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TESTING FOR INTERNATIONAL FINANCIAL MARKETS INTEGRATION

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Testing for International Financial Markets Integration

Abstract

This paper examines the extent to which financial markets across the main international financial centres integrated between 1988 and 2001 in the face of technological change and capital market liberalisation. Two empirical approaches are adopted based on principal components analysis and cointegration tests, applied respectively to covered interest rate differentials and real interest rates.. The results suggest that some financial integration occurred during the 1990s but that integration is far from complete at the international level. The study also confirms differing trends in the integration of financial markets in different geographical regions.

Key words: international finance, financial markets, integration, principal components analysis, cointegration test.
JEL classification: F36

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1. Introduction

Over the last two decades, the topic of globalisation has figured prominently in policy debates as the major developed countries have sought to develop closer economic linkages[1]. The frontiers between economies are being dismantled, stage by stage, in many parts of the world as the process of integration continues. Such developments involve an increasing mobility of goods, services and factors of production (primarily capital), as well as an intensification of communication flows.

This study investigates one particular aspect of globalisation, namely the extent of financial integration that took place between the main international financial centres between 1988 and 2001. The reduction in the cost of information, the improvement in trading systems technology, the development of new financial instruments and the relaxation of certain legal restrictions have stimulated global capital movements. A critical question arises, however, concerning the degree of international financial integration that has actually been achieved.

The degree of financial integration between countries has important implications for the way in which monetary policy is conducted in an open economy context. It is recognised that a high degree of international capital mobility acts as a constraint on the operation of independent monetary policies (Claassen, 1996). In particular, capital market globalisation implies, inter alia, a convergence of interest rates through arbitrage operations. Changes in interest rate differentials between domestic financial markets can therefore provide an indicator of the degree of financial integration occurring (Kazemi *et al.*, 1997).

Financial markets may be related vertically or horizontally: the vertical relationship is strictly associated with the term structure of interest rates, while the latter arises when the "price of assets, denominated in different currencies, with similar risk and maturity characteristics tends toward equality easily and quickly" (Holmes, 2001, pp. 1-2). This paper examines the second type of relationship – horizontal integration. The primary aim is to investigate whether interest rates with similar characteristics, across several countries, have had a tendency to converge. Earlier studies in this area, for example those conducted by Logue *et al.* (1976) and Nellis (1982, 1983), focused on the covariability of interest rate levels and interest rate changes to assess the degree of integration.

The results and conclusions reported by various studies to date in this field of research have often contradicted each other. For example, Merrick and Saunders (1986) and Williamson (1991) inspected the dispersion in real interest rates across a selection of countries and concluded that there was no evidence to indicate a decline in coverage – in other words, there had been no tendency of real interest rates. Various reasons may explain this finding. One reason, put forward by Frankel and Froot (1987), is associated with agents' expectations and exchange rate risk, which differ across markets and countries. Another reason, identified by Kimbrough (1987), is concerned with the fact that, while in some cases *nominal* interest rates may tend to equalise, when considered in *real* terms the results may differ markedly. Similarly, the study by Mark

(1985) was unable to find evidence of convergence among interest rates when adjustment is made for different national tax rates.

In contrast, Holmes and Pentecost (1996) used unit root and time-varying parameter tests to confirm the existence of closer international financial integration based on interest rate movements. Their study covers the period from March 1979 to August 1992. They concluded that monetary policies across the European Union (EU) member states had converged in recent years, despite the turbulence witnessed in the early 1990s as a result of developments within the Exchange Rate Mechanism of the European Monetary System (EMS). A similar conclusion was reached by Alexakis et al. (1997) using cointegration as a test. Countries were divided into two distinct groups: the EMS members and the non-EMS members. In both cases, results confirmed a tendency for real interest-rate convergence in the long run. Moreover, the fact that EMS membership was linked with lower exchange volatility had reinforced the convergence among these countries' capital markets over time. Other papers which have investigated financial integration include Karfakis and Moschos (1990), Koedijk and Kool (1992), Katsimbris and Miller (1993), Holmes and Pentecost (1999), Martin and Rey (2000), Lee (2002) and Grabel (2003).

In this paper we contribute to the literature by investigating the movement of interest rates over time in seven international financial centres. Unlike a number of previous studies, we do not restrict ourselves to one particular region of the world. The reason for taking a broader perspective is to provide an insight into the global integration of financial markets rather than simply a narrower integration within economic blocks, such as the EU. However, we also report some regional results. As a check on the robustness of the international and regional results, two different test procedures are used, namely principal components analysis and a cointegration test.

The underlying motivation for the research stems from the claim that international financial markets are integrating (Lane and Milesi-Ferretti, 2003), which deserves further empirical testing. Beyond that, the research findings presented here have important implications for exchange rates, which are affected by interest rate movements, and asset valuation and portfolio management in an international context, in the sense that a tendency towards greater convergence of interest rates provides for a more stable environment for financial decisions.

The remainder of the paper is organised as follows: section 2 explains the underlying principles of the two test procedures employed; section 3 describes the data set and clarifies the choice of periods analysed; while section 4 presents and discusses the statistical results. Finally, section 5 summarises and sets out the main conclusions of the study and the implications for the international economy.

2. Methodology of the Test Procedures

A brief description of principal components analysis and the cointegration test is set out below for those readers unfamiliar with the techniques. Each approach offers potentially different insights into the degree of financial integration achieved across countries. Principal components analysis concentrates on *patterns of movements* in interest rates but, as such, does not offer a quantifiable measure of the *degree* of integration. In contrast, cointegration tests do permit judgements about the degree of integration between financial markets. By comparing the results from both tests, the aim is to provide more robust conclusions on the extent of integration across the international financial markets studied than are provided by one statistical method alone.

2.1. Principal Components Analysis

Principal components analysis is a method of transforming a given set of variables into a new set of composite variables, referred to as principal components, which are orthogonal to each other.

The variables included in this study are based on the concept of *covered interest parity* (Frankel, 1992). In international financial markets it is possible to borrow a currency, convert it into a second currency where it is invested, and sell this currency forward against the initial currency. Profits are derived from discrepancies between interest rate differentials in the two currency countries and the discount or premium between the currencies involved in the forward transaction. In other words, if the exchange markets are operating efficiently, then arbitrage should guarantee that the covered interest differential on similar assets denominated in different currencies is equal to zero at any point in time. The covered interest differential (*cid)* is defined as:

$$cid_{it} = r_{US} - (r - \theta)_{it} \tag{1}$$

where r corresponds to 3-month treasury bill rates and θ represents the forward exchange premia of currency i against the US dollar, as defined in Buckley (2000). The i countries which are the subject of the analysis in this paper are the United Kingdom (*UK),* Germany *(G),* France *(F),* Japan *(J),* Singapore *(S)* and Hong-Kong *(HK)*, over the time period *t= June 1988* to *May 2001,* with the United States *(USA*) as the reference country. These countries include the main international financial centres, accounting for most of the world's international capital transactions in value terms.

The most important and idiosyncratic attribute of principal components analysis is its data-reduction capability. The statistical technique is centred on the calculation of correlation

coefficients for the covered interest rate differentials in the six selected countries compared with the USA. Based on the correlation coefficients, principal components analysis assesses whether there exists some underlying pattern of relationships such that the data can be effectively reduced to a set of factors, less in number than the set of covered interest rate variables. Therefore, each covered interest rate differential is embodied in a linear function of unobservable common-factor variates and an underlying, specific variate. The factors may be assumed to be source variables and represent the observed interrelationships in the data.

The principal components analysis problem can be expressed summarily as:

$$z_j = a_{j1}F_1 + a_{j2}F_2 + ... + a_{jn}F_n + d_jU_j \quad (2)$$

where each of the n observed variables (z_j) is described linearly in terms of n new uncorrelated components $F_1, F_2, ..., F_n$, each of which is in turn is defined as a linear combination of the n original variables. The coefficient a_{ji} is the factor loading (regression weight) on the ith factor and U_j denotes a unique factor, i.e. it is the part that is influenced by idiosyncratic determinants, specific to each variable, z_j, with a loading of d_j. A factor loading is simply the correlation between the time series of observations on the covered interest rate differentials from a single country and the associated factor.

The major obstacle in principal components analysis is related to identifying the nature of each factor because the factors themselves are not directly observable. However, the focal point of the present paper is on the nature of the interdependence of the covered interest rate differentials in the main international financial centres and *not* on the actual identification of the factors themselves that may be the cause of integration.

There are six technical stages involved in principal components analysis. These are:

1. The preparation of a *correlation matrix* from the variables (i.e. the set of covered interest differentials: cid_{UK}, cid_G, cid_F, cid_J, cid_S and cid_{HK}).
2. The derivation of c*ommunalities*, which show the variance in each country's covered interest rate differential that is explained by the common factors in total.
3. The extraction of *factor loadings*, which are then used to help identify the factors themselves. It is important to note that loadings are extracted in a way that ensures that the factors are orthogonal.
4. The *rotation* of the initial factor loadings to a terminal solution, which is carried out to aid the search for interpretable factors. The varimax orthogonal rotation is used in order to identify factors orthogonal to one another and also factors where the variance of the squared loadings is maximised.
5. The *cumulative percentage variance* of the interest rates explained by each factor is presented.
6. The largest *principal component* is examined to assess whether it is stationary.

The method of principal components makes no particular assumption about the underlying structure of the variables. The central point is to obtain their best linear combination. Hence, the first component or factor may be viewed as the single best summary of the linear relationships exhibited in the data and is obtained by maximising the variance which it explains. The second factor is defined as the second best linear combination of variables, under the condition that the second component is orthogonal to the first, which means that it accounts for most of the residual variance after the effect of the first factor is removed from the data. Subsequent factors are defined similarly until all the variance in the data is exhausted. Unless at least one variable is perfectly determined by the rest of the variables in the data, the principal components solution requires as many components as there are variables.

The factors which have eigenvalues greater than one contribute most to the total variance of the variables and hence describe more of the data than any other factor. As a result, these are examined more closely. The degree of international financial integration, based on covered interest rate differentials, is assessed by the explanatory power of the most powerful factor – that is, by the first factor - and the number of other significant factors extracted. Logue et al. (1976) and Nellis (1982, 1983) conclude that the emergence of a single factor, explaining nearly all the observed variance in the data set, would be indicative of a high degree of financial market integration. However, if several factors were to emerge, with each explaining only a relatively small percentage of the variation in the data, then this would imply that financial markets are segmented with each factor significantly affecting only one country's covered interest rate differential.

In order to address the question of how much *interdependence* there is in the *n* variables considered, the first largest principal component (LPC) is obtained and investigated to see whether or not it is stationary. If the variables to be examined have a unit root, then they will have infinite variances. In this case, it is most likely that the first LPC, which explains the largest variation of all the variables as a group, is I(1) and therefore confirms the existence of a common trend, as described in Stock and Watson (1988). If the first LPC is I(0) then all the remaining principal components will also be stationary and there are no common trends. This result would suggest that the covered interest differential variables are themselves stationary and confirm that covered interest parity holds across the sample (Holmes and Pentecost, 1999).

2.2. Cointegration Tests

A particularly popular technique that has been used to explore interest rate movements towards equalisation is the application of standard regression procedures (Throop, 1980[2], Frankel 1989). However, as Stock (1987) argues, regression techniques are not appropriate when dealing with series that have a unit root but trend together, due to the fact that that the estimated standard errors are not consistent. In order to overcome this problem, Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1992) have developed a methodology centred on *cointegration*. The technique of cointegration evolves around the idea that certain variables "should not diverge from each other by too great an extent, at least in the long run" (Granger,

1991). In other words, although the variables are nonstationary, they can be combined together into a single series which is itself stationary.

There are currently two main approaches to the problem of testing for cointegration: one is referred to as the *residual-based* approach and is based on the augmented Dickey-Fuller (ADF) test of cointegration; the other is the *Johansen's Maximum Likelihood* approach. The latter is employed in this paper as it appears to be more reliable and efficient, especially when more than two I(1) variables are involved (Pesaran and Pesaran, 1997), as is the case in this study. It specifically provides a framework to test for cointegration within the context of a vector autoregressive (VAR) error correction model.

The Johansen Maximum Likelihood procedure is based on a process of N I(1) variables in an $(n \times 1)$ vector X as an unrestricted regression:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots + A_p X_{t-p} + \varepsilon_t \tag{3}$$

where $t = 1, 2, \ldots, T$, p represents the number of time lags and ε_t is an independently and identically distributed n-dimensional vector with zero mean and variance matrix $\sum_{\varepsilon}$. A is an $(n \times n)$ matrix of parameters. Equation (3) can then be re-arranged as follows:

$$\Delta X_t = \sum_{i=1}^{p-1} \pi_i \Delta X_{t-i} + \pi X_{t-p} + \varepsilon_t . \tag{4}$$

where

$$\pi = -\left(I - \sum_{i=1}^{p} A_i \right)$$

and

$$\pi_i = -\left(I - \sum_{j=1}^{i} A_j \right)$$

I is the identity matrix. The rank of π is equal to the number of independent cointegrating vectors (r) which exist between the variables in X. It can be obtained by testing for the number of characteristic roots of π that are significantly different from 1. Johansen (1988) demonstrates that this can be conducted using two test statistics:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{5}$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{6}$$

where $\hat{\lambda}_i$ are eigenvalues and T is the number of usable observations.

Johansen (1988) and Johansen and Juselius (1990) provide the critical values of both statistics, which are generated using simulation studies.

3. Data Overview

The data employed in this study are end-of-month spot exchange rates, forward exchange rates and 3-month treasury bill rates. The information has been tabulated for the financial centres of seven countries: the USA, the UK, Germany, France, Japan, Singapore and Hong Kong. These represent the main financial centres across America, Europe and Asia. The spot and forward exchange rates data used were taken from the International Monetary Fund's *International Financial Statistics*. Data on 3-month treasury bill rates were obtained from Datastream.

In order to ensure the absence of gaps in any of the country data sets, the period of the analysis chosen runs from January 1988 through to May 2001. This time period embraces a number of major developments in the global economy which have impacted on economic policies. Particular events have shaped the economic environment since the late 1980s and, *a priori*, are likely to have had implications for the degree of financial integration among the major financial centres. As a result, three sub-periods were identified: January 1988 – December 1991, January 1992 – June 1997, and July 1997 – May 2001.

The first sub-period is characterised by the widespread adoption of supply-side policies in many Western countries (Toye, 1992). This led to major restructuring of many corporate sectors and job markets and the opening up of markets in the wake of reforms such as deregulation (Burda and Wyplosz, 2001)[3], the reshaping of industrial relations (Chapman, P. and Temple, P., 1998)[4] and competition policies (Levinsohn, 1996; Tsoukalis,1997; Furse, 2002)[5]. In addition, during this period preparations were made for the completion of the European Single Market programme, to facilitate the free movement of people, goods, services and capital. This had an important impact on the global economy because members of the (then called) European Community had (and still have) incentives to increase financial and commercial relations with their EU partners, sometimes at the expense of relations with other countries (Jorgensen *et al.*, 2001[6]).

The second sub-period considered is between January 1992 and June 1997. This was a period of recovery of the major industrialised economies from the effects of the early 1990s recession. As recovery gathered pace, a global economic boom emerged as aggregate demand increased, while unemployment and inflation both decreased. The period was also characterised by the determination of European governments to meet the EU Maastricht criteria (Cini, 2003). Meanwhile, in East Asia, after three decades of virtually uninterrupted economic expansion, Thailand, Indonesia, South Korea and Malaysia, part of the so-called 'Asian Economic Miracle', suffered capital flight and serious financial disruption in mid-1997. In consequence, their economies weakened (Hallwood and MacDonald, 2000). Four main stages were associated with the East Asia crisis: the exchange market crisis in Thailand; the spillover of the Thai crisis into other emerging market economies with vulnerable external positions, both in Eastern Europe and

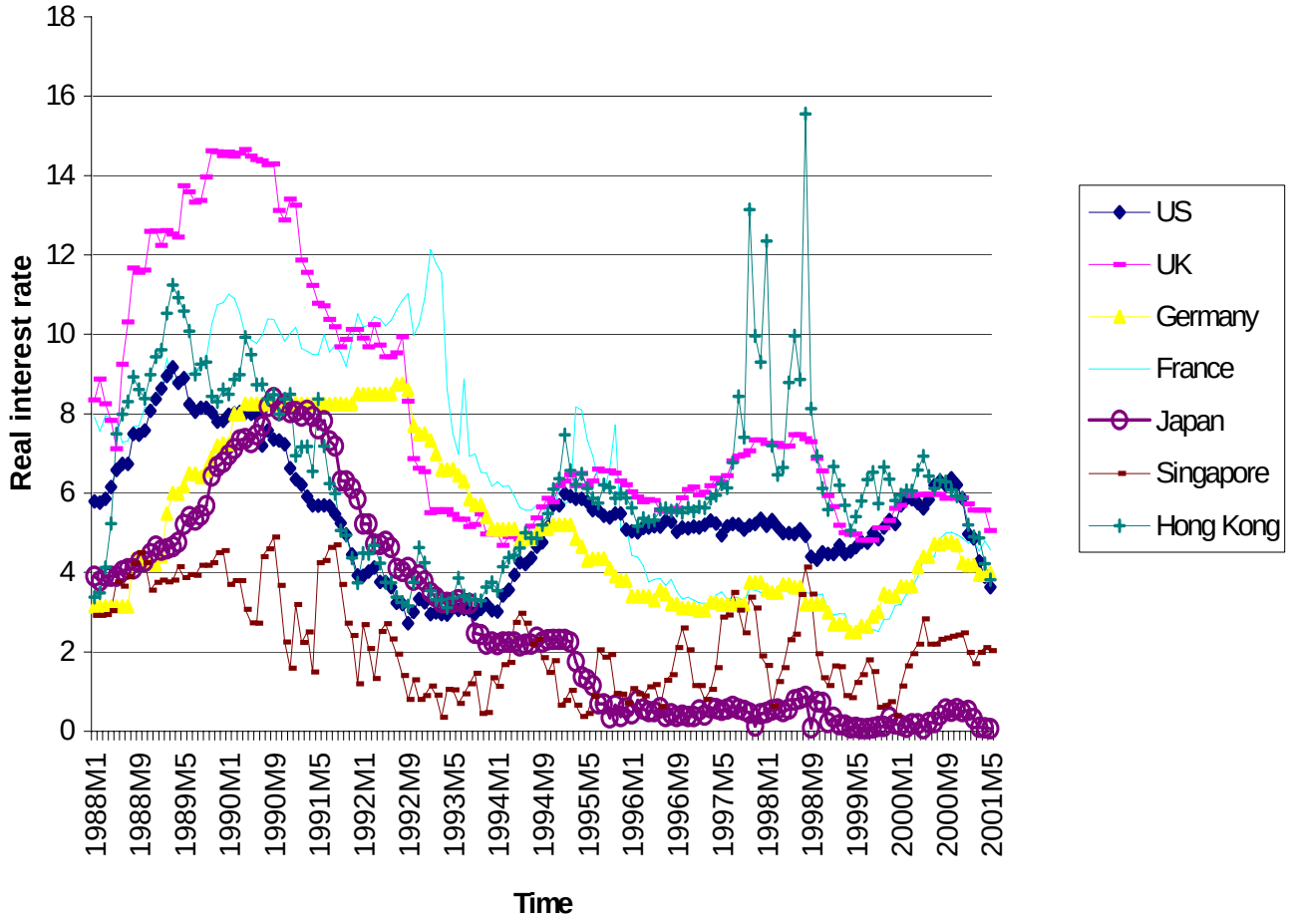
Southeast Asia; the widening of the economic crisis among other ASEAN countries; and finally the spread of deflationary pressures to other economies in the region with consequent effects on international financial markets (de Brouwer, 1999).

This, therefore, marked the beginning of the last sub-period, which started in July 1997. During this period East Asia experienced first a financial crisis and then a slow recovery from sharp economic decline (World Bank, 2000), although Japan was still feeling the strain in 2001 with unemployment at historically high levels, even though interest rates had been reduced to practically zero (IMF, 2002). At the beginning of this last sub-period, European and American stock markets were experiencing boom conditions. However, the "bubble" burst in March 2000, when shares in dotcom companies crashed. Private investment and demand suffered and this marked the start of a period of economic slowdown across the major economies (Baker, 2000).

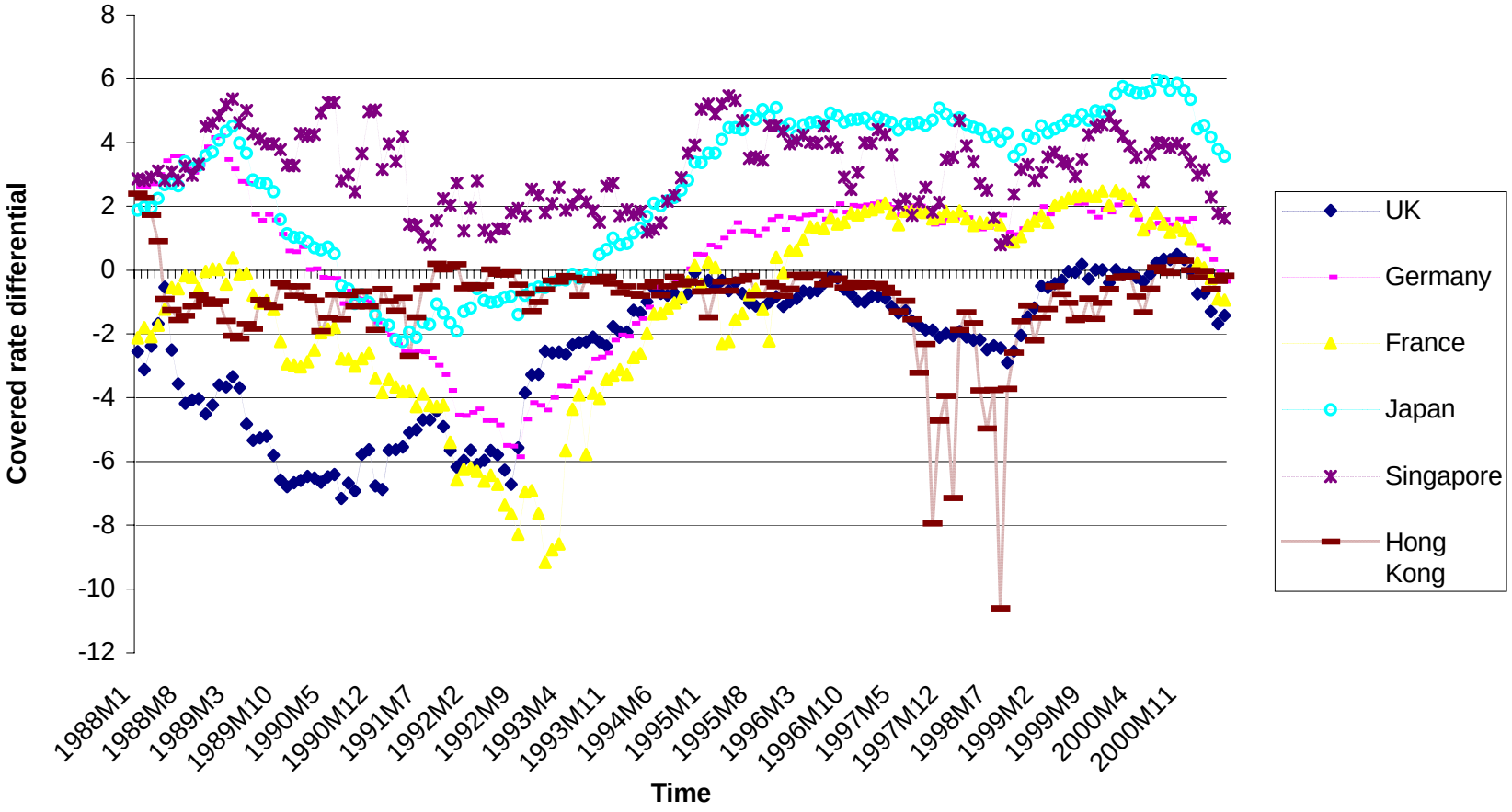
Figure 1 shows real interest rates movements in the seven countries considered over the period studied. Three conclusions may be drawn from Figure 1. The first is that real interest rates have decreased significantly in the UK, France and Germany, which were severely affected by the recession of the early 1990s. By mid-2001, real interest rates in these countries had fallen to levels not observed for more than two decades. By contrast, real interest rates in Japan and Singapore remained relatively low throughout the period. When Hong Kong was incorporated into China on 1 July 1997 there was an initial period of interest rate turbulence, but later real interest rates fell and stabilised. Finally, from the graph we can conclude that the trend of US interest rates has remained roughly constant. Both at the beginning and end of the period the interest rate was approximately 6%. There was a significant decreasing trend at the beginning of the 1990s, but US interest rates remained relatively stable at between 5 and 6%, up to the end of our data period.

Figure 1

Real interest rates, January 1988 – May 2001



The second point to note is that the interest rates seem to have converged after 1990, although convergence was interrupted in the mid-1990s. However, it remains to be assessed whether they converged to an extent where it can safely be concluded that financial markets were definitely achieving a greater degree of international integration. Using the USA as the benchmark economy and attempting to assess whether covered interest rates are converging towards this benchmark, Figure 2 confirms that the results are not straightforward to interpret. Individually, some of the countries seem to have experienced a narrowing of the differential between their own covered interest rates and that of the USA, but as a group the trend is less obvious. In summary, the visual evidence on financial integration in Figures 1 and 2 is inconclusive and a more detailed statistical analysis is necessary.



Note: M refers to the month in each calendar year.

4. The Statistical results

The statistical results presented in this paper are sub-divided into those concerning (a) the principal components analysis and (b) cointegration tests. In (a) covered interest rate differentials are used, while in (b) we use real interest rates. Covered interest rates are analysed in the first case because the USA is used as the point of reference and the test measures the difference of each rate in relation to the US rate. The cointegration test is applied to the actual real interest rates for each country over the study period.

4.1. The Principal Components Analysis

As explained in section 2.1, the principal components method investigates, inter alia, the largest principal component (LPC) with the LPC having an eigenvalue equal to or bigger than 1. Holmes and Pentecost (1999) have used the test and argue that if the first LPC is stationary then we can conclude that there is a strong tendency towards closer financial integration. Conversely, if the first LPC is not stationary then weak evidence of financial integration exists.

The variables were constructed as stated in section 2 above and represent the covered interest differentials between a country *i* and the USA. Table 1 presents three groupings of the countries: Group 1 includes all the countries under investigation, Group 2 includes only the European countries and Group 3 only the Asian countries. The table indicates the time periods covered with the first one spanning the whole period of analysis, running from January 1988 to May 2001, and the other time periods relating to the significant events in the international economy in the 1990s described earlier.

Where the results indicate that there is one significant principal component explaining a large part of the variance, i.e, associated with a high R^2, then there is evidence of some financial integration. Where there is more than one principal component and a low R^2 for the LPC, then there is less evidence of financial integration. The principal components results in Table 1 show that there is more than one significant principal component (i.e. with an eigenvalue greater than 1) in two of the three sub-periods when all of the countries studied are included, i.e. for the Group 1 results. The exception is in the period from January 1992 to June 1997, although even in this period the second largest principal component has a value very close to 1 (i.e. 0.991). For the remaining groups, only one largest principal component emerges in all cases, with the exception of Group 3 (the Asian countries studied) during the whole period of analysis, 1988 to 2001. However, for these countries again the second largest component is only a little under 1 in the sub-periods 1988 to 1991 and 1992 to 1997.

The cumulative R^2 values reveal the contribution of the principal components expressed as percentages of the variation in deviations from covered interest parity (CIP). Based on these results and the eigenvalues, we can conclude that there is little evidence of financial integration

across the seven financial markets during the entire period 1988 to 2001, but stronger evidence of financial integration across the European and to a lesser degree the Asian countries studied. The R^2 values for the LPC lie between 0.55 and 0.586 for the Group 1 results, but between 0.703 and 0.912 in the case of Group 2, i.e. Germany, France and the UK. Looking at the evidence on financial integration between Japan, Singapore and Hong Kong provided by the R^2 values, there is more support for a finding of financial integration occurring in the last sub-period investigated, 1999 to 2001, than in earlier sub-periods.

Table 1

Principal Components based on deviations from Covered Interest Parity *

	Group 1 ***All 7 countries***		***Group 2*** ***France, Germany, UK***		***Group 3*** ***Japan, Singapore, Hong Kong***	
Time periods	**Eigenvalue**	**Cum R^2**	**Eigenvalue**	**Cum R^2**	**Eigenvalue**	**Cum R^2**
1988M1 – 2001M1	3.519	0.586	2.321	0.774	1.438	0.479
	1.110	0.772	0.572		1.078	0.839
	0.894				0.483	
1988M1 - 1991M12	3.470	0.578	2.336	0.779	1.625	0.542
	1.558	0.838	0.608		0.928	
	0.628					
1992M1 - 1997M6	4.623	0.711	2.735	0.912	1.789	0.596
	0.991		0.222		0.986	
	0.444					
1997M7 - 2001M5	3.301	0.550	2.108	0.703	1.996	0.665
	1.670	0.828	0.835		0.655	
	0.498					

* The eigenvalues presented are the largest of the vector of variables considered and cum R^2 is the cumulative R squared. M refers to the month in each calendar year.

In order to further assess the extent of the financial integration achieved, augmented Dickey-Fuller (ADF) tests on the first largest principal component (LPC) were undertaken. The

results are provided in Table 2. It will be seen for Group 1 that the first LPC is not stationary, therefore again we only have weak evidence of financial integration across all seven countries. The same results of non-stationarity applies to the results for country Groups 2 and 3, except for Group 2 in the sub-period 1992 to 1997.

As shown in Table 1, Group 2 has one significant LPC in each period considered and the cumulative R^2 values reveal that the first LPC accounts for 70.3% to 91.2% of the variation in the deviations from covered interest parity across the entire study period. Linking the results in Tables 1 and 2, we can conclude, therefore, that there is support for the proposition that the Group 2 countries were achieving financial integration. However, this trend seems to have peaked in the sub-set period 1992 to 1997, after which both the eigenvalue for the LPC and the R^2 value are lower. The explanation for this result probably lies in the UK's decision to opt out of adopting the EU single currency when it was established in 1999. Finally, the results regarding Group 3 indicate that financial markets in Hong Kong, Japan and Singapore were converging particularly in the last sub-period.

Table 2:

ADF tests on the first LPC

		Group 1		**Group 2**		**Group 3**	
		All7 countries		***France, Germany, UK***		***Japan, Singapore***	
		Levels	**Differences**	**Levels**	**Differences**	**Levels**	**Differences**
1988M1 – 2001M1	**LPC1**	-1.2398	-10.7029*	-1.9793	-3.8261*	-2.3228	-6.4620*
1988M1 – 1991M12	**LPC1**	-1.2683	-6.0303*	-0.98741	-4.9839*	-1.2372	-4.6823*
1992M12 – 1997M6	**LPC1**	-2.0740	-3.4207*	-3.31*	-	-1.5331	-5.6891*
1997M7 – 2001M5	**LPC1**	-1.9792	-8.3535*	0.55397	-4.7238*	-1.5909	-7.3960*

* Test statistic significant at 95% level of confidence. M refers to the month in each calendar year.

Table 3 reports the factor loadings which apply to the first LPC. They are all positive with the exception of those for Hong Kong. The increasingly higher factor loadings for the UK, Germany and France (except for the last period) and Japan are consistent with the notion that these countries were increasing their financial integration. The reason that factor loadings became lower in the last period, 1997-2001, is almost certainly related to the fact that the European Monetary Union member economies in this period were integrating more with each other, as part of their long term goal of monetary union (particularly France and Germany who are part of the Euro zone, but also the UK which has yet to agree to monetary union). As a result,

in this last sub-period the EU countries appear to have less financial interdependence with other countries included in the study.

Table 3

Factor Loadings attached to the first LPC

	United Kingdom	Germany	France	Japan	Singapore	Hong Kong
			1988M1-2001M5			
Group 1	0.721	0.912	0.947	0.962	0.557	-0.190
Group 2	0.770	0.901	0.958	-	-	-
Group 3	-	-	-	0.864	0.823	-0.124
			1988M1-1991M12			
Group 1	0.560	0.970	0.971	0.969	0.562	-0.138
Group 2	0.738	0.967	0.925	-	-	-
Group 3	-	-	-	0.747	0.873	-0.553
			1992M1-1997M6			
Group 1	0.890	0.988	0.934	0.977	0.804	-0.146
Group 2	0.923	0.981	0.960	-	-	-
Group 3	-	-	-	0.938	0.935	-0.180
			1997M7-2001M5			
Group 1	0.820	0.696	0.712	0.810	0.848	0.512
Group 2	0.523	0.960	0.956	-	-	-
Group 3	-	-	-	0.792	0.887	0.76

M refers to the month in each calendar year.

4.2. The Cointegration tests

In order to carry out a cointegration test, we need primarily to examine whether the variables investigated, in this case real interest rates in the seven countries, have one or more unit roots. Results for the ADF tests and Phillips Perron (PP) tests are reported in Table 4. The main difference between the two tests lies in the Phillips and Perron test carrying out a non-parametric correction to the ADF statistics. The critical values for this test are the same (Pesaran and Pesaran, 1997). The tests ADF1 and PP1 include a constant but not a trend. ADF2 and PP2 include both a constant and a trend. The unit root tests for real interest rates are presented both in levels and in differences and the results indicate that they all have a unit root (with the exception of Singapore) - i.e. the variables are only stationary in differences. The statistics presented

regarding the order of augmentation of the Dickey-Fuller test are based on the Akaike Information Criterion (AIC) and correspond to an alternative adjusted form of R^2, with a different trade-off between goodness of fit and parsimony (Kennedy, 1998). The AIC minimises *ln(SSE/t)+2k/t*, where *ln* is the natural logarithm, *SSE* is the error sum of squares, *t* is time and *k* represents the number of explanatory variables.

Table 4

Unit root tests

Countries	*ADF test 1*		*ADF test 2*		*PP test 1*		*PP test 2*	
	Levels	**Differences**	**Levels**	**Differences**	**Levels**	**Differences**	**Levels**	**Differences**
US	-2.6348	-4.9012*	-2.7089	-4.9509*	-2.0567	-7.7164*	-1.5757	-6.9964*
UK	-1.6450	-3.4242*	-2.1533	-3.4522*	-0.65823	-13.2025*	-0.7730	-13.3892*
Germany	-1.5036	-4.5253*	-3.2867	-4.4256*	-0.42242	-13.5691*	-1.6080	-12.9191*
France	-1.1960	-4.4405*	-2.3782	-4.4225*	-1.0975	-12.0780*	-1.6913	-12.0785*
Japan	-1.1673	-3.1021*	-2.8033	-3.7297	-0.15403	-7.3589*	-1.0731	-7.6729*
Singapore	-2.0826	-8.0330*	-1.9044	-8.0786*	-3.5237*	-	-3.9105*	-
Hong Kong	-1.8795	-5.5408*	-1.8582	-5.5375*	-1.9483	-17.2549*	-2.0184	-17.1109*

* Statistically significant at a 95% level of confidence (95% critical value for ADF1 and PP1 statistic = -2.8811; 95% critical value for ADF2 and PP2 statistic = -3.4407).

Owing to the lack of clarity about whether or not the series as a whole is stationary (due to the fact that the results for Singapore appear to be stationary in levels in the PP tests and those for Japan are not stationary in differences based on one of the ADF tests, both at the 95% confidence level), an alternative test employed developed by Im, Pesaran and Shin (1997). While the ADF test is regarded as was considerably more powerful than other unit root tests, its power decreases with smaller samples for the alternative hypothesis H_1: $\delta = \delta_0 < 1$, when δ_0 is near unity and the Im, Pesaran and Shin (IPS) test is superior for use with panel data. The simple ADF test regards the size-power trade-off as dependent on the order of augmentation. This again does not constitute a problem in the IPS test.

The IPS test is based on the average of the individual unit root t-statistics and, in its most generalized version, which accounts for possible serial correlation between the disturbances in the Dickey-Fuller regressions, it takes the following form:

$$\Psi_{\bar{t}} = \frac{\sqrt{N\left\{\bar{t}_{NT}(p,\rho) - \frac{1}{N}\sum_{i=1}^{N} E\left[t_{iT}(p_i,0)\,|\,\beta_i = 0\right]\right\}}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} Var\left[t_{iT}(p_i,0)\,|\,\beta_i = 0\right]}}, \tag{7}$$

where $\bar{t}_{NT}(p,\rho) = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i,\rho_i)$ and $t_{iT}(p_i,\rho_i)$ corresponds to the individual t statistic for testing $\beta_i = 0$ in the following ADF (p_i) regressions:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \sum_{j=1}^{p_i} \rho_{ij} \Delta y_{i,t-j} + \varepsilon_{it}, \quad i = 1,...,N; t = 1,...,T. \tag{8}$$

The values of $E\left[t_{iT}(p_i,0)\,|\,\beta_i = 0\right]$ and $Var\left[t_{iT}(p_i,0)\,|\,\beta_i = 0\right]$ are reported in IPS (1997), evaluated via stochastic simulations.

Applying this test to the data, the results for $\Psi_{\bar{t}}$ are –19.0713 (with a constant but without a trend) and –19.0692 (with a constant and a trend). The values are both significantly above the critical values of -2.27 and –2.86 respectively, at the 99% confidence level. Indeed, the test statistic provides evidence that the series as a whole is stationary when the variables are in differences. Due to this finding, it is highly probable (although not certain) that the interest rates are cointegrated with each other. These results are in line with those reported in Aggarwal and Mougoue (1996) for Japan, Hong Kong and Singapore, using the Park and Sung (1994) procedure and with those reported by Alexakis et al. (1997) for certain other currencies, using the Phillips-Perron test.

In order to implement the Johansen Maximum Likelihood approach to test for cointegration, a general (unrestricted) vector autoregressive (VAR) model needs to be formulated. This summarily consists of regressing each variable in the model on all the other variables, lagged a number of times. The number of lags in the VAR system needs to be specified. The strategy adopted was again based on the Akaike Information Criterion (AIC), which suggested the use of only one lag. Another criterion which is very popular is the Schwarz Bayesian criterion (SBC) which also suggested a VAR of order 1. The results are reported in Table 5 and show that both the AIC and SBC tests identify this lag as having the highest value.

Table 5

Choice Criteria for selecting the Order of the VAR

Order	AIC*	SBC**	Order	AIC*	SBC**
0	-1599.0	-1609.5	*7*	-531.0307	-1056.7
1	**-463.4161**	**-547.5266**	***8***	**-535.3398**	**-1134.6**
2	-466.1048	-623.8120	*9*	-545.5206	-1218.4
3	-493.0549	-724.3588	*10*	-543.2889	-1289.8
4	-495.4174	-800.3179	*11*	-538.5092	-1358.6
5	-518.8832	-897.3804	*12*	-530.5763	-1424.3
6	-533.8775	-985.9714			

* AIC: Akaike Information Criterion; ** SBC: Schwarz Bayesian Criterion.

The final set of results presented are based on the maximum likelihood tests developed by Johansen (1988) and Johansen and Juselius (1990). These enabled us to conclude whether real interest rates in the international financial markets studied were indeed moving together in the long run. Table 6 reports the results. Both the trace and maximal eigenvalue test results are provided.

We first tested for cointegration among the real interest rates and for the whole period, 1988-2001, and for each of the sub-periods separately, as given in section 3. These results are shown in Table 6 (note that, for each sub-period the number of lags in the VAR system is specified).

Table 6

Multivariate cointegration tests: whole group, 1988-2001, and sub-periods

Whole period: 160 observations from 1988M2 to 2001M5.

Order of Var = 1.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	68.2951 (46.47)	205.2196 (132.45)
r<=1	r=2	47.8294 (40.53)	136.9245 (102.56)
r<=2	r=3	39.1941 (34.40)	89.0952 (75.98)
r<=3	r=4	25.1727 (28.27)	49.9010 (53.48)
r<=4	r=5	10.9108 (22.04)	24.7284 (34.87)
r<=5	r=6	8.3320 (15.87)	13.8175 (20.18)
r<=6	r=7	5.4855 (9.16)	5.4855 (9.16)

Test restriction (1,-1,-1,-1,-1,-1,-1,0): $\chi^2_{(15)}$=78.7703 [0.00]

Sub-period 1: 44 observations from 1988M5 to 1991M12.

Order of VAR=4.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	84.6796 (46.47)	270.0668 (132.45)
r<=1	r=2	68.9266 (40.53)	185.3872 (102.56)
r<=2	r=3	46.4044 (34.40)	116.4606 (75.98)
r<=3	r=4	28.8551 (28.27)	70.0561 (53.48)
r<=4	r=5	20.2308 (22.04)	41.2011 (34.87)
r<=5	r=6	14.2981 (15.87)	20.9703 (20.18)
r<=6	r=7	6.6722 (9.16)	6.6722 (9.16)

Test restriction (1,-1,-1,-1,-1,-1,-1,0): $\chi^2_{(16)}$=96.3041[0.00]

An intercept term was included in these tests ;
r is the number number of co-integrating vectors

Table 6 (continued)

Multivariate cointegration tests: whole group, 1988-2001, and sub-periods

Sub-period 2: 66 observations from 1992M1 to 1997M6.

Order of VAR=1

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	54.9006 (46.47)	187.3192 (132.45)
r<=1	r=2	43.6460 (40.53)	132.4186 (102.56)
r<=2	r=3	26.6567 (34.40)	88.7726 (75.98)
r<=3	r=4	24.1658 (28.27)	62.1159 (53.48)
r<=4	r=5	21.5113 (22.04)	37.9501 (34.87)
r<=5	r=6	11.1684 (15.87)	16.4389 (20.18)
r<=6	r=7	5.2705 (9.16)	5.2705 (9.16)

Test restriction (1,-1,-1,-1,-1,-1,-1,0): $\chi^2_{(12)}$=53.4757[0.00]

Sub-period 3: 47 observations from 1997M7 to 2001M5.

Order of VAR=5

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	126.1083 (46.47)	369.8838 (132.45)
r<=1	r=2	91.2092 (40.53)	243.7755 (102.56)
r<=2	r=3	70.4376 (34.40)	152.5663 (75.98)
r<=3	r=4	40.7671 (28.27)	82.1287 (53.48)
r<=4	r=5	21.9861 (22.04)	41.3616 (34.87)
r<=5	r=6	14.1500 (15.87)	19.3755 (20.18)
r<=6	r=7	5.2255 (9.16)	5.2255 (9.16)

Test restriction (1,-1,-1,-1,-1,-1,-1,0): $\chi^2_{(16)}$=191.4550 [0.00]

The number of cointegrating vectors provides an indication of how strong the relationship is between the countries' interest rates. The higher the number of cointegrating vectors, the stronger is the cointegration relationship. If six (i.e. $n - 1$) cointegrating vectors are obtained, then interest rate equalisation can be said to be present. The results supported the presence of convergence among the main financial centres, although the level of convergence is not as close to interest rate parity as exists for EU members in Holmes and Pentecost (1999) studying the period from January 1994 to March 1996. This is indicative of a continuing problem of exchange rate volatility in the international economy and resulting risk and uncertainty faced by economic agents. Nevertheless, as we move from the first period considered towards the last period, there is a visible increase in the number of cointegrating vectors.

Table 7 shows a similar analysis, but now concentrating upon the different sub-groups of countries, as described earlier in section 4.1. These results support those found for the whole group: there is evidence of some convergence within each sub-group, but the evidence is not sufficiently strong to allow us to argue for the existence of complete financial integration. Complete integration would be consistent with the final test statistic in each sub-group being significant. This is never the case.

Finally, Table 8 shows the results obtained from bivariate tests with the USA, i.e. UK with USA, Germany with USA, Japan with USA, etc.. These confirm the findings shown in Table 6 and 7, except for the case between the USA and France, where financial market integration is not present. This appears to indicate (not surprisingly) that French monetary policy in the 1990s was significantly independent from that of the USA and was mainly related to European, and especially German, interest rate policy.

Table 7

Multivariate cointegration tests: sub-groups of countries for period 1988-2001

1. Sub-group 1: Germany, UK and France

160 observations from 1988M2 to 2001M5. Order of VAR=1.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	33.2520 (22.04)	59.4335 (34.87)
r<=1	r=2	21.0488 (15.87)	26.1815 (20.18)
r<=2	r=3	5.1327 (9.16)	5.1327 (9.16)

Test restriction (1,-1,-1,,0): $\chi^2_{(4)}$=20.1537 [0.00]

2. Sub-group 2: Japan, Singapore and Hong Kong

153 observations from 1988M9 to 2001M5. Order of VAR=1.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	28.8924 (22.04)	56.3754 (34.87)
r<=1	r=2	26.4775 (15.87)	27.4830 (20.18)
r<=2	r=3	1.0055 (9.16)	1.0055 (9.16)

Test restriction (1,-1,-1,,0): $\chi^2_{(4)}$=48.6261 [0.00]

3. Sub-group 3: US, Germany, UK and France

160 observations from 1988M2 to 2001M5. Order of VAR=1.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	38.8461 (28.27)	89.4598 (53.48)
r<=1	r=2	34.6475 (22.04)	50.6138 (34.87)
r<=2	r=3	11.2439 (15.87)	15.9662 (20.18)
r<=3	r=4	4.7224 (9.16)	4.7224 (9.16)

Test restriction (1,-1,-1,-1,0): $\chi^2_{(6)}$=39.6692 [0.00]

Table 7 (continued)

Multivariate cointegration tests: sub-groups of countries for period 1988-2001

4. Sub-group 4: US, Japan, Singapore and Hong Kong			
159 observations from 1988M3 to 2001M5. Order of VAR=2.			
Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	31.4418 (28.27)	78.3144 (53.48)
r<=1	r=2	27.0091 (22.04)	46.8726 (34.87)
r<=2	r=3	17.0814 (15.87)	19.8635 (20.18)
r<=3	r=4	2.7821 (9.16)	2.7821 (9.16)
Test restriction (1,-1,-1,-1,0): $\chi^2_{(6)}$=46.7326 [0.00]			

An intercept term was included in these tests.

Table 8

Bivariate cointegration tests

1. US and RRUK

157 observations from 1988M5 to 2001M5. Order of Var = 4.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	24.4942 (15.87)	28.4615 (20.18)
r<=1	r=2	3.9674 (9.16)	3.9674 (9.16)

Test restriction (1,-1,0): $\chi^2_{(2)}$=16.4845 [0.00]

2. US and Germany

159 observations from 1988M3 to 2001M5. Order of Var = 2.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	21.2298 (15.87)	29.3608 (20.18)
r<=1	r=2	8.1310 (9.16)	8.1310 (9.16)

Test restriction (1,-1,0): $\chi^2_{(2)}$=9.5141 [0.00]

3. US and France

157 observations from 1988M5 to 2001M5. Order of Var = 4.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	9.1951 (14.88)	10.8090 (17.86)
r<=1	r=2	1.6139 (8.07)	1.6139 (8.07)

Table 8 (continued)

Bivariate cointegration tests

4. US and Japan

157 observations from 1988M5 to 2001M5. Order of Var = 4.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	21.4480 (15.87)	23.4070 (20.18)
r<=1	r=2	1.9590 (9.16)	1.9590 (9.16)

Test restriction (1,-1,0): $\chi^2_{(2)}$=20.9785 [0.00]

5. US and Singapore

158 observations from 1988M4 to 2001M5. Order of Var = 3.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	22.6078 (15.87)	24.7731 (20.18)
r<=1	r=2	2.1653 (9.16)	2.1653 (9.16)

Test restriction (1,-1,0): $\chi^2_{(2)}$=20.8548 [0.00]

6. US and Hong Kong

154 observations from 1988M8 to 2001M5. Order of Var = 2.

Hypothesis		*Test Statistic (95% Critical Value)*	
Null	*Alternative*	*Eigenvalue Test*	*Trace Test*
r=0	r=1	18.3092 (15.87)	19.7815 (20.18)
r<=1	r=2	1.4723 (9.16)	1.4723 (9.16)

Test restriction (1,-1,0): $\chi^2_{(2)}$=7.9647 [0.01]

An intercept term was included in these tests.

5. Conclusions

This study has investigated whether international financial markets integrated between 1988 and 2001 by analysing interest rate convergence across the seven major financial centres, namely the USA, UK, France, Germany, Singapore, Hong Kong and Japan. Two main methods were adopted to examine whether interest rates had moved closer together. Principal components analysis is based on studying the largest principal component and covered interest rate differentials were used in order to determine whether financial integration was occurring. When all of the countries as a single group were analysed, according to the principal components analysis there was no evidence of greater financial integration over the entire period studied. Evidence for financial integration was found for only one of the sub-periods, 1992 to 1997. However, looking at sub-groups of countries, the story is more complex. There is evidence of financial integration amongst the European countries included in the study, namely the UK, France and Germany, between 1988 and 2001. The latter result reflects that these economies are all members of the EU. Their monetary policies have become more closely linked over time in preparation for European Monetary Union, although the UK's failure to adopt the Euro in 1999 led to a slight easing of financial integration between the UK, France and Germany after 1997. Turning to the Asian economies in the study, namely Japan, Hong Kong and Singapore, the results for the sub-periods provide some evidence of more integration between these countries' financial centres, in this case especially in the later years.

The cointegration analysis added to the conclusions from the principal components method. Real interest rate relationships across the financial centres studied increased over time, suggesting increasingly closer integration of the main international financial markets. The results from the study suggest that further international financial integration did occur during the 1990s with implications for exchange rates and domestic monetary policy. At the same time, however, the results confirm that complete integration was far from having been achieved by 2001. Therefore, while there are some differences between the results for the two statistical methods used, with the cointegration study finding more evidence than the principal components analysis of closer financial integration across all of the financial markets included, both methods highlight the greater integration achieved between the main European financial markets and, to a lesser degree, between the main Asian markets.

The results from this study add to the findings of the studies reviewed earlier on international financial integration. They suggest that there is some evidence of a gradual trend towards more financial integration after 1988 but mainly concentrated on integration at the regional level. Also, the period from 1997 to 2001 provided evidence of some reduced integration when considering all seven financial markets together. This was at the time when some of the European financial markets were more closely integrating. This finding leads to the tentative suggestion that while the liberalisation of money and capital market transactions internationally has led to some further financial integration, the development of regional monetary unions, notably in the EU may have led to some reduction in wider international financial integration. Clearly, this is a controversial finding and deserves much more research.

The research needs to focus on how regional monetary unions might adversely affect financial integration with non-member countries.

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Footnotes

[1] For instance, Visco (2001, p. 3) to the House of Lords' Inquiry into the global economy claimed that "globalisation offers an opportunity to improve well-being in both developing and developed countries" through a variety of indicators that promote closer economic linkages among OECD countries. A similar approach was endorsed by Ambassador Valaskakis (2003) at the G8 Pre-Summit Conference on Governing Globalisation, Dr. Sathirathai, Minister of Foreign Affairs of Thailand at the United Nations Conference on Trade and Development (2002) and Alan Greenspan (US Federal Reserve chairman) at the Banco de Mexico's 75th Anniversary Conference in Mexico (2000).

[2] In his study, Throop uses regression analysis on equations relating US interest rates to comparable foreign interest rates. Other studies which use regression analysis are Cumby and Mishkin (1986), Mark (1985), Merrick and Saunders (1986) and Marston (1995).

[3] A number of other countries started to privatise and deregulate industries such as telecommunications in the late 1980s and early 1990s.

[4] Rapid inflation and the powerful bargaining power of unions in the 1970s led to the labour market reforms started by the Conservative government in the UK in 1979, which were then followed by a number of other Western European countries.

[5] One of the issues associated with reform of competition policies is the close link between competition and international trade. Indeed, disparities in national laws may lead, for instance, to the creation of secondary import barriers, increased complexity in the territorial effects of commercial decisions and conflicts of "laws".

[6] Jorgensen et al. (2001) examined the share of EU intra- and extra-trade between 1965 and 1998 and concluded that throughout the period there was a steady increase in intra-EU exports as a percentage of total exports in the 15 member states of the EU. This is a sign of possible trade diversion but trade creation was also responsible for part of the increase.