment, and a response to changes in world trading rules, indicated, for example, by the focus on trade and investment in services in the Uruguay Round (Wibulswasdi and Tanvanich 1992). Australia, Hong Kong,

**Table 1 Summary of current and capital account liberalisation, 1980, 1990 and 1994**

| | | Current account restrictions | | | Capital account restrictions | | | Surrender export receipts | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1980 | 1990 | 1994 | 1980 | 1990 | 1994 | 1980 | 1990 | 1994 |
| Australia | *o* | – | – | – | • | – | – | • | – | – |
| Hong Kong | *o* | – | – | – | – | – | – | – | – | – |
| Indonesia | *o* | – | – | – | – | – | – | • | – | – |
| Japan | *o* | – | – | – | • | – | – | – | – | – |
| Korea | *r* | – | – | – | • | • | • | • | • | • |
| Malaysia | *o* | – | – | – | – | – | – | • | • | • |
| Philippines | *r* | • | • | • | • | • | • | • | • | – |
| Singapore | *o* | – | – | – | – | – | – | – | – | – |
| Taiwan | *r* | • | – | – | • | • | • | • | • | • |
| Thailand | *r* | – | – | – | • | • | • | • | • | • |

*Notes:* *o* indicates open capital account.
*r* indicates restrictions on the capital account.
• indicates application of restrictions.

*Source:* IMF, *Annual Report on Exchange Arrangements and Exchange Restrictions*, various.

Indonesia, Japan and Singapore are the countries in this survey with what may be termed free capital markets, followed by Malaysia and Thailand with relatively free capital accounts, while the Philippines and, to a greater extent, Korea and Taiwan are countries which still maintain a relatively high degree of control over capital movements. The currencies of Australia, Japan and, since 1992, the Philippines are independently floating, while the currencies of other countries are managed floats with varying weights given to major trade currencies.[2]

Hong Kong had a floating exchange rate from 1974 to October 1983, and the Hong Kong dollar was effectively fixed to the US dollar thereafter. It has had the longest and most consistently open exchange system in the region: the abolition of restrictions on the capital account in 1972, the lifting of the moratorium on bank licensing in 1978, and the consequent entry of foreign banks have ensured tight competition and expansion in both the domestic money market and the foreign exchange market (Ho et al. 1995). The sole, innocuous restriction in the capital account applies to the licensing of financial institutions.

The Australian dollar was floated and exchange controls removed in December 1983. The only controls that remain on the capital account relate to the Australian dollar investments of foreign governments and multilateral official organisations, and to approval procedures for

large-ticket foreign direct investment (FDI) in particular sectors. The yen is also an independently floating currency determined by market supply and demand. Major capital account liberalisation took place in December 1980, when transactions were allowed unless explicitly prohibited and the requirement of an underlying real transaction was removed, and in June 1984 when controls on euroyen transactions and exchange conversions (for example, allowing domestic banks to accept long-term foreign currency deposits) were eased (Suzuki 1987). Remaining controls relate to limits on FDI and notification requirements for outward investment. The authorities retain the right to reinstate emergency controls.

The Singaporean dollar is a managed float within a band set by the Monetary Authority of Singapore (MAS) against a basket of currencies of major trading partners. Singapore also has a relatively long history of an open capital account. The withholding tax on interest applied to non-residents was abolished in 1968 and the capital account was liberalised progressively in the wake of the float of sterling in 1972, culminating in the removal of almost all capital controls in June 1978. The remaining formal control is that domestic financial institutions not lend more than $S5 million to non-residents or residents for use outside Singapore without the permission of the MAS. This is a tool for the MAS to prevent speculation and maintain control over the exchange rate and, consequently, inflation. There is no offshore market in Singaporean dollars, and the MAS is reported to use other, more subtle, means to limit international use of the Singaporean dollar, including limiting the amount of local currency that banks can lend (raised from $S50m to $S70m in 1992) and the use of local currency funds to trade international stocks (Euromoney 1994, p. 25). It is also reported to use informal guidance. Ariff et al. (1995, pp. 371–5, 378–9), for example, note that institutions which operate in the Asian currency market do so under the aegis of the MAS and are subject to licensing requirements, and so are sensitive to informal guidance. They also cite a 1982 episode when Singaporean banks which accepted Singaporean dollar funds in Hong Kong (avoiding Singaporean reserve requirements) and on-lent those funds in Singapore were penalised by the MAS and the practice stopped. They argue that supervision is now used to prevent similar transactions with forward cover to limit the international use of the Singaporean dollar.

Indonesia is well known for its open capital account and has employed a liberal exchange system with minimal controls since August 1971 (Cole and Slade 1995, p. 152). Remaining restrictions are limited to FDI, controls on which have declined substantially over time, and on foreign borrowing by government bodies and state banks. There are no limitations on the

international or domestic remittance of foreign exchange or rupiah. Bank Indonesia determines the exchange rate under a system of managed float against a basket of currencies.

The ringgit is a managed float currency whose value is based on a basket weighted by trading partner shares and currencies of settlement. Malaysia's capital account has been progressively liberalised since the float of the ringgit in June 1973, and spot and forward exchange transactions are free. Approval is required for a wide range of inward FDI and for all outward FDI which is financed within Malaysia. Foreign borrowing by residents is controlled but permission is forthcoming for borrowing for productive purposes, while borrowing in ringgit by non-residents also requires permission but is usually not granted (IMF 1995, p. 308). Exporters must repatriate foreign exchange within six months (Lin and Chung 1995, p. 247). The authorities have imposed temporary restrictions on exchange markets when the ringgit has been under pressure, as, for example, in 1986 and 1993–94. This is discussed in more detail below.

Since November 1984, the baht has been determined by the Exchange Equalisation Fund, which is part of the Bank of Thailand (BOT), on the basis of a peg to a composite of currencies. This allows a degree of flexibility not available when the baht was pegged to the US dollar. While payments on the current account are unrestricted, some payments restrictions still apply on the capital account and foreign exchange export proceeds must be converted or deposited in foreign exchange deposits with authorised banks. For example, most remittances are uncontrolled and inward FDI is permitted freely, but outward FDI over US$5 million and portfolio and property investments abroad by residents require approval. Major liberalisation of the capital account was implemented in May 1990: commercial banks were allowed to process trade-related foreign exchange transactions without BOT approval; in April 1991: official approval was no longer required for capital outflow, except when over a certain limit or for investment in foreign stock or property markets; and in April 1992: exporters were allowed to transfer foreign currency deposits for overseas debt payment or make payment in baht using non-resident accounts (Wibulswasdi and Tanvanich 1992). Apart from existing controls on capital outflow, banks' allowable net foreign exchange positions and variations in withholding taxes on foreign borrowing are reputedly used to control capital inflows (Warr and Nidhiprabha 1995). Officials from the BOT describe the Thai capital account as 'one that is formally open but not fully' (Nijathaworn and Dejthamrong 1994, p. 2). The BOT has stated its intention to remove remaining capital controls in the near future.

The Philippines peso has floated independently since September 1992 (before which it was a managed rate tied largely to the US dollar), but payments restrictions still apply on both the Philippine current and capital accounts. Inward FDI must be registered and approval is required for outward FDI over US$1 million and foreign borrowing. Preference is given to export-oriented and priority sectors. There has been substantial easing of controls on the capital account since 1991 (Yap et al. 1995). For example, foreign exchange receipts can now be retained, authorised banks can buy and sell foreign exchange without official approval, residents and non-residents are allowed to maintain foreign currency deposits in the Philippines, and residents are allowed to maintain deposits abroad (although some limitations apply to the peso deposits of non-residents).

Korea follows a liberal managed float, introduced in March 1990, by which the exchange rate varies within a band around a rate posted by the Bank of Korea (since November 1994, 1.5 per cent), where the rate posted is the average of the previous day's rate. The authorities maintain some restrictions on capital transactions and require the surrender of export proceeds. The form of controls has varied with the direction of capital flows, with current controls directed at stymieing inflows and easing upward pressure on the won. Major reforms were instituted in 1988 but were subsequently reversed in 1989 when economic conditions deteriorated. Controls remain on inward FDI and on foreign borrowing by Korean firms and banks. Portfolio investment abroad is limited. In the first half of the 1990s, there was progressive reduction in documentation requirements for spot and forward exchange transactions (although the in-principle requirement of trade backing still applies for forward transactions), a progressive relaxation in controls on foreign exchange positions, and an apparent shift in the mindset with the introduction of a negative list in September 1992 under which transactions were allowed unless expressly prohibited (Kim and Lee 1994). Foreign borrowing limits and restrictions in investing in overseas stock were partially eased in 1994.

The New Taiwan dollar was formally floated in July 1978 but a market was only established in February 1979 and the rate remained strongly influenced by the Central Bank of China (Taiwan Province). From April 1989, the rate was allowed to fluctuate within a band set by the Foreign Exchange Center (Chen 1990). The capital account was partially liberalised in 1986 and July 1987 when the Central Bank of China lifted controls on trade-related transactions in the current account and allowed residents to hold foreign currencies. Approval is still required, however, for large (>US$1m) outward foreign exchange transactions, with an annual limit of US$5 million (Emery 1988) until February 1994 and US$10 million thereafter.

The limit before July 1987 was US$5,000. Limits remain on the foreign exchange position of banks. Capital controls in Taiwan appear to be still relatively tight.

## Data and estimation issues

Definitions, sources and graphs of the interest rate data are presented in Appendix 1. In general, the interbank market rate is used as the representative money market rate, largely because of the relative lack of development of other money market instruments. Estimations are conducted using the Microfit β test version and RATS. Three econometric issues need to be addressed before progressing.

Firstly, the tests in this paper are mostly conducted using end-month data of three-month interest rates, forward discounts and depreciations, and the overlapping observations generate a moving average error of order two in the error of the estimating equation. This biases the standard errors but is corrected by using the Newey-West estimator of the covariance matrix (Newey and West 1987). The lag in the Parzen window is set equal to the length of the induced MA process (Greene 1993). Unless otherwise stated, the standard errors reported in this paper are Newey-West corrected.

Secondly, financial returns tend to exhibit periods of relative volatility and stability, and this suggests that estimation can be made more efficient by modelling the conditional variance of the error term (Bollerslev et al. 1994; Pagan 1995). In fact, generalised autoregressive conditional heteroscedasticity (GARCH) occurs with some data sets here. The order of GARCH is tested by examining the order of ARCH(q) in an OLS estimation, and the log likelihood function is maximised with a parsimonious specification of the error variance using the Microfit β test version. Unless otherwise reported, estimations do *not* include GARCH errors.

Stationarity is the third issue that arises in the estimations. The results from a time series analysis of money market interest rates are presented and discussed in detail in de Brouwer (1995). The conclusion from that analysis is that money market rates in these countries are non-stationary and are I(1) processes in the full sample from 1975 to 1994 and in the four 5-year sub-samples. The caveat is that standard tests have low power in discriminating between integrated and near-integrated, strongly autoregressive processes. The apparent first-order integration of interest rates motivates the search for cointegration between interest rates. Interest differentials and forward and spot exchange rate changes in general appear to be

stationary (as reported in the text of this paper) and standard statistical tests are applied, but there are important exceptions, discussion of which is deferred to later.

## Covered interest rate parity

It is generally assumed that markets are efficient in the sense that market participants search for arbitrage possibilities and conduct trade when it is profitable, and that efficiency rises as the collection, storage and analysis of information improve. If arbitrage possibilities are exploited, then the existence of a non-zero covered interest differential (CID), defined as

$$(1) \qquad CID_t = i_t^* + f_{t,t+k} - i_t,$$

indicates either that assets are not fully comparable or that there are impediments to trade in them, where $i$ is the nominal interest rate, an asterisk denotes the US, and $f$ is the $k$-period forward discount of the home currency (calculated as the difference between the logarithms of the forward and spot exchange rates). Non-comparability may be due to differences in liquidity or maturity, or to political and default risk which give rise to a country or political risk premium. Impediments to trade may arise because of transactions costs (bid-ask spread and brokerage fees), financial constraints (margin requirements associated with forward transactions, illiquidity in a market, and credit limits), and government regulation (taxation, market access controls, exchange controls, interest rate ceilings) (Rivera-Batiz and Rivera-Batiz 1994). In reality, covered interest differentials are not zero, but in deep and liberalised financial markets, impediments tend to be negligible and differentials close to zero (Ito 1986; Frankel 1993). For example, the average *absolute* covered interest differential from 1982M9 to 1988M4 for 'open' Atlantic developed economies was 0.24 percentage points, in contrast to 1.15 percentage points for 'closed' Atlantic developed economies.[3] A positive covered interest differential occurs when the foreign covered rate, defined as the foreign interest rate plus the forward discount, is greater than the domestic rate, and so indicates domestic controls on capital outflow when access to the foreign market is free (which is the case since the foreign market is the US market). Conversely, a negative covered interest differential occurs when the foreign covered rate is smaller than the domestic rate, and so indicates domestic controls on capital inflow.

There are a number of studies which have examined covered interest parity in East Asian economies. Goldsborough and Teja (1991) tested whether parity held in Australia, Hong Kong,

Japan, Malaysia, New Zealand and Singapore from 1987M1 to 1990M3, and reported a significant degree of financial integration. Chinn and Frankel (1992) assessed parity for Australia, Hong Kong, Japan, Malaysia, New Zealand and Singapore against the US dollar from 1982M9 to 1992M3, and found that the average covered interest differential for these countries moved from about minus one percentage point to about zero over this time, indicating a shift from control on capital inflow to a neutral position. Given the liberalisation that has occurred, as discussed above, these results are not surprising.

While the previous studies are relatively recent, there is scope for expanding them in three ways. Firstly, further advances in technology and information processing and the internationalisation of financial intermediation have made the identification and exploitation of arbitrage possibilities easier, and so markets may be even more integrated in the 1990s than previously. In Tokyo, Sydney, Hong Kong and elsewhere in the region, for example, financial institutions are employing more mathematicians and technicians, they are using ever-more high-powered computer hardware and ever-better storage, communications and processing software, and their dealers are scouring markets in a range of assets all day every day in the pursuit of arbitrage opportunities, creating what O'Brien (1992, p. 99) calls a 'seamless global financial market'.

Secondly, the earlier studies use regression analysis and focus on average changes in parity but do not examine episodes of exchange control. For example, Chinn and Frankel (1992) present recursive regressions with common break-points but do not identify influences which may be important in a particular market at a particular time. This paper extends the regression analysis and examines events in markets. This is shown to be important since some countries have applied controls on capital selectively and episodically rather than systematically.

Thirdly, the previous studies focus on the developed forward markets of East Asia, where the data are of high quality. The existence and depth of these markets is itself an indication of substantial integration and a tendency for covered interest parity is anticipated. Forward markets have existed for some time in countries such as Korea, Indonesia, Taiwan and Thailand, even if they are incomplete. This paper assesses covered interest parity not just for Australia, Hong Kong, Japan, Malaysia and Singapore, but also for Taiwan and Thailand using new data, and so provides an opportunity to compare the integration of some of the most and some of the least developed markets in the region (Glick 1988; Emery 1991).

Covered interest parity holds when

$$(2) \qquad i_{t,k} = i^*_{t,k} + f_{t,t+k}.$$

Covered interest parity is tested by re-arranging and parameterising equation (2) as

$$(3) \qquad f_{t,t+k} = \alpha + \beta\left(i_t - i_t^*\right) + u_t \,,$$

and the null hypothesis of covered interest parity is a=*0*, β=*1*.[4] Interest rate and exchange rate quotes are end of period when available, they are taken as close together in time as possible, and an attempt was made to draw rates from assets which are as comparable as possible (Frenkel and Levich 1975). The interest differential and forward discount are stationary for all countries except Australia, which the standard tests indicate are I(1) and cointegrated, and Taiwan, which the tests indicate are I(1) but not cointegrated.[5] Table 2 summarises the results from estimating equation (3) using OLS in levels for all countries, except for Australia, for which the estimates are corrected for bias using the technique of Phillips and Hansen (1990), and Taiwan, for which estimation is in first differences.[6] The coefficients and standard error of the constant and slope are presented in columns (2) and (3) and their joint significance and marginal significance in column (4).

**Table 2 Test of covered interest parity**

| Country | (1) Period | (2) Constant (α=0) (% points) | (3) Interest differential (β=1) | (4) α=0, β=1 ($\chi^2(2)$) |
|---|---|---|---|---|
| Australia (*o*) | 85M12–94M12 | -0.06 (0.04) | 0.94* (0.03) | 51.42* (0.000) |
| Hong Kong (*o*) | 84M1–94M12 | -0.04* (0.01) | 0.97 (0.05) | 26.7* (0.000) |
| Japan (*o*) | 84M1–94M10 | -0.01* (0.002) | 1.01* (0.005) | 40.1* (0.000) |
| Malaysia (*o*) | 85M1–94M10 | 0.14* (0.03) | 0.87* (0.03) | – |
| (restricted sample) | 87M1–92M6 | 0.20* (0.03) | 0.93 (0.04) | 90.2* (0.000) |
| Taiwan (*r*) | 91M11–94M4 | 0.00 (0.04) | 0.59 (0.20) | 4.32 (0.115) |
| Thailand (*r*) | 85M1–94M9 | -0.30 (0.16) | 0.99 (0.05) | 7.6* (0.022) |
| Singapore (*o*) | 80M1–94M5 | 0.20* (0.03) | 0.96 (0.03) | – |

*Notes:* * indicates statistical significance at the 5 per cent level.
*o* indicates open capital account.
*r* indicates restrictions on the capital account.

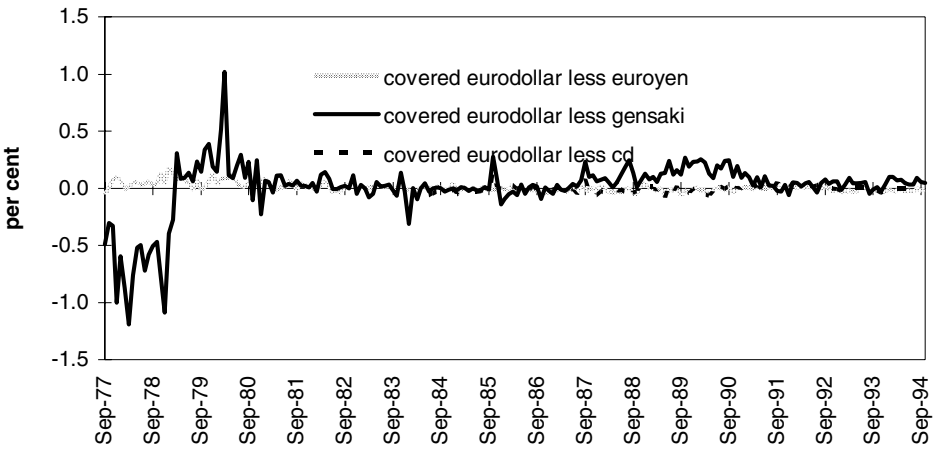
Covered interest parity is rejected for all countries in the sample (except Taiwan for which the standard errors are very large), in most instances due to the significance of the constant. That

is, there is a non-zero covered interest differential. For all countries except Taiwan and Malaysia (full sample), the slope coefficient is numerically very close to one, although it is marginally statistically different from one for Australia and Japan. The rejection covered interest parity is, apart from Taiwan, economically trivial.[7] For all countries except Thailand,[8] the average three-month covered interest differential is significantly less than one percentage point in absolute terms.

The covered interest differential is smallest and the slope coefficient is numerically closest to one for Japan, which is not surprising given that the data are euro rates.[9] The results for Japan are important in two respects. Firstly, the interest rates used are euro rates drawn from assets with identical maturity and risk, and, along with the forward and spot exchange rates, they are drawn at approximately the same time on the same day so time measurement errors are minimised; the only reason for covered interest parity not to hold in this case is that there are transactions costs (measured by the bid-offer spread) and these have a minor numerical effect. Secondly, to the extent that covered interest parity holds in East Asian countries against US dollar assets, it will also (very nearly) hold between them and traded yen assets.

Since the data used for Japan are euro rates, they are by definition not directly affected by domestic regulation, exchange control or political risk. The extent of these effects can be seen by estimating the covered interest differential using domestic onshore and covered foreign offshore returns. Figure 1 plots the covered eurodollar rate and euroyen rate spread with both the covered eurodollar–gensaki spread and, from 1980, the covered eurodollar–certificate of deposit (CD) spread.[10] Measurement errors increase when local rates are used, as shown by an increase in 'spikes', and episodes of domestic market control are apparent. Until the late 1970s, controls were maintained on gensaki transactions and drove domestic yen interest rates above euroyen rates, suggesting controls on capital inflow aimed at stemming yen appreciation (Ito 1986). After 1980, however, the covered interest differential settled mostly to zero, except in 1988 to 1990, when there was a sustained positive differential in the gensaki-based differential but not in the CD-based differential, a fact which suggests that the 1988–90 episode was peculiar to the gensaki market. This appears to reflect thinness in the gensaki market at a time of market expectation of substantial capital gains to be made by holding bonds on the balance sheet.[11] While the CD rate is said to be manipulated by banks at times,[12] the distortion does not appear to be profitable in terms of arbitrage and the CD rate is essentially identical to the euroyen rate (and these rates are indistinguishable in Figure 1).

**Figure 1 US covered interest rate less Japanese interest rate**




*Note:* CD = certificate of deposit.

Australia, Hong Kong and Singapore are similar in that, while covered interest parity is rejected, the rejection is marginal and numerically insubstantial and their covered interest differentials appear to have declined in the 1990s. For Australia, the average differential declined from -0.2 per cent from 87M1 to 90M12, to -0.1 per cent from 91M1 to 94M12.[13] The euro covered differential, data for which are only available from mid-1992, is approximately zero. The average differential is smaller for Hong Kong and fell from -0.035 from 1984 to 1991 to -0.021 from 1992 to 1994. For Singapore, the average differential declined from 0.26 in 80M1 to 90M12, to 0.11 in 91M1 to 94M6. The developments in technology and trading mentioned earlier suggest that markets can now conduct arbitrage more finely, and this improvement occurred largely around the turn of the decade. The result for Singapore is noteworthy in that the various controls used by the MAS to isolate the domestic Singapore dollar money market from the Asian (US) dollar market appear to have no obvious effect on the covered interest differential.

The results for Malaysia, Thailand and, especially, Taiwan are less supportive of parity. While covered interest parity is rejected for Malaysia over the full data period from 1985 to 1994, this is largely due to two episodes of selective control in exchange markets in 1986 and

1994: once these episodes are excluded from the sample, the interest differential and the forward rate move one-for-one with each other. The average covered differential from 1987 to 1993 is 0.16 percentage points, in contrast to 0.93 in 1986 and -1.46 from February to April 1994. In 1986, sustained weakening of commodity prices, exports and domestic output from 1984 placed downward pressure on the ringgit and induced speculation against the currency, especially in April and August. While interbank rates rose substantially during these episodes, the large positive covered differentials at these times indicate (undeclared) controls on capital outflow to support the ringgit. In contrast, from late 1993, the ringgit faced strong upward pressure as short-term capital flowed into the high-yielding money and share markets. In response, Bank Negara Malaysia prohibited banks from conducting swaps and forward transactions which were not related to trade, investment or inventory; raised and extended reserve requirements on all deposits from abroad (including the vostro accounts of foreign banks with Malaysian banks); set a ceiling on domestic banks' net external liabilities; and prohibited residents from selling short-term financial instruments to foreigners in January and February 1994.[14] These restrictions were mostly eased by mid-1994 and the covered differential narrowed significantly.

Despite the thinness in the market and exchange controls applied over at least the 1980s, the statistical tests for Thailand are supportive of covered interest parity, although this seems to be due to large standard errors (the standard error of the equation is 1 percentage point, which is at least 10 times that for other countries except Taiwan).[15] The differential averaged -0.34 percentage points over the past decade, which is only slightly greater in absolute terms than the average 0.24 for developed free markets in the 1980s. The average in the second half of the 1980s is -0.49, compared to -0.17 in the 1990s, which suggests increased integration and is consistent with the removal of some major capital controls in the early 1990s. These figures belie large variation in the covered interest differential at times, for example, -0.85 per cent from 1986 to mid-1989 and -1.7 per cent in the first half of 1993, both of which suggest controls on capital inflow and both of which were periods of baht appreciation. The fact that one of these episodes occurs after the May 1990 and April 1991 reforms suggests that liberalisation of the capital account is not complete.

Parity is formally accepted for Taiwan using 90-day data in first differences, but it is only just so and it is only because the standard errors are relatively very large. (Parity is strongly rejected in levels.) The standard errors are much wider than in the Australian, Malaysian and Singaporean cases, and the slope coefficient is substantially lower numerically.[16] The covered interest differential was largely negative from November 1991 until March 1993 (average of

-0.2 percentage points for 90-day assets), and positive thereafter (average of 0.15 percentage points). The particularly large negative differential from June to August 1992 is coincident with the record appreciation of the New Taiwan dollar around July 1992, when the $NT–$US rate broke the $NT25 barrier, falling to $NT24.65 from a peak of $NT40.4 at September 1985. A negative differential implies controls on capital inflow, which is consistent with the authorities standing against the appreciation of the New Taiwan dollar, and, indeed, the authorities closed the market during this time. This caused considerable uncertainty in the forward market, with the buy–sell spread widening substantially in August and September.

## Uncovered interest rate parity

### *Basic tests of uncovered interest parity*

The standard macroeconomic approach to analysing the impact of foreign interest rates on domestic interest rates is the uncovered interest parity condition,

$$(4) \qquad i_{t,k} = i^*_{t,k} + \Delta s^e_{t,t+k},$$

the usual test of which is the parameterisation of equation (4) as

$$(5) \qquad \Delta s^e_{t,t+k} = \alpha + \beta(i_{t,k} - i^*_{t,k}) + \varepsilon_t .$$

The null hypothesis of uncovered interest parity is $\beta$=1. In this specification, a possible exchange risk premium is subsumed into the constant and, to the extent that it is time-varying, into the error term. The expected depreciation is not directly observable but may be proxied by the forward rate, survey expectations or the actual depreciation over the period $t$ to $t+k$ on the assumption that expectations are rational in the Muthian sense that they are formed using all available information (and so, accordingly, the market may err in its exchange rate predictions but not on a systematic basis). All methods have major drawbacks but the rational expectations approach is used here for comparability with the literature.[17] The actual depreciation may be decomposed into an expected depreciation, which is formed on the basis of all available information ($\Omega_t$), and a forecast error term ($\varpi_t$) which has an expected mean of zero,

$$(6) \qquad \Delta s_{t,t+k} \equiv \Delta s^e_{t,t+k} + \varpi_t ,$$

where $\Delta s^{e}_{t,t+k} = E_t\left[\Delta s_{t,t+k} \middle| \Omega_t\right]$ and $E\left[\varpi_t \middle| \Omega_t\right] = 0$, and is substituted into equation (5),

$$(7) \qquad \Delta s_{t,t+k} = \alpha + \beta(i_{t,k} - i^{*}_{t,k}) + \omega_t ,$$

where ωis a composite error term, $\omega_t = \varpi_t + \varepsilon_t$. Given equations (4) and (6), the uncovered interest differential (UID) is defined as

$$(8) \qquad UID_{t,k} = i^{*}_{t,k} + \Delta s_{t,t+k} - i_{t,k} .$$

The change in the log of the exchange rate and the estimated uncovered interest differential in all countries appear stationary (at the 1 per cent level) over the periods listed in Table 3, but the evidence for stationarity of the interest differential is more ambiguous. The standard tests suggest that the interest differentials of Australia, Hong Kong, Indonesia, Singapore and Thailand are stationary at the 5 per cent critical level and those of Japan and Taiwan at the 10 per cent level, while those of Korea, Malaysia and the Philippines are not stationary.[18] This indicates that there is more persistence in interest differentials than in the depreciation, which suggests that the interest differential and depreciation may be different processes. This is more apparent for countries which have exercised substantial (even if occasional) control over the capital account. It also suggests that the domestic rate and US interest rate are not likely to be cointegrated for Korea, Malaysia and the Philippines at conventional levels.

The estimations of equations (7) and (8) are reported in Table 3.[19] Given that equation (7) has performed very poorly in the literature, with an average coefficient of about -0.8 even in well-developed and sophisticated markets (Froot and Thaler 1990), it is not expected to perform well with this data set. Indeed, looking at column (2), this expectation is met.[20] The null that β=1 is rejected in all cases except Taiwan and the rejection is marginal for Korea (using OLS). The slope coefficient is also positive for Indonesia, the Philippines and Thailand but is negative otherwise, and significantly so for Hong Kong, Malaysia, Japan and Singapore. Herein lies the anomaly: if parity is conditional on arbitrage, it should hold in open markets but not in closed ones, but the countries with what are regarded as the more liberalised, developed and open financial markets in the region tend to be the ones which most strongly reject uncovered interest parity, while the countries with what are regarded as the more repressed and insular financial markets are the ones where parity holds or is closer to holding.

This is addressed below, but it is worth noting at this stage that the contrast is between economies with open and closed capital accounts, not between economies with flexible or fixed/managed exchange rates. Accordingly, the argument that the outcome simply reflects the 'fact' that exchange rate movements are more predictable in fixed or managed rate systems is not compelling. If this were the case, there should be no distinction between Hong Kong and Singapore on the one hand, and Korea and Taiwan on the other.

**Table 3 Mean uncovered differential and uncovered interest parity**

| Country | Period | (1) $\Delta s_{t,t+k} = \alpha + \beta id_{t,k}$ α=0 | (2) $\Delta s_{t,t+k} = \alpha + \beta id_{t,k}$ β=1 | (3) Mean uncovered differential |
|---|---|---|---|---|
| Australia (*o*) | 80M1–94M9 | -0.13 (0.55) | -0.53* (0.41) | -0.44 (0.57) |
| Hong Kong (*o*) | 84M1–94M9 | -0.04 (0.03) | -0.29* (0.07) | 0.06 (0.05) |
| Indonesia (*o*) | 87M1–94M8 | 0.90* (0.12) | 0.02* (0.07) | -0.69* (0.13) |
| Japan (*o*) | 80M1–94M7 | -2.80* (0.65) | -2.41* (0.75) | -0.71 (0.64) |
| Korea (*r*) | 80M1–94M9 | -0.10 (0.23) | 0.58* (0.15) | -0.59* (0.22) |
| Malaysia (*o*) | 81M1–94M7 | -0.51* (0.19) | -1.04* (0.20) | 0.49 (0.29) |
| Philippines (*r*) | 87M1–94M2 | 0.34 (1.15) | 0.23* (0.37) | -1.83* (0.55) |
| Singapore (*o*) | 80M1–94M9 | -2.03* (0.40) | -2.29* (0.47) | 0.02 (0.25) |
| Taiwan (*r*) | 80M11–94M3 | 0.14 (0.20) | 1.25 (0.22) | -0.58* (0.24) |
| Thailand (*r*) | 86M1–94M6 | -0.34 (0.20) | 0.14* (0.20) | -0.71* (0.16) |

*Notes:* * indicates statistical significance at the 5 per cent level.
*o* indicates open capital account.
*r* indicates restrictions on the capital account.

Now consider the uncovered interest differential in column (3). In his study of G7 countries, Marston (1993) found average uncovered interest differentials (relative to the USA) from 1966 to 1989 to be negative but not significant, although the standard errors were large, and he interpreted this as evidence in support of uncovered interest parity in the long run. Montiel (1993) found that mean differentials are generally different from zero in developing countries. In the Western Pacific economies, the average uncovered differential is not significantly different from zero over periods of several years for Australia, Hong Kong, Japan, Malaysia and Singapore, but *is* both significant and negative for Indonesia, Korea, the Philippines, Taiwan and Thailand. Note that the countries with significant negative uncovered differentials

are also the ones with positive slope coefficients in the basic uncovered interest parity test equation.

A negative and significant uncovered interest differential arises because of *persistent* expectation errors, currency or country risk premia or impediments to capital inflow into the countries. Given the length of the sample period, expectation errors are likely to be netted out, and, moreover, if expectation errors are not systematically important for G7 countries (Marston 1993), they are unlikely to be for non-G7 Asian countries.[21] The explanation for the significant differential, therefore, seems to lie with risk premia or impediments to capital inflows in these countries.[22] The NT dollar and won are relatively controlled rates not subject to sharp discrete changes, and Taiwan and Korea still employ capital controls, which suggests that the uncovered differential exists because of restrictions on capital flows. The numerical rejection of covered interest parity for Taiwan in the 1990s supports this view. Capital flows have also been controlled in both the Philippines and Thailand and the currencies in these countries have been subject to sharp discrete changes (the peso in 1983, 1984 and 1990; the baht in 1981 and 1984). This suggests that the uncovered interest differential in these countries may reflect a combination of controls and exchange risk premia. The uncovered differential on peso investments is about two and half times the size of that on rupiah and baht investments, which suggests an additional exchange risk, probably due to the greater political and macroeconomic instability of the Philippines. The rupiah, on the other hand, is a market-determined rate subject to large depreciations (1983 and 1986) and capital controls do not exist, which suggests that the uncovered differential is explained by an exchange risk premium. Das Gupta and Das Gupta (1994) present evidence that the margin between Indonesian and US interest rates is explained not by current account or fiscal imbalances but by domestic financial sector risks. The tentative conclusion, then, is that the negative uncovered differential for Korea and Taiwan is due to controls, that for the Philippines and Thailand is due to a combination of controls and currency risk premia, while that for Indonesia is due to a currency risk premium.

### *Explaining the anomaly*

This still leaves unresolved the issue of why changes in the interest differential have the expected positive effect on a currency depreciation only in repressed or riskier economies, but a perverse negative effect in countries with developed and open financial systems. An explanation may lie in the argument expounded by McCallum (1994) about the reaction function of central banks.

He states that the monetary authority attempts to trade off movements in the exchange rate and the interest differential such that it sets the local interest rate lower than otherwise when the currency is appreciating and higher than otherwise when the currency is depreciating. He also states that the monetary authority tries to prevent the interest differential from departing too far from its recent value. These factors imply that the interest differential evolves as,

$$id_t = \lambda \Delta s_t + \sigma id_{t-1} + \zeta_t , \tag{9}$$

where *id* is the interest differential (domestic less foreign rate), $\lambda$ is positive since the depreciation is denoted by a positive $\Delta s$, $\sigma$ is the stickiness in the interest differential, and $\zeta$ is a random (policy) influence.

McCallum does not explain this reaction function further. At first glance, it would appear to be an unusual way to model a central bank's reaction function since central banks explicitly target domestic inflation and real income, not the interest differential. The specification can be rationalised, however, by the following line of argument. Assuming that inflation and real income are functions of the interest rate (among other things), when the central bank uses the local money market rate as its instrument, it can be said to be *implicitly* targeting this interest rate. Since the authorities try to smooth inflation and real output over the economic cycle, such targeting also implies interest rate smoothing. Moreover, central banks intervene in money markets to eliminate the effects of temporary, but possibly large, imbalances in the supply and demand for overnight cash, and this has an additional smoothing effect. When the foreign central bank has a similar target or operational rule, the foreign interest rate — and hence the interest differential — is also smoothed. The smoothing of the interest differential, therefore, follows from the combined operations of the two central banks. Central banks in the region also tend to be concerned with movements in the exchange rate, given the implications of changes in it for inflation or for the real exchange rate. This is particularly the case when the exchange rate is fixed or managed, as is the case for seven of the ten economies in this survey. Given that the differential is defined in regard to the US interest rate, this characterisation only makes sense as long as the US central bank is not concerned with adjusting US interest rates to influence the exchange rate. This would seem to be the case.

McCallum then considers uncovered interest parity, writing it with an error term, $\xi$, to represent 'the myriad of minor influences' (p. 123) that prevent parity,

(10) $\Delta s^{e}_{t,t+k} = id_t - \xi_t$.

If there are systematic influences that drive a wedge between the expected depreciation and the interest differential, then the error term may be an ARMA process. Substituting equation (9) for the interest differential and assuming that the wedge term is AR(1),

(11) $\xi_t = \rho\xi_{t-1} + \upsilon_t$,

equation (10) becomes

(12) $\Delta s^{e}_{t,t+k} = \lambda\Delta s_t + \sigma id_{t-1} + \zeta_t - \upsilon_t - \rho\xi_{t-1}$.

McCallum then shows (as reproduced in Appendix 2) that the rational expectations solution of the exchange rate depreciation is

(13) $\Delta s_t = \left[(\rho-\sigma)/\lambda\right]id_{t-1} - (1/\lambda)\zeta_t + \left[1/(\lambda+\sigma-\rho)\right]\upsilon_t$.

He argues that a negative coefficient on the interest differential is not inevitable but is likely since interest differentials are generally highly autocorrelated, that is, $\sigma$ is close to one and systematic wedges in the parity condition are probably small, that is, $\rho$ is close to zero, for his sample of the G3 (p. 125).

How is this relevant to the anomalous results outlined above? In the first place, interest differentials do tend to be highly autocorrelated for the economies in this survey. The first-order autocorrelation coefficients for Australia, Japan and Taiwan, for example, are 0.92, 0.95 and 0.91 respectively for the sample lengths outlined in Table 2. But the key is $\rho$, the persistence in the wedge that prevents uncovered interest parity. When the uncovered interest differential is highly autocorrelated, $\rho$ is close to one and offsets $\sigma$. A partial offset implies that $\beta$ is negative, a full offset implies that $\beta$ is zero, and a more than complete offset implies that $\beta$ is positive. $\rho$ is positive when there are transactions costs, an exchange risk premium or capital controls. If the risk premium is time-varying rather than constant, then $\rho$ is expected to be smaller, and if exchange controls are systematic rather than episodic, then $\rho$ is expected to be closer to one.

This appears to fit well with the countries examined. $\beta$ is positive and significant for Korea and Taiwan, both of which have historically enforced systematic capital controls. $\beta$ is positive

but not significant for the Philippines and Thailand, which have enforced capital controls but are also subject to bouts of currency weakness. $\beta$ is positive but insignificant for Indonesia, which has relatively open foreign exchange markets but recent experiences of major currency instability. $\beta$ is negative, mostly significantly so, for Australia, Hong Kong, Japan, Malaysia and Singapore, which are countries with open capital accounts, relative exchange rate stability and hence low $\rho$. Exchange controls in Malaysia have been applied periodically but not systematically. In short, the results across different countries and exchange rate regimes dovetail with McCallum's exposition of the interaction between the standard uncovered interest parity condition and the central bank's policy function. This does not 'prove' McCallum's model but it is evidence in support of it, and it suggests that uncovered interest parity may contain information about the degree of financial integration. One extension of the analysis would be to use different ARMA specifications of the error term in equation (10).

If the model is correct, then two implications should follow. The first is that the behaviour of $\beta$ over time should reflect changing openness in the capital account. Appendix 3 sets out plots of rolling regressions of $\beta$ estimated by OLS with samples of 60 observations. $\beta$ is mostly (if not always) negative for Australia, Hong Kong, Japan, Malaysia and Singapore and mostly positive for Korea and Taiwan. The movement in $\beta$ appears to be consistent with priors about developments in the capital account in various countries. For example, $\beta$ is positive for Malaysia only in 1986 and in early 1994, which coincides with the two episodes of exchange control. $\beta$ gradually became negative in Korea in the second half of the 1980s, but sharply reversed and became positive in 1989, coincident with the reversal of capital account and financial reform. $\beta$ has been consistently positive in Taiwan, indicating little easing in the true bind of controls. On the other hand, caution is advised in interpreting these results since there is some instability in this coefficient in all countries.

The other implication of the model is that, if it is correct, it should be possible to decompose $\beta$ into underlying structural parameters — estimating $\rho$ and $\lambda$ from equation (9) and, given $\beta$ from equation (7), $\sigma$ This is not successful. For Korea and Taiwan, for example, the exchange rate targeting coefficient, $\lambda$, obtained by estimating equation (9), is not significantly different from zero. If this were the case, $\beta$ would be indeterminate. In the case of Australia, the estimates of $\lambda$ and $\sigma$ from equation (9) are 0.007 and 0.92, which, for an estimate of $\beta$ of -0.53, implies that the stickiness in the wedge in the parity condition, $\rho$, is 0.99. This is implausibly high.

### *Cointegration of interest rates*

Analysis of uncovered interest parity is typically conducted in terms of the relationship between the expected depreciation and the interest differential, but it can be restated with the focus on the relationship between domestic and foreign interest rates, given expectations about movements in the exchange rate. In particular, if interest rates and the exchange rate are I(1) processes, then it is interesting to ask whether domestic and foreign interest rates are cointegrated and, if so, does the cointegrating relation show a greater tendency for interest rates to equalise over time? In this framework, the expected depreciation is I(0) and does not enter the cointegrating relation but may be part of the dynamics of the relationship.[23] Chinn and Frankel (1992) and Glick and Moreno (1994) state that there is little evidence of cointegration between domestic and foreign rates, but it is worth exploring this issue in more depth.

The long-run relationship between rates is

$$(14) \qquad i_{t,k} = \tilde{\alpha} + \tilde{\beta} i^*_{t,k} + \nu_t,$$

where the constant term is a wedge parameter between interest rates, possibly due to a risk premium or other asset differences. If interest rates are integrated processes of order 1, they are also cointegrated if the residual, $\nu_t$, is I(0). The method used in this paper to test for cointegration and estimate the cointegrating vector is the vector autoregression (VAR) maximum likelihood technique outlined by Johansen and Juselius (1990). Letting $X = [i^*, i]'$, the VAR is

$$(15) \qquad X_t = \mu + \sum_{i=1}^{n} \Pi_i X_{t-i} + \varepsilon_t,$$

which may be rewritten without loss of generality as a vector error correction model,

$$(16) \qquad \Delta X_t = \mu + \pi X_{t-1} + \sum_{i=1}^{n-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t \text{ where } \pi = -[I - \Pi_1 - \ldots - \Pi_n].$$

Given that $\pi$ is a 2x2 matrix, $i^*$ and $i$ are cointegrated if $\pi$ is of rank 1. If the matrix is of rank 2, then the interest rates are stationary, while if the matrix is of rank 0, then the interest rates are integrated but not cointegrated. If the matrix is of rank 1, it can be decomposed as the product of two matrices, $\alpha\beta'$, with $\beta'$ the cointegrating vector. The rank of $\pi$ is assessed on the basis of two tests on the characteristic roots of $\pi$, the lambda max test statistic, which tests the null

hypothesis of $r$ cointegrating vectors against the alternative hypothesis that there are $r+1$ cointegrating vectors, and the trace test statistic, which tests the null hypothesis that the number of cointegrating vectors is less than or equal to $r$ against a general alternative (where the maximum value of $r$ is the dimension of $\pi$ ).

The results for the ten countries in this study are presented in Table 4. Columns 1 and 2 present the lambda max and trace test statistics for one cointegrating vector and, based on these statistics, column 3 summarises whether the domestic and foreign rate are cointegrated, with *c* indicating cointegration and *nc* indicating no cointegration. A constant term is included in the cointegrating relation and the estimate, equivalent to $\tilde{\alpha}$ in equation (14), is presented in column 4 (in percentages rather than decimals). The coefficient equivalent to $\tilde{\beta}$ in equation (14) is presented in column 5 and the chi-square (1) test statistic equivalent to the test that $\tilde{\beta}$ is 1 and the chi-square (2) test statistic equivalent to the joint test that $\tilde{\alpha}=0$, $\tilde{\beta}=1$ are presented in columns 6 and 7 respectively. The three-month ahead change in the log of the exchange rate is included in the regression as an I(0) variable. Generally, a lag length of 4 was selected for the VAR.[24]

The claim that there is little evidence of cointegration between domestic and foreign interest rates would seem to be too strong. Over the full sample, domestic rates in Hong Kong, Indonesia, Japan, Singapore, Taiwan and Thailand are cointegrated with the US rate, although this is so in all sub-periods only for Hong Kong and Taiwan. The result for Hong Kong is expected, given that the HK dollar is pegged to the US dollar and capital flows are uncontrolled. For all countries except Indonesia and Korea, the local rate is cointegrated with the US rate in the 1990s. For all countries except Malaysia, the US interest rate has a positive impact on the local interest rate, which indicates that capital controls do not succeed in isolating domestic rates from foreign rates entirely. This impact has been increasing numerically over time in Hong Kong, Indonesia, Singapore and Thailand, but decreasing in Taiwan. In all cases of cointegration, the constant term in the cointegrating relation is significant, indicating that assets are not identical, and in all cases, apart from Japan and Taiwan in the 1980s, it is positive, indicating that local assets generally require a premium over US assets. Some premium is expected since the US asset is US treasury bills and other country assets are interbank or non-official securities, but it is notably large for Indonesia and the Philippines, which are countries with episodes of currency and financial instability. It is not possible to identify a sensible long-run relationship between interest rates in Korea and Malaysia over the past 15 years, and in Malaysia's case, the impact of the US rate is negative from the mid-1980s.

**Table 4 Cointegration of domestic and foreign interest rates**

| Country | Period | (1) lambda $H_0$:r=0, $H_1$: r=1 | (2) trace $H_0$:r=0, $H_1$: r>=1 | (3) cointeg. | (4) $\tilde{\alpha}$ | (5) $\tilde{\beta}$ | (6) $\tilde{\beta}$=1 $\chi^2(1)$ | (7) $\tilde{\alpha}$=0, $\tilde{\beta}$=1, $\chi^2(2)$ |
|---|---|---|---|---|---|---|---|---|
| Australia (*o*) | 80M1–94M12 | 11.80 | 14.85 | nc | -0.94 | 2.23 | 3.48# | 8.66* |
| | 80M1–84M12 | 12.81 | 16.37 | nc | 0.00 | 1.13 | 0.08 | 3.34 |
| | 85M1–89M12 | 10.30 | 17.30 | nc | -3.38 | 4.11 | 1.98 | 10.07* |
| | 90M1–94M12 | 27.85* | 32.04* | c | -0.15 | 1.63 | 3.72# | 6.36* |
| Hong Kong (*o*) | 84M1–94M12 | 23.44* | 29.28* | c | 0.21 | 0.80 | 3.38# | 6.71* |
| | 85M1–89M12 | 16.95* | 19.39# | c | 1.34 | -0.91 | 1.83 | 8.50* |
| | 90M1–94M12 | 29.86* | 31.86* | c | 0.00 | 1.06 | 4.18* | 13.54* |
| Indonesia (*o*) | 83M1– 94M8 | 18.71* | 20.03* | c | 2.05 | 0.68 | 1.17 | 15.27* |
| | 85M1–89M12 | 18.35* | 24.72* | c | 3.30 | -0.02 | 2.59 | 13.91* |
| | 90M1– 94M8 | 13.52 | 16.22 | nc | 1.62 | 0.81 | 0.23 | 7.15* |
| Japan (*o*) | 80M1–94M10 | 15.70* | 19.00# | c | 0.06 | 0.61 | 3.56# | 9.97* |
| | 80M1–84M12 | 11.78 | 13.99 | nc | -0.01 | 0.62 | 1.29 | 8.49* |
| | 85M1–89M12 | 7.02 | 12.48 | nc | 0.31 | 0.48 | 0.49 | 5.62# |
| | 90M1–94M10 | 19.41* | 34.00* | c | -0.20 | 0.98 | 0.01 | 13.51* |
| Korea (*r*) | 80M1–94M12 | 7.43 | 11.90 | nc | 2.30 | 0.39 | 1.04 | 4.78# |
| | 80M1–84M12 | 14.02# | 15.14 | nc | -0.79 | 1.37 | 1.59 | 2.76 |
| | 85M1–89M12 | 5.47 | 6.30 | nc | -3.83 | 3.41 | 1.56 | 5.13# |
| | 90M1–94M12 | 8.87 | 11.89 | nc | 3.45 | -0.10 | 4.23* | 8.72* |
| Malaysia (*o*) | 81M11–94M10 | 9.44 | 13.86 | nc | 2.50 | -0.53 | 4.39* | 4.39 |
| | 81M11–84M12 | 4.47 | 8.55 | nc | 1.69 | 0.19 | 0.58 | 0.71 |
| | 85M1–89M12 | 8.02 | 12.42 | nc | 3.19 | -0.86 | 2.14 | 6.41* |
| | 90M1–94M10 | 19.54* | 26.64* | c | 2.50 | -0.59 | 12.15* | 12.34* |
| Philippines (*r*) | 80M1– 94M5 | 8.18 | 11.68 | nc | 4.02 | -0.08 | 0.99 | 4.72# |
| | 80M1–84M12 | 10.28 | 12.63 | nc | 6.16 | -1.01 | 7.50* | 7.95* |
| | 85M1–89M12 | 15.24# | 17.81 | nc | -3.15 | 4.40 | 5.14* | 12.02* |
| | 90M1– 94M5 | 17.08* | 23.78* | c | 1.67 | 2.17 | 8.06* | 11.96* |
| Singapore (*o*) | 80M1–94M12 | 14.95# | 18.23# | c | -0.13 | 0.73 | 5.41* | 11.56* |
| | 80M1–84M12 | 8.61 | 14.07 | nc | 0.19 | 0.65 | 1.33 | 6.94* |
| | 85M1–89M12 | 7.66 | 10.08 | nc | 0.03 | 0.56 | 3.09# | 7.29* |
| | 90M1–94M12 | 25.14* | 29.16* | c | -0.09 | 0.79 | 11.05* | 22.92* |
| Taiwan (*r*) | 80M11– 94M6 | 22.22* | 26.83* | c | 1.08 | 0.41 | 9.39* | 9.45* |
| | 80M11–84M12 | 15.56# | 19.95# | c | -0.16 | 0.84 | 0.13 | 9.48* |
| | 85M1–89M12 | 17.69* | 19.24# | c | -0.45 | 1.06 | 0.05 | 8.60* |
| | 90M1– 94M7 | 18.08* | 23.90* | c | 1.16 | 0.65 | 4.46# | 13.44* |
| Thailand (*r*) | 80M1–94M12 | 20.82* | 27.98* | c | 0.87 | 0.86 | 0.80 | 11.24* |
| | 80M1–84M12 | 8.93 | 14.24 | nc | 1.56 | 0.62 | 1.97 | 5.05# |
| | 85M1–89M12 | 9.15 | 12.74 | nc | -2.60 | 2.46 | 2.27 | 4.35 |
| | 90M1–94M12 | 15.62# | 22.33* | c | 0.54 | 1.30 | 1.50 | 8.96* |

*Notes:* # indicates significant at the 10 per cent level.
* indicates significant at the 5 per cent level.
*o* indicates open capital account.
*r* indicates restrictions on the capital account.
c indicates cointegration.
nc indicates no cointegration.

One explanation of the insignificance of US interest rates on Malaysian rates may be that Malaysia is part of a 'yen bloc', but this explanation is not very persuasive. Arbitrage is by definition concerned with the relationship between a pair of interest rates, and arbitrage over a set of interest rates is simply the condition that arbitrage holds over all pairs in the set. If the theoretical motivation for testing for a long-run relationship between rates is that arbitrage drives the rates of comparable assets together, then there seems little additional information to be gleaned by testing for cointegration between more than two rates. Even if Malaysia were part of a yen bloc, it would still be tied to US interest rates by arbitrage. It also begs the question that if the ringgit is tied to the yen, why do US interest rate shocks have a positive effect on yen interest rates but not on ringgit interest rates? In terms of the long-run relationship between interest rates, the findings of Chinn and Frankel (1992) and Glick and Moreno (1994) that the influence of US and Japanese rates on East Asian rates changes over time are difficult to interpret. What those findings may point to, however, is that the *dynamics* of uncovered interest parity — the fact that the influence of the foreign rate on the domestic rate in the short term depends on expectations about changes in the exchange rate — are important and can reveal information about which exchange rate the monetary authority targets. But the point still holds that movements in the exchange rate would not be expected to reveal information about long-run or equilibrium parity relationships since the expected depreciation is stationary. This suggests that estimation of a cointegrating vector over short periods may not be informative, and, indeed, cointegration is most evident (and perhaps the vectors most plausible) in tests over the full sample. In this context, the evidence of cointegration is weaker for countries with managed exchange rates *and* capital controls, like Korea, Malaysia, the Philippines and Thailand, and for countries which are thought to have large and time-varying risk premia, like Indonesia and the Philippines.

### *Accounting for innovations over time*

Another way to assess the time-varying influence of the foreign interest rate on the domestic interest rate is to decompose the forecast error variance of a vector autoregression of the three-month domestic and foreign interest rates and the three-month ahead exchange rate depreciation (that is, decompose the forecast error variance of equation (15) where $X = [i_{*t,\,k}, i_{t,\,k}, \Delta s_{t,\,t+k}]'$). Like Glick and Moreno (1994), the analysis is restricted to the domestic rate equation but, unlike Glick and Moreno (1994), the depreciation is included since it is a potentially important

conditioning variable. In terms of the domestic rate equation, the variance decomposition isolates the proportion of the variance in the domestic rate due to the innovation in the domestic rate itself and to the foreign rate and depreciation over specified time lengths, and so provides fresh insight into the source and persistence of shocks to the domestic interest rate (see Enders 1995, pp. 294–312).

In order to identify the shocks, a recursive structure is imposed on the original system underlying the reduced system outlined in equation (15),

$$(17) \qquad \begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ a_{31} & a_{32} & 1 \end{bmatrix} \cdot \begin{bmatrix} i^*_{t,k} \\ i_{t,t} \\ \Delta s_{t,t+k} \end{bmatrix} = \mu' + \sum_{i=1}^{n} \Pi'_i \begin{bmatrix} i^*_{t-i,k} \\ i_{t-i,k} \\ \Delta s_{t-i,t-i+k} \end{bmatrix} + \varepsilon'_t .$$

The foreign interest rate is not determined contemporaneously by either the domestic rate or the expected depreciation, the domestic rate is determined contemporaneously by the foreign rate but not by the expected depreciation, and the expected depreciation is determined contemporaneously by both the foreign and domestic interest rates. This ordering is one way to exactly identify the system. It is well known, however, that the assignment of the variance may vary with the ordering of the variables and so some explanation of why this ordering is appropriate is required. If the home country is relatively small, it is not unreasonable to assume that the US rate is unaffected by local conditions (Glick and Moreno 1994). But some feedback may be expected between the local rate and the expected depreciation. However, in McCallum's (1994) model the evolution of the interest differential turns on the recent depreciation, rather than expected future depreciation (equation (9)), while the expected depreciation turns on the current interest differential (equation (10)), which suggests the ordering outlined above. The alternative sub-ordering for the domestic and expected depreciation was tested and, while the magnitudes change, the qualitative results do not. The variance decompositions were estimated for a fourth-order VAR using RATS. The focus is on how the variance decomposition has evolved over time and three five-year sub-periods from 1980 to 1994 are examined. Table 5 reports the percentage of total variance of the domestic interest rate explained by the foreign rate, domestic rate and three-month ahead change in the natural log of the exchange rate 6, 12 and 24 months out.

The proportion of innovations to the domestic interest rate due to the foreign interest rate has increased over time in Australia, Hong Kong, Indonesia, Japan, the Philippines, Singapore

**Table 5 Variance decomposition of the domestic interest rate**

| Country | Period | % of variance due to foreign rate | | | % of variance due to domestic rate | | | % of variance due to Δ log spot exchange rate | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | number of months | | | number of months | | | number of months | | |
| | | 6 | 12 | 24 | 6 | 12 | 24 | 6 | 12 | 24 |
| Australia (*o*) | 80M4–84M12 | 9 | 19 | 21 | 59 | 53 | 51 | 32 | 28 | 28 |
| | 85M1–89M12 | 17 | 2 | 32 | 81 | 74 | 67 | 2 | 2 | 1 |
| | 90M1–94M9 | 47 | 57 | 60 | 39 | 27 | 21 | 14 | 15 | 19 |
| Hong Kong (*o*) | – | – | – | – | – | – | – | – | – | – |
| | 85M1–89M12 | 34 | 56 | 59 | 62 | 40 | 37 | 4 | 4 | 4 |
| | 90M1–94M9 | 79 | 86 | 89 | 19 | 11 | 8 | 2 | 3 | 3 |
| Indonesia (*o*) | – | – | – | – | – | – | – | – | – | – |
| | 85M1–89M12 | 5 | 11 | 16 | 94 | 86 | 80 | 1 | 3 | 4 |
| | 90M1–94M5 | 9 | 22 | 25 | 61 | 49 | 45 | 31 | 29 | 30 |
| Japan (*o*) | 80M1–84M12 | 30 | 35 | 37 | 65 | 61 | 59 | 5 | 4 | 4 |
| | 85M1–89M12 | 6 | 22 | 33 | 91 | 74 | 62 | 3 | 4 | 5 |
| | 90M1–94M7 | 23 | 57 | 81 | 70 | 40 | 17 | 7 | 3 | 2 |
| Korea (*r*) | 80M4–84M12 | 5 | 16 | 20 | 93 | 81 | 76 | 2 | 3 | 4 |
| | 85M1–89M12 | 12 | 30 | 30 | 85 | 60 | 43 | 3 | 10 | 27 |
| | 90M1–94M9 | 7 | 8 | 10 | 92 | 91 | 89 | 1 | 1 | 1 |
| Malaysia (*o*) | 81M5–84M12 | 31 | 37 | 3 | 57 | 47 | 49 | 12 | 16 | 16 |
| | 85M1–89M12 | 5 | 10 | 13 | 71 | 52 | 50 | 24 | 38 | 37 |
| | 90M1–94M7 | 8 | 14 | 24 | 91 | 83 | 72 | 1 | 3 | 4 |
| Philippines (*r*) | 80M5–84M12 | 5 | 4 | 12 | 81 | 68 | 64 | 14 | 28 | 24 |
| | 85M1–89M12 | 7 | 31 | 50 | 88 | 62 | 44 | 5 | 7 | 6 |
| | 90M1–94M2 | 17 | 42 | 52 | 76 | 53 | 44 | 7 | 5 | 4 |
| Singapore (*o*) | 80M5–84M12 | 52 | 45 | 43 | 42 | 49 | 51 | 6 | 6 | 6 |
| | 85M1–89M12 | 43 | 54 | 54 | 50 | 38 | 36 | 7 | 8 | 10 |
| | 90M1–94M9 | 50 | 63 | 69 | 48 | 35 | 28 | 2 | 2 | 3 |
| Taiwan (*r*) | 81M3–84M12 | 29 | 28 | 27 | 68 | 67 | 67 | 3 | 5 | 6 |
| | 85M1–89M12 | 17 | 42 | 48 | 72 | 50 | 43 | 11 | 8 | 9 |
| | 90M1–94M3 | 11 | 9 | 9 | 83 | 67 | 65 | 6 | 24 | 26 |
| Thailand (*r*) | 80M5–84M12 | 75 | 54 | 11 | 20 | 13 | 30 | 5 | 33 | 59 |
| | 85M1–89M12 | 10 | 29 | 40 | 89 | 65 | 54 | 1 | 6 | 6 |
| | 90M1–94M6 | 14 | 26 | 38 | 76 | 62 | 52 | 10 | 12 | 10 |

*Notes:* *o* indicates open capital account.
*r* indicates restrictions on the capital account.

and Thailand, such that the foreign rate now accounts for a greater proportion of innovations than the domestic rate does itself in Australia, Hong Kong, Japan, the Philippines and Singapore. Home currency depreciation has also been a source of innovations to the domestic interest rate in all countries, less so in Hong Kong, Japan, Korea and Singapore, but notably so in Australia, Indonesia and Malaysia. Overall, domestic factors appear to dominate in Korea, Malaysia, Taiwan and Thailand.

There is an important issue of interpretation in these results. Increased importance of foreign shocks in successive periods can be due to (at least) two factors. In the first place, it may be that there are more or bigger shocks to foreign rates than to local rates. Or, alternatively, it could be that the shocks are the same, but domestic markets are more open and so foreign shocks have a bigger relative impact than before. Only the latter should properly be regarded as 'increased integration'. Table 6 sets out the standard deviations and coefficients of variation of the US Treasury Bill rate and domestic rates during the sub-periods referred to in Table 5. Variability has increased in the United States but it has also done so, often by a substantial amount, in most countries, but particularly in Australia, Hong Kong, Indonesia, Japan and Singapore. This suggests that, for these countries at least, the increased importance of foreign shocks is not due to more variability in US rates but to more openness in their domestic financial systems.

## Real interest rate parity

Uncovered interest parity, the absence of a currency risk premium, the Fisher effect and relative purchasing power parity are preconditions for real interest rates to be equalised across countries and, given the existence of an uncovered interest differential for a number of countries in the region, equalisation is unlikely (see Piggott 1994 for evidence for G10 countries). This section presents evidence on whether real interest rates in East Asia tend to equalise over time and why not.

If the Fisher effect holds, the real interest rate differential may be decomposed as

$$(18) \qquad r^*_{t,k} - r_{t,k} = i^*_{t,k} - \dot{p}^{e*}_{t,t+k} - i_{t,k} + \dot{p}^{e}_{t,t+k}$$

Adding and subtracting the expected depreciation of the spot rate over the $k$-period to the right-hand side of equation (18), the real interest differential becomes

$$(19) \qquad r^*_{t,k} - r_{t,k} = \left[i^*_{t,k} + \Delta s^e_{t,t+k} - i_{t,k}\right] - \left[\dot{p}^{e*}_{t,t+k} + \Delta s^e_{t,t+k} - \dot{p}^{e}_{t,t+k}\right]$$

where the first bracketed term is the uncovered interest differential and the second bracketed term is relative purchasing power parity. Given the Fisher effect, real interest rates converge only if both uncovered interest parity and relative purchasing power parity hold. Expectations are assumed to be formed rationally in the Muthian sense, and so the real interest differential is measurable as

**Table 6 Relative variability in foreign and domestic interest rates**

| Country | Period | Standard deviation | Coefficient of variation |
|---|---|---|---|
| United States (*o*) | 80M4–84M12 | 2.49 | 0.23 |
| | 85M1–89M12 | 1.05 | 0.15 |
| | 90M1–94M9 | 1.70 | 0.36 |
| Australia (*o*) | 80M4–84M12 | 12.12 | 0.18 |
| | 85M1–89M12 | 14.51 | 0.17 |
| | 90M1–94M9 | 8.21 | 0.44 |
| Hong Kong (*o*) | – | – | – |
| | 85M1–89M12 | 2.05 | 0.29 |
| | 90M1–94M9 | 2.02 | 0.37 |
| Indonesia (*o*) | – | – | – |
| | 85M1–89M12 | 2.50 | 0.19 |
| | 90M1–94M5 | 3.93 | 0.32 |
| Japan (*o*) | 80M1–84M12 | 2.15 | 0.28 |
| | 85M1–89M12 | 1.00 | 0.20 |
| | 90M1–94M7 | 2.29 | 0.47 |
| Korea (*r*) | 80M4–84M12 | 4.30 | 0.27 |
| | 85M1–89M12 | 1.78 | 0.17 |
| | 90M1–94M9 | 2.29 | 0.16 |
| Malaysia (*o*) | 81M5–84M12 | – | – |
| | 85M1–89M12 | 1.00 | 0.25 |
| | 90M1–94M7 | 1.47 | 0.23 |
| Philippines (*r*) | 80M5–84M12 | 7.91 | 0.49 |
| | 85M1–89M12 | 6.79 | 0.39 |
| | 90M1–94M2 | 4.92 | 0.27 |
| Singapore (*o*) | 80M5–84M12 | 2.19 | 0.24 |
| | 85M1–89M12 | 0.89 | 0.19 |
| | 90M1–94M9 | 1.65 | 0.41 |
| Taiwan (*r*) | 81M3–84M12 | 4.29 | 0.40 |
| | 85M1–89M12 | 1.98 | 0.41 |
| | 90M1–94M3 | 1.91 | 0.26 |
| Thailand (*r*) | 80M5–84M12 | 3.68 | 0.32 |
| | 85M1–89M12 | 3.03 | 0.33 |
| | 90M1–94M6 | 3.16 | 0.36 |

*Notes:* *o* indicates open capital account.
*r* indicates restrictions on the capital account.

$$r^*_{t,k} - r_{t,k} = \left[ i^*_{t,k} + \Delta s_{t,t+k} - i_{t,k} - \xi_{t+k} \right] - \left[ \dot{p}^*_{t,t+k} + \Delta s_{t,t+k} - \dot{p}_{t,t+k} - \xi_{t+k} - \zeta_{t+k} \right] \tag{20}$$

where $\xi$ is a white noise depreciation forecast error and $\zeta$ is a white noise inflation forecast error.

Table 7 follows equation (20) and decomposes the mean real interest differential into the mean uncovered interest differential and mean purchasing power differential for countries in the region from 1980 to 1994 (using consumer price indexes). It differs from Tables 2 and 3 in that the estimations are based on quarterly rather than monthly observations (since price data are generally only quarterly).

**Table 7 Decomposition of the real interest differential**

| Country | Period | Real interest differential | Uncovered interest differential | Purchasing power parity |
|---|---|---|---|---|
| Australia (*o*) | 80Q1–94Q4 | -0.58* (0.16) | -0.49 (0.68) | 0.09 (0.67) |
| Hong Kong (*o*) | 84Q4–94Q4 | 1.03* (0.13) | 0.05 (0.07) | -0.98* (0.15) |
| Indonesia (*o*) | 86Q3–94Q2 | -0.70* (0.29) | -0.81* (0.20) | -0.11 (0.26) |
| Japan (*o*) | 80Q1–94Q3 | 0.11 (0.11) | -0.94 (0.87) | -1.05 (0.85) |
| Korea (*r*) | 80Q1–94Q4 | -0.62* (0.18) | -0.65* (0.27) | -0.03 (0.29) |
| Malaysia (*o*) | 81Q1–94Q3 | 0.05 (0.14) | 0.48 (0.34) | 0.43 (0.32) |
| Philippines (*r*) | 85Q5–94Q2 | -1.73* (0.35) | -1.97* (0.62) | -0.24 (0.57) |
| Singapore (*o*) | 80Q1–94Q4 | 0.26* (0.10) | -0.04 (0.31) | -0.30 (0.33) |
| Taiwan (*r*) | 80Q4–94Q1 | -0.24 (0.18) | -0.49 (0.36) | -0.25 (0.43) |
| Thailand (*r*) | 80Q1–94Q3 | -0.47* (0.20) | -0.93* (0.23) | -0.46* (0.18) |

*Notes:* * indicates statistical significance at the 5 per cent level.
*o* indicates open capital account.
*r* indicates restrictions on the capital account.

Only in Japan, Malaysia and Taiwan do real interest rates not diverge systematically from real US rates. In Taiwan's case, the mean is relatively large but so are the standard errors, while the mean is relatively small for Japan and Malaysia. In all three countries, numerically large nominal interest differentials are offset by numerically large inflation differentials. Real interest rates in Hong Kong diverge from US real rates over time due to the failure of purchasing power parity, which is not unexpected since nominal rates in Hong Kong closely follow US rates, but consumer price inflation is substantially above that of the US (due to high productivity in the traded goods sector and a secular shift in expenditure towards the services sector). Real interest rates are not equalised in Australia or Singapore, and this appears to be due to an uncovered interest differential in the case of Australia and a purchasing power differential in the case of Singapore.[25] Real interest rates in Indonesia, Korea, the Philippines and Thailand have

systematically diverged from US rates, due unambiguously to the failure of uncovered interest parity. Purchasing power parity also fails in Indonesia and Thailand, but the failure of uncovered interest parity accounts for most of the real interest differential. Given that the analysis is in terms of averages calculated using quarterly data over an 8–15 year period, the effect of expectation errors is minimised.

This analysis has two implications for research related to the East Asian economies assessed in the book. The first is for applied analysis. Capital controls and exchange risk premia are a recurring source of the wedge between local and foreign interest rates. But this is not always the case, with Hong Kong and Singapore being notable examples. The wedge in these cases arises because of the failure of purchasing power parity. The upshot is that empirical modelling based on the assumption that the real interest wedge simply reflects capital controls may be misleading. A major source of the wedge, however, *is* due to capital controls and so it is more than appropriate to motivate theoretical work by claiming that capital controls are a major cause of non-zero real interest differentials.

## Overview

Money and foreign exchange markets in the region have grown and become more open as governments have deregulated markets and as market players have expanded operations and technology. As Chinn and Frankel (1992) have pointed out, covered interest differentials narrowed considerably over the 1980s, and this paper shows that differentials are generally even smaller in the 1990s. This would appear to be due to efficiency gains in technology and to the internationalisation of banking. However, covered interest differentials are not uniformly minimised: the monetary authorities in Malaysia, Taiwan and Thailand have at times imposed exchange controls in order to influence foreign exchange market outcomes, and, apart from Taiwan, the effects of these controls are not clearly identified by the generalised analytic techniques popular in the literature. Informal controls as exist in Singapore do not appear to isolate the local market. While parity is technically also rejected for Australia, Hong Kong, Japan and Singapore, the rejection is not economically significant. The test could not be applied to Indonesia, Korea and the Philippines because of a lack of data.

The standard view in the literature is that uncovered interest parity contains little or no information about financial openness. This paper has argued that this is premature. In the first place, information about controls and risk premia may be gleaned by examining *average*

uncovered interest differentials. For example, the mean differential over the past decade or so is negative and significant for Indonesia, Korea, the Philippines, Taiwan and Thailand — probably due to controls on capital inflow for Korea and Taiwan, a combination of controls and exchange risk premia for the Philippines and Thailand, and an exchange risk premium for Indonesia — but is not different from zero for Australia, Hong Kong, Japan, Malaysia and Singapore. An interpretation consistent with this result is that, while expectation errors may have a substantial impact on estimating parity in the short run, they are not systematic and net out over the longer run.

In the second place, the standard test of uncovered interest parity (regressing the depreciation over period $t$ to $t+k$ on a constant and the interest differential on $k$-period instruments) applied to countries in the region yields some unusual results. Namely, a rise in the domestic rate relative to the foreign rate is associated with a subsequent appreciation of the exchange rate in countries with open and developed financial markets, but either a depreciation in countries with exchange controls or no change in the exchange rate in countries with exchange risk premia. The anomaly that parity is more likely to hold in repressed economies, but not liberalised economies, was shown to be consistent with McCallum's (1994) model of the interaction of uncovered interest parity and a monetary policy reaction function. Indeed, if McCallum's (1994) model is correct, then standard tests of uncovered interest parity may reveal a lot more about financial integration than usually thought and in a rather unexpected way: the more closed the capital account or the riskier the country, the more likely is the slope coefficient to be positive and significant. As shown in the empirical work of this paper, the oft-derided 'perverse' negative slope coefficient may appear really to be an indication of financial openness and low risk. An interpretation consistent with this result is that uncovered interest parity is not necessarily of itself a flawed device for exposition of argument or simulation modelling.

In the third place, the uncovered parity condition can be rewritten with the domestic rate on the left-hand side, and the foreign rate and expected depreciation on the right-hand side. Given non-stationarity of interest rates, the relationship between interest rates can be examined within a cointegration framework. Domestic rates are positively correlated with the US rate in all countries except Malaysia, and cointegrated with US rates over all or most of the past 15 years for most countries. Only rates in Hong Kong were shown to be equal to the US rate over the full period (because of the fixed exchange rate regime), but rates in Australia, Singapore and Thailand have more closely approximated US rates over time. The decomposition of variance from vector autoregressions over time showed that innovations to the domestic rate due to the

foreign interest rate have increased over time in Australia, Hong Kong, Indonesia, Japan, the Philippines, Singapore and Thailand. Moreover, the foreign rate now accounts for a greater proportion of innovations than the domestic rate itself in Australia, Hong Kong, Japan, the Philippines and Singapore. Capital controls do not isolate domestic rates completely from foreign rate developments, but Korea, Malaysia and Taiwan still appear to be relatively isolated. Overall, the evidence favours the view that markets have become increasingly integrated and assets increasingly substitutable as controls have been eased.

A number of papers have also tested whether there is a greater tendency for real interest rates to be equalised and have interpreted these results as increased financial integration. This inference is generally invalid unless real interest rates are conditioned for exchange rate and inflation expectation errors, risk premia, imperfect pass-through of changes in inflation expectations to nominal interest rates, and real exchange rate dynamics. Mean real interest rate differentials relative to the US were estimated and found to be insignificantly different from zero only for Japan, Malaysia and Taiwan (for which the standard errors were large). The mean real interest rate differential was decomposed for countries in the region and the main cause of systematic wedges between domestic and foreign real interest rates was shown to be the failure of uncovered interest parity for Indonesia, Korea, the Philippines and Thailand, and of relative purchasing power parity for Hong Kong and Singapore.

The policy implications from this analysis are fourfold. Firstly, exchange controls can be effective in the short run, as the experience of Taiwan, Malaysia and (perhaps) Thailand suggests. The important caveat is, however, whether the trigger for the controls is a flow of short-term 'hot' money or fundamental macroeconomic imbalance. As the failure to avert a ringgit depreciation in 1986 in the face of deteriorating macroeconomic fundamentals in Malaysia demonstrates,[26] interventions may be ineffective if they are used by the authorities to avoid structural adjustment. In this case, deferring necessary adjustment may itself carry additional costs. Even if the controls are effective (in the face of 'hot money' flows), there are downsides to their use. In the first place, they occur at the cost of frustrating foreign exchange transactions and generating greater uncertainty and risk for market participants. Speculators may be the target of controls but it is difficult, if not impossible, to distinguish the 'hot' from the underlying 'regular' transactions. Moreover, as selective interventions become routine, markets may start to price in a risk premium and investor confidence may be undermined. The evidence suggests that controls are not effective in the medium to long term. The experience of

Singapore indicates that softer controls, like moral suasion, do not have an effect over time (if they are inconsistent with the incentives of market players).

Secondly, countries in the region with capital controls generally have higher real interest rates than countries with free markets. As domestic financial markets are liberalised, policies which maintain this wedge may imply an unnecessarily higher cost of capital and impediment to growth. (This is not necessarily the case if the controls are associated with less volatility in the exchange rate and a lower exchange risk premium in interest rates.)

Thirdly, the deepening of international financial linkages in the countries surveyed in this paper highlights the need for more market-based monetary management tools and procedures and for more market-consistent domestic macroeconomic policy. If markets are more open and susceptible to external influences, a new discipline is forced on policy. This in turn can have far-reaching and unforeseen consequences for the structure of the economy and the operation of goods and labour markets.

Fourthly, there is an increasing focus within the APEC forum on identifying and measuring impediments to trade in services in the Asia Pacific region. For example, the Pacific Economic Cooperation Council (PECC) issued a preliminary report in November 1995 identifying legal restrictions in trade and investment in goods and services in APEC-member countries. This information will subsequently be used in implementing APEC's liberalisation program. What is more relevant to such discussions is not the existence of legal restrictions as such, but whether the restrictions matter. That is, do they affect the outcome in markets? In the case of the financial markets examined in this paper, the conclusion would be that there are restrictions in markets in some countries in East Asia, particularly Korea and Taiwan, and that these restrictions generate an outcome different to that which a free market would produce.

## Appendix 1: Definitions and sources of interest rate data

Inflation rates are quarterly and calculated using the consumer price index (code 64) published by the IMF *International Financial Statistics*. Sources of financial prices are:

### Australia

*domestic interest rate*: alternatively, the last-week average of the 3-month Australian Treasury Note auction rate, Reserve Bank of Australia, and the 3-month Australian eurodollar rate quoted in the Swiss market at 10 am on the last working day of the month, Bank for International Settlements, unpublished series.
*foreign interest rate*: alternatively, the 3-month secondary market US Treasury Bill rate, Nikkei database, and the 3-month US eurodollar rate quoted in the Swiss market at 10 am on the last working day of the month, Bank for International Settlements, unpublished series.
*forward discount and spot rate depreciation*: forward discount calculated alternatively from the mid-rate of the spot and 3-month forward exchange rate at 4 pm on the last Friday of the month, Reserve Bank of Australia, unpublished series, and the 3-month forward discount on the Australian dollar quoted in London at midday on the last (Swiss) working day of the month, Bank for International Settlements, unpublished series, and the end-month spot rate at 4 pm on the last day of the month, Reserve Bank of Australia, *Bulletin.*

### Hong Kong

*domestic interest rate*: the end-period 3-month Hong Kong dollar interbank offer rate, *Hong Kong Monthly Digest of Statistics*.
*foreign interest rate*: the 3-month interbank offer US dollar interest rate in the Singapore market (SIBOR) at the last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*forward discount and spot rate depreciation*: calculated from the mid-rate of the end-month spot and 3-month forward Hong Kong dollar/US dollar exchange rate, Barclays Bank International, published by Datastream.

## Indonesia

*domestic interest rate*: monthly weighted average of all maturities of interbank market rates, Bank Indonesia, *Indonesian Financial Statistics*.
*foreign interest rate*: the 3-month interbank offer US dollar interest rate in the Singapore market (SIBOR) at the last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*spot rate depreciation*: calculated from the mid-rate of the end-month spot rupiah/US dollar exchange rate, IMF, *International Financial Statistics*.

## Japan

*domestic interest rate*: alternatively, 3-month euroyen rate quoted in the Swiss market at 10 am on the last working day of the month, Bank for International Settlements, unpublished series, and 3-month gensaki and 3-month secondary market certificate of deposit interest rates, Nikkei database.
*foreign interest rate*: 3-month US eurodollar rate quoted in the Swiss market at 10 am on the last working day of the month, Bank for International Settlements, unpublished series.
*forward discount and spot rate depreciation*: 3-month forward discount on the yen quoted in London at midday on the last (Swiss) working day of the month, Bank for International Settlements, unpublished series, and the end-month spot rate (about 8 am Swiss time), Bank of Japan, *Economic Statistics Monthly*.

## Korea

*domestic interest rate*: average daily rate on call money, weighed by volume of transactions, Bank of Korea, *Monthly Statistical Bulletin*.
*foreign interest rate*: the 3-month interbank offer US dollar interest rate in the Singapore market (SIBOR) at the last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*spot rate depreciation*: calculated from the mid-rate of the end-month spot won/US dollar exchange rate, IMF, *International Financial Statistics*.

## Malaysia

*domestic interest rate*: 3-month Kuala Lumpur interbank rate (KLIBOR) at last Friday of the month, Bank Negara Malaysia, *Quarterly Bulletin*.
*foreign interest rate*: the 3-month interbank offer US dollar interest rate in the Singapore market (SIBOR) at last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*forward discount and spot rate depreciation*: calculated from the mid-rate of the end-month spot and 3-month forward ringgit/US dollar exchange rate, Barclays Bank International, published by Datastream.

## Philippines

*domestic interest rate*: end-month 91-day treasury bill rate, IMF, *International Financial Statistics*.
*foreign interest rate*: end-month 3-month secondary market US Treasury Bill rate, Nikkei database.
*spot rate depreciation*: calculated from the mid-rate of the end-month spot peso/US dollar exchange rate, IMF, *International Financial Statistics*.

## Singapore

*domestic interest rate*: the 3-month interbank offer Singapore dollar interest rate at last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*foreign interest rate*: the 3-month interbank offer US dollar interest rate in the Singapore market (SIBOR) at last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*forward discount and spot rate depreciation*: calculated from the mid-rate of the end-month spot and 3-month forward Singapore dollar/US dollar exchange rate, Monetary Authority of Singapore.

## Taiwan

*domestic interest rate*: alternatively, the end-month 10 to 30 day Taiwan interbank rate, and the 1 to 90 day Taiwan secondary market NCD market rate, Central Bank of China on Taiwan.

*foreign interest rate*: alternatively, the 1-month US secondary market CD rate, Bank of International Settlements, unpublished series, and 3-month SIBOR at the last Friday of the month, Monetary Authority of Singapore, *Statistical Bulletin*.
*forward discount and spot rate depreciation*: alternatively, calculated from the mid-rate of the end-month spot and 1-month forward exchange rate, Central Bank of China on Taiwan, and calculated from the mid-rate of the end-month spot and 3-month forward exchange rate, Central Bank of China on Taiwan.

## Thailand

*domestic interest rate*: weighted monthly average of the Thai interbank market rate, Bank of Thailand.
*foreign interest rate*: monthly average of the eurodollar rate quoted in the London market, Bank of Thailand.
*forward discount and spot rate depreciation*: monthly average of the forward discount on the baht/US dollar spot and 1-month forward exchange rates, Bank of Thailand, unpublished series. Spot rate is from IMF, *International Financial Statistics*.

## Appendix 2: Graphs of Interest Rate Data

**Figure A1.2 Australia: exchange rate and interest differential**

**Figure A1.3 Australia: covered and uncovered interest differential**

**Figure A1.4 Hong Kong and USA: 3-month interest rates**

**Figure A1.5 Hong Kong exchange rate and interest differential**

**Figure A1.6**

**Figure A1.7**

**Figure A1.8**

**Figure A1.9**

**Figure A1.10**

**Figure A1.12**

**Figure A1.11**

**Figure A1.13**

**Figure A1.14**

**Figure A1.17**

**Figure A1.16**

**Figure A1.18**

**Figure A1.15**

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**Figure A1.20**

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**Figure A1.21**

**Figure A1.24**

**Figure A1.23**

**Figure A1.25**

**Figure A1.26**

**Figure A1.28**

**Figure A1.27**

**Figure A1.30**

## Appendix 3: The solution for McCallum's (1994) model

The notation used in this paper differs slightly from McCallum (1994). The interest differential, $x$ in McCallum's notation, over the period $t$ to $t+k$ is called $id_{t,t+k}$ in this paper but it is assumed that $k$ is only one period so $t+k$ is $t+1$ and so this second subscript is dropped for simplicity. The depreciation of the exchange rate over the period $t$-$k$ to $t$ is denoted $\Delta s_{t,k}$ but since $k$ is one period the second subscript is again dropped for simplicity. The expected depreciation of the exchange rate over the period $t$ to $t+k$ is denoted $\Delta s^e_{t,t+k}$ and is written as $\Delta s^e_{t,t+1}$ since $k$ is one period but the second subscript is retained to emphasise that it is forward-looking and different to the actual past depreciations.

The evolution rule for the interest differential, given the central bank objective function, is

(A3.1) $$id_t = \lambda \Delta s_t + c\, id_{t-1} + \zeta_t,$$

which is equation (9) in the text. The uncovered interest parity is written with an error term, $\xi$

(A3.2) $$\Delta s^e_{t,t+1} = id_t - \xi_t,$$

which is equation (10) in the text. The error term is autoregressive, indicating persistence in the deviation from uncovered parity,

(A3.3) $$\xi_t = \rho \xi_{t-1} + \upsilon_t,$$

which is equation (11) in the text. Combining these equations yields,

(A3.4) $$\Delta s^e_{t,t+1} = \lambda \Delta s_t + \sigma id_{t-1} + \zeta_t - \upsilon_t - \rho \xi_{t-1}.$$

The state variables for the rational expectations solution of the exchange rate depreciation, $\Delta s_t$, are $id_{t-1}$, $\zeta_t$, $\xi_{t-1}$ and $n_t$ and the solution is assumed to be of the linear form,

(A3.5) $$\Delta s_t = \phi_1 id_{t-1} + \phi_2 \xi_t + \phi_3 \zeta_{t-1} + \phi_4 \upsilon_t.$$

Taking one-period-ahead expectations of (A3.5) yields,

(A3.6) $$\Delta s^e_{t,t+1} = \phi_1 id_t + \phi_3 \rho \zeta_{t-1} + \phi_3 \upsilon_t ,$$

and substituting equation (A3.1) for $id_t$ and equation (A3.5) for $\Delta s_t$ in (A3.1) yields,

(A3.7) $$\Delta s^e_{t,t+1} = \left[\phi_1^2 \lambda + \phi_1 \sigma\right] id_t + \left[\phi_1 \phi_2 \lambda + \phi_1\right] \xi_t + \left[\phi_1 \phi_3 \lambda + \rho\right] \zeta_{t-1} + \left[\phi_1 \phi_4 \lambda + 1\right] \upsilon_t .$$

Equating (A3.7) to (A3.4), substituting (A3.5) for $\Delta s_t$, and setting the expression equal to zero yields,

(A3.8)

$$0 = \left[\phi_1^2 \lambda + \phi_1 \sigma - \phi_1 \lambda - \sigma\right] id_{t-1} + \left[\phi_1 \phi_2 \lambda + \phi_1 - \phi_2 \lambda - 1\right] \xi_t + \left[\phi_1 \phi_3 \lambda + \phi_3 \rho - \phi_3 \lambda + \rho\right] \zeta_{t-1} + \left[\phi_1 \phi_4 \lambda + \phi_3 - \phi_4 \lambda + 1\right] \upsilon_t$$

Excluding the trivial solution by which the variables are set to zero, the solution is obtained by setting each of the bracketed terms to zero and solving for the undetermined coefficients, yielding,

(A3.9) $$\begin{aligned} \phi_1 &= -c / \lambda \\ \phi_2 &= -1 / \lambda \\ \phi_3 &= \rho / (\lambda + \sigma - \rho) \\ \phi_4 &= 1 / (\lambda + \sigma - \rho) \end{aligned} .$$

Substituting these coefficients into equation (A3.5) yields the interim solution,

(A3.10) $$\Delta s_t = -\frac{c}{\lambda} id_{t-1} - \frac{1}{\lambda} \xi_t + \frac{\rho}{\lambda + \sigma - \rho} \zeta_{t-1} + \frac{1}{\lambda + \sigma - \rho} \upsilon_t$$

Substituting equation (A3.10) into the evolution rule for the interest differential in equation (A3.1) yields the expression for the interest differential,

(A3.11) $$id_t = \frac{\lambda}{\lambda + \sigma - \rho} \zeta_t ,$$

which, if true at time *t*, is also true at time *t–1*,

(A3.12) $$id_{t-1} = \frac{\lambda}{\lambda + \sigma - \rho} \zeta_{t-1} .$$

Multiplying both sides by $\rho/(\rho - \sigma)$ and adding and subtracting $\sigma$ in the numerator of the left-hand side expression yields,

(A3.13) $$\left(1+\frac{\sigma}{\rho-\sigma}\right)id_{t-1} = \frac{\lambda\rho}{(\rho-\sigma)(\lambda+\sigma-\rho)}\zeta_{t-1}.$$

Taking the second term in brackets on the LHS over to the RHS and multiplying it by $\lambda/\lambda$ yields,

(A3.14) $$id_{t-1} = \frac{-\lambda\sigma}{\lambda(\rho-\sigma)}id_{t-1} + \frac{\lambda\rho}{(\rho-\sigma)(\lambda+\sigma-\rho)}\zeta_{t-1}.$$

Multiplying both sides by $(\rho-\sigma)/\lambda$ yields

(A3.15) $$\frac{\rho-\sigma}{\lambda}id_{t-1} = \frac{-\sigma}{\lambda}id_{t-1} + \frac{\rho}{(\lambda+\sigma-\rho)}\zeta_{t-1}.$$

Substituting this into equation (A3.10) yields the solution which appears in the text as equation (13) and is equivalent to McCallum's (1994, p. 125) equation (25),

(A3.16) $$\Delta s_t = \left[(\rho-\sigma)/\lambda\right]id_{t-1} - (1/\lambda)\zeta_t + \left[1/(\lambda+\sigma-\rho)\right]\upsilon_t.$$

## Appendix 4 Time-Varying Estimates of Beta

**Figure A3.1**

**Figure A3.2**

**Figure A3.3**

**Figure A3.4**

**Figure A3.5**

**Figure A3.6**

## Notes

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1 Exchange restrictions on the capital account include restrictions on inward and outward foreign direct investment and other short- and long-term capital movements. Exchange restrictions on the current account include restrictions on foreign exchange transactions and sources of funding associated with imports, exports and invisibles. The requirement to surrender export receipts is separately identified.

2 Guciano (1995) presents estimates of currency weights for various East Asian countries at mid-1995: the weights for the Singapore dollar are 0.5 for the US dollar (USD), 0.4 for yen (Y) and 0.1 for deutschemark (DM) and Swiss franc (SFR); the weights for the rupiah are 0.5 for Y, 0.4 for USD and 0.1 for DM and SFR; the weights for the ringgit are 0.4 Y, 0.3 USD, 0.2 DM and 0.1 other; the weights for the baht are 0.7 USD and 0.3 Y, and; the weights for the New Taiwan dollar are 0.5 USD, 0.3 Y and 0.2 DM/SFR. Guciano (1995) argues that the weight given to the yen increased and that given to the US dollar decreased markedly in the first half of 1995, due to the surge in the yen in early 1995, with the shift typically about a 10 per cent shift to the yen. The US dollar remains the key reserve currency in the region.

3 This is based on Frankel (1993a). Frankel calculates the covered interest differential for each region by summing the *actual* covered differentials, which gives insight more into the nature of capital controls in a region rather than whether impediments to arbitrage are relatively small or large.

4 To the extent that equation (3.2) is an identity, it does not contain an error term and can be written with either variable as the dependent variable. Equation (3.2) is in fact an approximation of the true relationship between interest rates and the forward discount, with the error in the approximation equal to the difference of the remainder terms of the linear approximations of $ln(1+i)$ and $ln(1+i^*)$. Strictly speaking, therefore, the null hypothesis is not correctly stated, but if the difference term is negligible as expected (given that interest rates are in decimals), then the constant should be dominated by other effects which are of interest.

5 The ADF(1) statistics for the interest differential and forward discount over the period stated in Table 1 are, respectively, -2.07 and -1.61 for Australia, -3.91* and -3.29* for Hong Kong, -2.80 and -2.91* for Japan, -3.98* and -3.58* for Malaysia (with trend), -3.81* and -4.45* for Singapore, -2.35 and -2.44 for Taiwan, and -3.72* and -3.36* for

Thailand, with the critical values based on Fuller (1976). The ADF(1) test on the error from a regression of the forward discount on the interest differential is -4.01* for Australia and -2.21 for Taiwan, with the critical values based on MacKinnon (1991).

6 Two points are relevant here. Firstly, the outcomes for Australia and Taiwan are not very sensitive to the different specification. The constant and slope coefficients (and standard error) in uncorrected levels are, respectively, -0.07 (0.02) and 0.95 (0.02) for Australia, and 0.30 (0.10) and 0.58 (0.13) for Taiwan (including a dummy for market closure in mid-1992), although the slope coefficient in Taiwan's case is different from 1 and the joint null is rejected (chi-square (2) is 10.6) in levels estimation. Secondly, ARCH(q) was statistically significant in the estimations for Australia (ARCH(5)), Hong Kong (ARCH(5)), Malaysia (ARCH(1) full sample only) and Singapore (ARCH(2)). The results for Australia and Hong Kong were not corrected — in Australia's case because the coefficient on ARCH(5) was explosive and in Hong Kong's case because the coefficient on the ARCH(5) process was statistically insignificant. The standard errors for Malaysia (full sample) and Singapore are not corrected for the bias induced by overlapping observations. While the covariance matrix is affected by overlapping observations, the uncorrected and corrected standard errors are generally very similar and statistical inference is unaffected, and so the bias maintained in not adjusting the standard errors in these two cases is probably negligible.

7 Financial institutions estimate forward discounts based on the existing interest differential, which is used by some to argue that covered interest parity tests are circular and hence meaningless. If all institutions estimate their forward discounts this way, and are able to exploit differences in the forward rates that different institutions quote, then parity should hold. But it will not necessarily hold if there are controls or inefficiencies in the market, and the tests are aimed at identifying economically meaningful deviations.

8 The Thai data are one-month data and so the average three-month covered differential is -0.90.

9 The differential before 1980 is positive, which is probably explained by the relatively unsophisticated technology of the time, the thinness of the market and the restriction on Japanese players from entering the euro market. The sample for Japan represents the modern period of free markets.

10 While the CD rate is usually regarded as the more representative open market rate in Japan in recent years (de Brouwer 1996), it only developed in the 1980s. In the 1970s, gensaki was the only open market in Japan, and it still remains relatively deep (outstandings at September 1994 totalled Y12.5 trillion compared to Y18.7 trillion in CDs), although it is less traded.

11 Viewed in isolation, the jump in the covered eurodollar–gensaki spread could be interpreted as evidence of controls on capital outflow, possibly to stem yen depreciation (the yen depreciated 18 per cent from Y125 at October 1988 to Y152.85 at June 1990).

This interpretation is not consistent with the eurodollar–CD spread and the absence of formal capital controls, and is better explained as a distortion peculiar to the gensaki market.

12 Banks sometimes reduce the issue of CDs in order to put upward pressure on CD rates and, therefore, on short-term lending rates (interview, Tokyo, 20 February 1995).

13 The data were carefully selected as the last working day of the month for both Australia and the USA. Daily Australian Treasury Note data were not available before December 1985, although weekly auctions were held. Tests which include data before December 1985 are likely to contain large measurement errors, and inferences drawn from these tests are misleading.

14 The 1986 episode is reported in Bank Negara Malaysia *Quarterly Bulletin* 1(1 and 2) and the 1993–94 episode is reported in Bank Negara Malaysia *Quarterly Bulletin* 9(1).

15 Moreover, Thai data are monthly averages.

16 When estimated in levels, the slope coefficient is numerically similar to that estimated in first-differences (0.58 compared to 0.59). Parity in levels is firmly rejected (the OLS standard error is 0.09).

17 On the assumption that expectations are formed rationally and that investors are risk-neutral, the forward discount may be used as a proxy of the expected depreciation, but it is well known that in practice the forward discount is a biased and uninformative predictor of expected depreciation (Attfield et al. 1985, pp. 161–76; Hodrick 1987). Alternatively, expectations may be proxied by surveys of the expectations of currency dealers. Survey measures, however, are highly correlated with the forward rate (Froot and Frankel 1989), they tend to be biased, they may be unreliable (who knows whether the respondents are telling the truth and whether they plan to act on what they say), or they may just not be available.

18 The ADF(1) statistics for the interest differential, change in the exchange rate and uncovered interest differential are, respectively, -3.14*, -6.88* and -6.76* for Australia; -3.87*, -6.16* and -4.65* for Hong Kong; -3.75*, -4.06* and -3.86* for Indonesia; -2.78#, 6.83* and -6.01* for Japan; -2.37, -3.39* and -3.30* for Korea; -2.26, -6.50* and -5.80* for Malaysia; -2.36, -3.41* and -3.27* for the Philippines; -3.92*, -7.04* and -6.47* for Singapore; -2.83#, -4.18* and -4.42* for Taiwan; and -3.38*, -6.67* and -5.54* for Thailand; where # and * indicate significance at the 10 and 5 per cent levels (Fuller 1976).

19 The diagnostics of equation (3.11) were tested for ARCH(q) up to 12 lags and in all cases conditional variances were found to be ARCH(1). The equations were re-estimated with ARCH(1) for all countries except Korea and the Philippines, for which the variances are explosive. If ARCH(1) errors are included, the slope coefficient is

-0.04 (with a standard error of 0.12) in the Korea equation and -0.24 (with a standard error of 0.28) in the Philippines equation. The results and inference are *not* qualitatively different for the other countries when estimation is by OLS or by OLS with the Newey-West correction for overlapping observations.

20 Chinn and Frankel (1992) test uncovered interest parity by regressing the domestic interest rate on a constant and the foreign (US) interest rate less the survey measure of expected depreciation. The slope coefficient is always significantly different from zero and the implied coefficient on the expected depreciation is negative in most cases.

21 Over shorter samples, the uncovered interest differentials may sometimes be significantly different from zero. When the sample is broken into five-year sub-samples, for example, the results do not change dramatically and usually countries which have zero differentials over the full period also have zero differentials over sub-periods. For example, the differentials and standard errors (in per cent) for Australia over three five-year sub-periods are 1.59 (0.83), -2.05 (1.19) and -0.90 (0.67), none of which is significant at the 5 per cent level. The striking exception is Hong Kong, for which the differential is 0.24 (0.08) for 85M1–89M12, but -0.12 ((0.05) for 90M1–94M12.

22 The uncovered differential is positive for Malaysia and only barely insignificant, which is consistent with impediments to capital outflow on average. As discussed above, the Malaysian authorities used controls to limit capital outflow from 1984 to 1986 and capital inflow for a short period in 1994.

23 McCallum's model does not affect this redefinition of uncovered interest parity. Rewriting equation (13) in terms of the domestic interest rate yields the equation,

$$i_t = i_t^* + \frac{\lambda}{\rho - \sigma} \Delta s_{t+1} .$$

24 The exceptions are Thailand, for which a lag length of 2 was selected to reduce serial correlation in the residuals from the estimation, and Australia for the period 85M1–89M12, for which a lag length of 2 was selected since longer lag lengths produce bizarre results (for a lag length of 4, there is cointegration with a constant of 49 and a slope coefficient of 31.77).

25 While the rejection of the null that the real interest differential in Australia is zero seems to be due to the failure of uncovered interest parity, the tests on quarterly and monthly data do not support this conclusion.

26 See Beng (1989, p. 9) and Bank Negara Malaysia annual reports for details.

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