Economic and Social Review Vol. 9 No. 4

A Quantitative Analysis of the Degree of Integration between Irish and UK Financial Markets

FRANCIS X. BROWNE
THOMAS O'CONNELL*
Central Bank of Ireland

I INTRODUCTION

In this paper, we investigate the quantitative relationship between Irish and UK interest rates. With varying degrees of emphasis, it is frequently stated that Irish interest rates mirror UK rates and can be treated, therefore, as exogenous, given the present exchange rate policy and the high degree of capital mobility between Ireland and the UK. It is easy to see why economists have focused on this question; as, for example, Branson (1976) shows in an elegant paper, the independent use of monetary policy in the sense of regulating the money supply requires that a central bank be able to regulate some domestic interest rate. If this *is* the case, a central bank can control the money stock by engaging in open-market operations on the financial asset whose interest rate it can alter. A by-product of the paper is evidence on the lags in the adjustment of Irish to foreign (UK) interest rates.

Before proceeding to the empirical sections of the paper, we note that two ways of measuring the degree of financial market integration have appeared in the literature. One approach focuses on the sensitivity of capital flows to interest-rate differentials (for example, see Hodjera, 1973); the second examines the relationship between interest rates in various countries. The two approaches are essentially equivalent in that capital flows tend to equate asset prices (and thus interest rates) in different countries.

*We wish to thank several colleagues at the Central Bank, two anonymous referees, and Dr. R. C. Geary for helpful comments on an earlier draft. The usual disclaimer applies.

The theoretical framework for the second of these approaches is the interest parity relation whereby interest-rate differentials on assets of comparable risk are related to the forward premium or discount on one of the two currencies of asset denomination *vis-à-vis* the other. (For an interesting empirical study of actual deviations from interest parity allowing for transactions costs, see Frenkel and Levich (1977).) In their wide-ranging paper, Logue *et al.* (1976) note two different empirical techniques for measuring the extent of financial integration. The first of these consists simply in employing measures of dispersion such as the standard deviation for examining the degree of similarity in interest rate levels among countries at different points in time. There are a number of deficiencies in such summary statistics, the most serious in the present context being that no account is taken of lags in the adjustment of interest rates across countries. In the second empirical technique, Logue *et al.* (1976), concentrating on *changes* in interest rates, employ factor analysis to measure the covariability of interest rates among countries; their conclusion is that certain common factors can be shown to have explained a large part of the fluctuations in interest rates in different countries over time.

In later sections of this paper, in the spirit of the second approach above, we describe and graph recent movements in interest rate levels in the UK and Ireland. Subsequently, we use cross-spectral methods to decompose interest rate time-series into their different frequency components, i.e., long-run or trend components and shorter cyclic fluctuations, in order to examine cross-covariances (cross-correlations) between interest rates. This technique is more powerful than the covariability analysis of Logue *et al.,* in that it enables us to establish in quantitative terms the relationship between interest rate movements in Ireland and the UK, identifying any lags if they exist. (The present exercise could be supplemented by applying formal tests of causality (see Granger, 1969), however, given the relative size of the two financial markets, it is clear that influences run from UK to Irish financial markets with negligible feedback.)

II RECENT TRENDS IN IRISH AND UK INTEREST RATES

In this section, we review recent developments in Irish interest rates and corresponding UK rates weekly (normally Friday figures) and illustrate them graphically. The time period covered is from January 1972 to December 1977, but, because of the non-availability of the data in the earlier part of the period, a number of the series start in early or mid-1973.

The interest rates selected for comparison are the deposit and overdraft rates for the Associated Banks and London Clearing Banks, Exchequer Bill

Chart A: 7-DAY INTER-BANK RATE

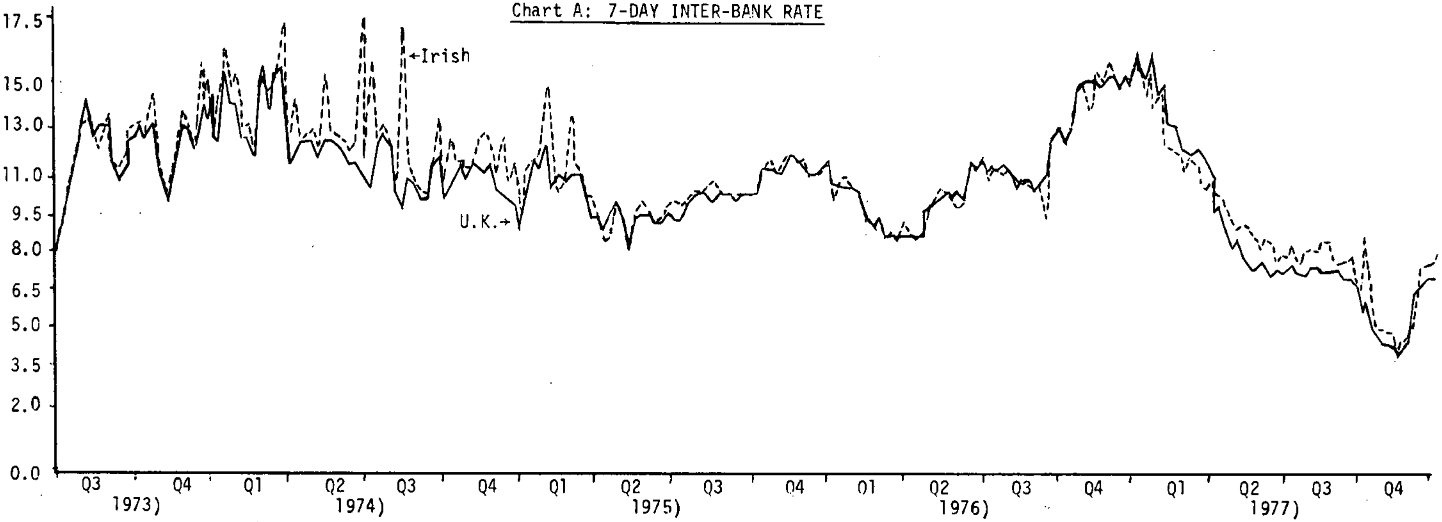


Chart B: 3-MONTH INTER-BANK RATE

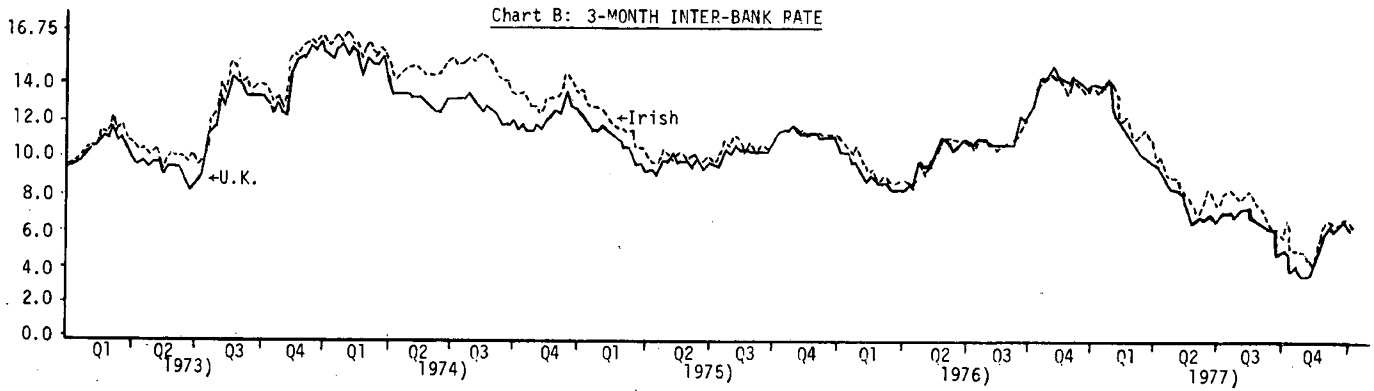


Chart C: COMMERCIAL BANKS' DEPOSIT RATES

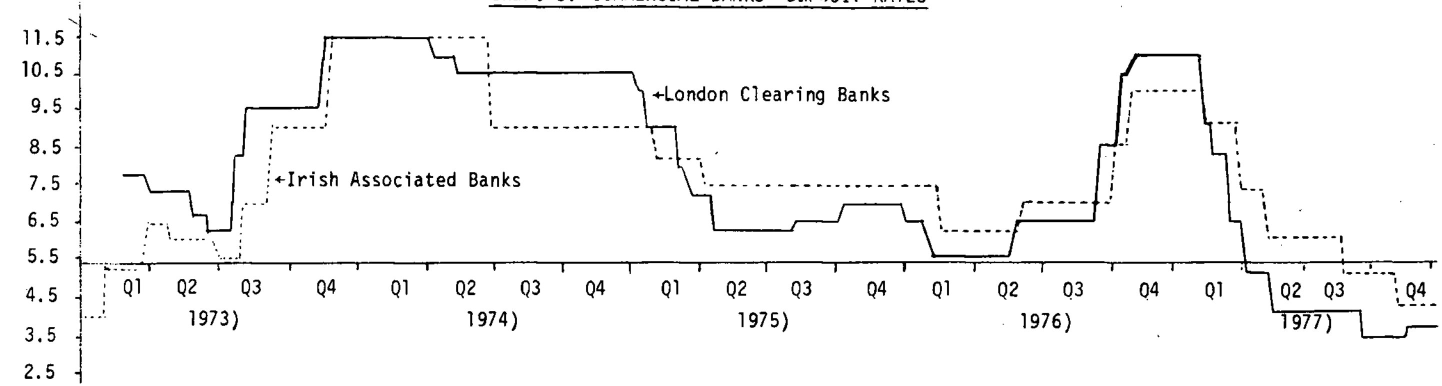
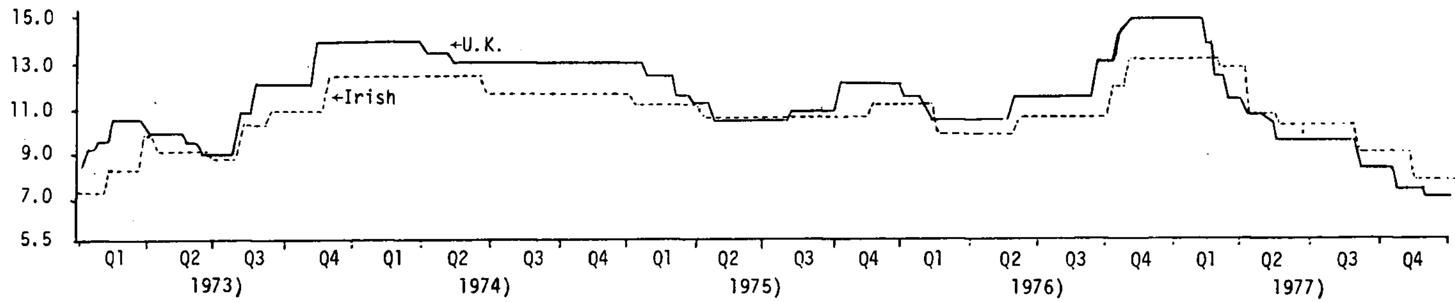


Chart D: COMMERCIAL BANKS' PRIME LENDING RATES



Rate and the UK Treasury Bill Rate, Inter Bank Market Rates – both 7 day and 3 months – and the Building Societies' Share Accounts and Mortgage Loan Rates.

The several pairs of Irish and UK interest rates fall into two categories. In the first category, the pair of interest rates practically coincide for most observations. In this category are the following pairs of interest rates: inter-bank rates, Exchequer Bill and UK Treasury Bill rates (90-day Government paper). In fact, the Exchequer Bill rate is set by reference to short-term rates in the UK (Central Bank, 1975, p. 87). The second category relates to those pairs of interest rates which are not so closely correlated. Bank deposit rates, bank lending rates and building society rates follow this pattern. While for these rates, the Irish one follows the general trend of the corresponding UK rate, a significant discrepancy is evident on several occasions.

Trends in Irish inter-bank rates, both 7-day and 3-month, and in commercial bank lending and deposit rates and their corresponding UK counterparts are illustrated in charts A to D. To conserve space, neither 90-day Government paper rates nor building society rates (which display the same general pattern as commercial bank rates) are graphed. We have not examined yields on Irish and UK Government bonds because the requisite yields to maturity are not available.

III SPECTRAL ANALYSIS OF INTEREST RATES

In this section, we complement the informal descriptive account of movements in Irish and UK interest rates by a more formal analysis using spectral methods.

III. 1 Spectral and Cross-Spectral Methods

The central idea underlying spectral analysis is that any time series can be represented by a weighted sum of many cosine and sine functions without leaving a residual. These cosine and sine components are uncorrelated and, since each component is associated with a cycle of a particular length (whose inverse is the frequency of that cycle), this representation of a time-series enables us to study the various cyclical components of the series. A graph of the weighted sum against frequency (w) is called the "power-spectrum" of the series. A large value of this function at a particular frequency ($w = w_1$, say) indicates that the time series has an important cycle at frequency $w_1/2\pi$, or, interpreting this in the time domain, that the series has a cycle length of $2\pi/w_1$ time units. Thus, we can use the estimated power spectrum to analyse a single time series. Inspection of the sample power spectrum can be quite revealing with respect to the characteristics of the time series. If, for example, the sample power spectrum is flat, we can infer that the time series is made up of an infinite number of cycles, all having the same importance, i.e., that the series is a "white noise" series.

A prerequisite for the application of spectral analysis is that the series be stationary, i.e., essentially trend-free in the mean and the variance. Strict stationarity requires that the underlying probability model be invariant over time. If the non-stationary character of the series is due to a trend, for example, then most of the power of the sample spectrum will be concentrated at low or zero frequency (corresponding to a cycle length of infinity). These large concentrations of power at low frequencies may bias the estimates of power at frequency levels containing less power.

The theoretical power spectrum of a single series is given by a relatively simple transformation of the autocovariances:

$$f(w) = \frac{1}{2\pi} \sum_{k=-\infty}^{\infty} \gamma(k) \exp(-i w k), \quad -\pi \leqslant w \leqslant \pi \tag{1}$$

where $\gamma(k)$ is the autocovariance function which is assumed to depend only on k, the distance between observations in time. (This, in fact, is a Fourier transform of the autocovariances.)

Given that the autocovariance function is symmetric about k=0, similarly the power spectrum will be symmetric about w=0 and can be written as (Harvey, (1975)):

$$f(w) = \frac{1}{2\pi} \left\{ \gamma(0) + 2\sum_{k=1}^{\infty} \gamma(k) \operatorname{Cos} w k \right\}$$

In effect, by using a periodic weighting function exp $(-i w k)$ or cos $(w k)$, the spectral density function picks up periodic movements in the autocorrelation function which themselves mirror precisely the periodicities in the time-series itself. A good intuitive discussion of this appears in Chow (1975, Ch. 4).

The power spectrum can be plotted against frequency w, which ranges from 0 to π. In order to assist with the interpretation of the spectrum, we can think of it being plotted against period P, where P is equal to $2\pi/w$ and thus obviously ranges from ∞ to 2. Thus, for example, a large value of the spectrum at zero frequency (i.e. w=0), indicates the presence of a cycle of infinite length or, in other words, a trend.

In this paper, we are focusing attention on the interrelationship between *pairs* of series rather than on the internal structure of a single series. With a pair of series, instead of the autocovariance in the single series case, we use the cross-covariance between the two series to which is applied the periodic weighting function as in the single series case. This leads to the employment of the cross-spectral density function as a means of studying the relationship between the pair of series. The cross-spectral density is given by:

$$f_{12}(w) = \frac{1}{2\pi} \sum_{k=-\infty}^{\infty} \rho_{12,k} \exp(-iwk) \quad (2)$$

where $\rho_{12,k}$ is the cross-correlation or normalised cross-covariance between the first series y_{1t} and the second series $y_{2,t-k}$. It will be noted that the possibility of a lagged relationship exists, and must be taken into account. (In fact, as we will see below, the cross-spectral analysis enables us to find the length of the lagged relationship, if any.)

Analogously to the single series case, the cross-spectral density uses the periodic weighting function to pick up periodic movements in the cross-correlation function, which in turn mirror the common periodicities in the two time-series. The cross-spectral density shows the degree of association between specific periodic components in the two series after adjustment for phase lag, if necessary.

Three statistical measures are available, which summarise the content of the cross-spectrum: these are the *coherence, gain* and *phase*. Briefly, the coherence is analogous to the R^2 in multiple regression and the gain is analogous to the regression coefficient in the regression of a specific periodic component of the first series on the same component of the second series. The phase angle indicates the extent to which the frequency component in one series leads or lags the same component in the second series.

III.2 Estimation of the Cross-Spectrum: Practical Problems

A number of practical problems arise in applying cross-spectral methods to actual time-series. The first such problem may be non-stationarity of the time-series being analysed; traditionally, spectral and cross-spectral densities are defined only for (covariance) stationary series. The principal requirement for covariance stationarity of a time-series is a stationary or constant mean or expected value. A feature of many economic time-series is their strong trends. Application of cross-spectral analysis to a pair of time-series with strong trends would result in the cross-spectral density taking on large values at zero or very low frequencies (reflecting long cycles) and low values at high frequency. This concentration of power causes a loss in efficiency in the estimation method.

A simple transformation of the original data, such as taking first differences, for example, may render a trended series stationary in the mean. The cross-spectrum of the transformed or filtered series can then be estimated efficiently, and the cross-spectrum of the original series recovered from that of the filtered series.

A second problem in the estimation of the cross-spectrum is the fact that, although the sample estimator of the cross-spectrum is asymptotically unbiased, its estimated variance does not go to zero as the number of observations go to infinity. Thus, it is possible that some peaks and troughs in the sample cross-spectrum at some frequencies may be incorrectly indentified as being due to a systematic cyclical relationship between the two series at those frequencies while, in truth, they are due to random sampling.

A method for obtaining a consistent estimate of the cross-spectral density is to apply a set of weights to the sample cross-correlation functions in equation (2), before performing the Fourier transform. The weighting function is called the *lag window* (see Chow (1975), p. 92).

It was pointed out earlier that a prerequisite for the application of cross-spectral methods is that the time-series be stationary. However, this is only a necessary condition. Ideally, each individual series should be prewhitened before applying cross-spectral analysis (see Jenkins and Watts (1968), Ch. 8). The reason for this is that the variance of the cross-covariance estimator is an increasing function of the autocovariances within each series. However, for a series which has been transformed by first or second differencing in order to induce stationarity in the mean, we might expect the coefficients of autocorrelation to be small, and thus the resulting distortion of the variance to be small. (The effect of detrending on the stochastic component of the series, the so-called Slutsky-Yule effect, can be assumed to be small for first or second differences.)

In order to obtain the white noise series corresponding to each interest rate series, a search procedure must be carried out to identify the most appropriate ARIMA model to fit each interest rate series. Given the time-consuming nature of this task, and given the fairly obvious manner in which the interest rate series are related, we have not proceeded to do this. In the event, however, the individual power spectra of the various interest rate series indicated that first differencing of the series was sufficient to reduce the series to white noise.

III.3 Cross-Spectral Analysis of Irish and UK Interest Rates

We have tested for trends in our interest-rate series by applying the Kendall rank test. This consists in taking a series $u_1, \ldots u_n$ and counting the number of cases, P, for which $u_j > u_i$ for $j > i$. Kendall (1973, p. 26) has shown that the expected number in a random series is $N(N-1)/4$. The excess of P over this number, if significant, suggests a rising trend; a deficiency suggests a falling trend. Using a specially-written computer program, we have computed Kendall's test statistic Z for the original interest-rate series, and for their first, second and third differences. Taking first, second and third differences corresponds to eliminating a linear, quadratic and cubic trend, respectively. The requisite degree of detrending is undertaken for each series, once an insignfiicant Z-value is obtained. The results of Kendall's test are recorded in Table 1.

It can be seen from the table that only the rates on 90-day Government paper can be regarded as trend-free in their original interest rate levels. First differencing is adequate for removing the trend from inter-bank market rates, both 7-day and 3-month, while differencing appears to be ineffectual for removing apparent trends in commercial bank and building society rates. (For the two-tailed test, the critical region for rejecting the null hypothesis of no trend is, for a Type I Error of 5 per cent, the set of Z's greater than 1.96 in absolute value.) Several features of the results should be noted. First, with one or two exceptions, the values of Z for comparable interest rates in Ireland and UK are very similar. Secondly, for the deposit and lending rates of commercial banks, the reason why the Z values suggest an emphatic negative trend is that these interest rate time-series are step-functions. For such series, the number of times for which, in a time-series $u_1, u_2 \ldots\ldots u_n$, $u_j > u_i$ for $j > i$ will be small; this gives rise to a large negative value of Z suggesting a downward trend. The difficulty in applying probability models to a time-series which behaves like a step-function is that the stochastic or random element in the series is attenuated; the number of changes in the series relative to the number of observations is very small.

Table 1: *Values of Kendall Z for original interest rate series and first and second differences*

Interest rate series	*Original*	*First difference*	*Second difference*
Assoc. Bank Deposits Rate (£5–£25,000)	–6.41	–18.22	–15.86
UK Bank Deposits (£10–£25,000)	–7.39	–15.84	–12.99
Irish Prime Lending	–3.07	–17.94	–15.52
UK Prime Lending	–2.75	–16.02	–13.48
Exchequer Bill	–0.12	–	–
UK Treasury Bill	0.76	–	–
7-day Inter-bank – Irish	–2.34	0.13	–
7-day Inter-bank – UK	–1.02	0.50	–
3-month Inter-bank – Irish	–4.45	0.06	–
3-month Inter bank – UK	–3.16	1.04	–
Irish Building Society – Share Account	–6.50	–20.47	–19.32
UK Building Society – Share Account	–6.30	–20.31	–18.52
Irish Building Society – Mortgage	6.38	–19.92	–18.92
UK Building Society – Mortgage	–6.16	–20.45	–18.92

We have applied cross-spectral analysis to five pairs of series: 7-day inter-bank rates, 3-month inter-bank rates, Exchequer Bill and UK Treasury Bill rates, Associated Bank and London Clearing Bank deposit rates and, finally, Irish and UK prime lending rates. (Since the pattern of building society and commercial bank interest rates is very similar, we have confined our attention to data on the latter). For those series for which the Kendall test is applicable, the degree of differencing used on the various interest rates is that suggested by Table 1.

(1) *7-day Inter-Bank Rates*

The power spectra for both the Irish and UK rate are large for very low frequencies indicating a long cycle or trend. In order to increase the efficiency of estimation (see section III.2 above), first differences of both series are taken; the power spectra of the transformed series have the desirable property of a random or white noise series, which has a flat power spectrum. The lag window used to obtain consistent estimates of the cross-spectrum was of the Parzen type with M = 35 lags. The number of lags conforms to the rule of thumb recommendation of Fishman (1969, p. 98) that it should not exceed one-third the number of observations.

The *cross-correlations* for the two interest rates exhibit a large value (0.5) for the contemporaneous cross-correlation and very small values for both lagged and lead cross-correlations. The plot of the *coherence* for the two series is given in Figure 1 and indicates a very high and significant degree of correlation between long-run components in the two series with the coherence falling for higher frequency components. In the diagram, the dotted line defines the 95 per cent confidence region; below this line the estimated coherence is not significantly different from zero at the 5 per cent significance level. The coherence is not significant for periodicities of less than 4 weeks and there is a large drop in the size of the coherence at the 6 week periodicity, a feature that cannot be explained readily.

A plot of the *phase angle* is presented in Figure 2. The small deviations from the horizontal axis is evidence in favour of there being no lag in the adjustment of the Irish to the UK rate and corroborates the findings for the cross-correlations. The dotted lines are 95 per cent confidence bounds; they have been drawn only for those periodicities (8 weeks and longer) for which the coherence is significant at the 5 per cent level. The phase graph lies well within the confidence bands and is supportive of a contemporaneous relationship between Irish and UK rates. For the low frequency components (reflecting the long-run relationship between the two interest-rate series), the *gain* is not significantly different from unity, indicating that all the variation

Figure 1. Coherence between UK and Irish 7-day inter-bank rates (N=201, M=35)

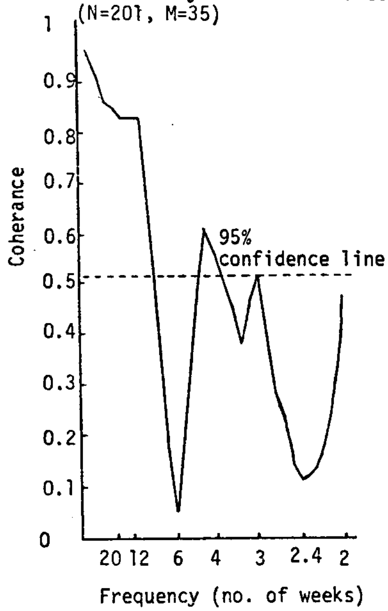


Figure 2. Phase Spectrum - UK and Irish 7-day inter-bank rates

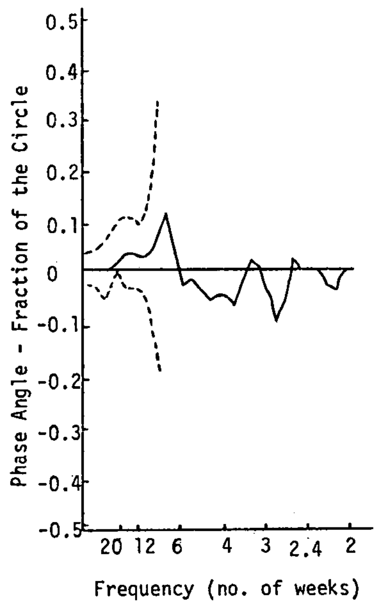


Figure 3. Coherence between UK and Irish 3-month inter-bank rates (N=201, M=35)

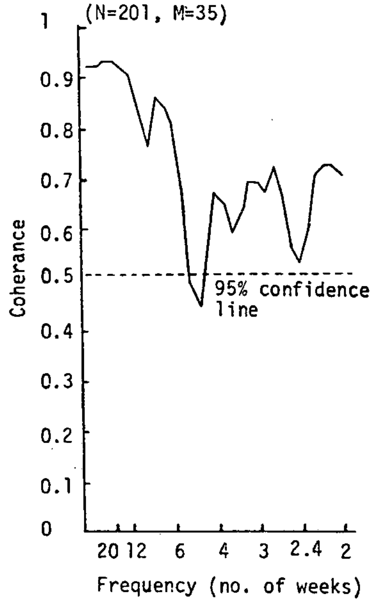
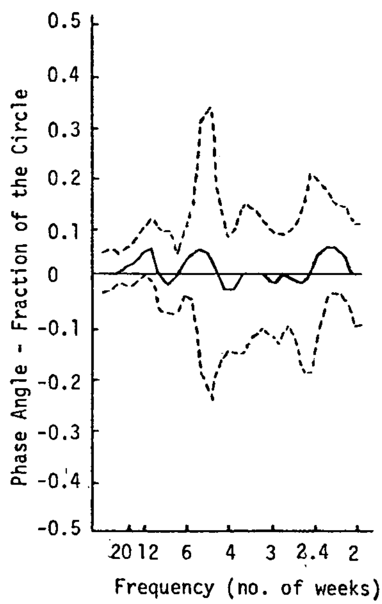


Figure 4. Phase Spectrum - UK and Irish 3-month inter-bank rates



in the UK rate is transmitted to the Irish rate in the long-run (defined as 8 weeks and longer).

One might have expected, on *a priori* grounds, a larger and significant coherence for higher frequency components – i.e., a closer relationship between short-run movements in the series – reflecting arbitrage between Dublin and London markets. The low coherence at high frequency may be accounted for by the comparatively independent movements of the two rates in 1974 (see graphs in Section II).

During 1974, there was a crisis of confidence in the London inter-bank market. This inevitably had repercussions on the Dublin market. In the words of the 1975 Annual Report of the Central Bank (p. 46): 'there was some lack of confidence in banks that were not members of large banking groups, and the (Central) Bank was concerned that this could endanger the stability of smaller banks and of the banking system as a whole'. In addition, during this period the requirement that 50 per cent of net inflows be placed with the Central Bank was still in operation, although this was waived in the case of some inflows from parent banks. Both of these factors (differential risk premia and penalties on inflows) served as a buffer in dampening the influence of UK rates on Irish rates, with the result that large divergences are evident between the two rates; as is evident from the jagged nature of the graph in Section II, however, these divergences, although large, did not persist for longer than 3 to 4 weeks.

(2) *3-Months Inter-Bank Rate*

As with the 7-day inter-bank rates, the individual spectra for the first differences of the three month inter-bank rates are virtually flat indicating that the null hypothesis, that the first difference of both series is white noise, is acceptable: thus the distortion to the estimated cross-spectrum arising from significant autocorrelations in each of the individual series will not arise.[1]

The estimated coherence is significant (at the 5 per cent level) at all frequencies except for one in the region of the five weeks periodicity. Although remaining significant, the coherence falls in value as we approach the high frequency components (see Figure 3). The hypothesis that the phase spectrum is uniformly distributed (indicating no lag in adjustment of the Irish rate to the UK rate, see Figure 4) is easily acceptable at the 5 per cent level of significance. Thus, the two processes are cross-correlated only simultaneously. Separate computations indicate that the gain (or regression coefficient between corresponding frequency components) is not signifi-

1 No statistical tables for individual spectra were available to the authors.

cantly different from unity; this implies that the magnitude of the fluctuation in the UK rate is completely transmitted to the Irish rate.

The results for the 3-months inter-bank rate are a very close approximation to what Jenkins and Watts (1968) call the fundamental model for cross spectra which is characterised by high and significant coherences at all frequencies, zero phase angle and constant gains. The time domain interpretation of this model is that of complete and instantaneous determination of the Irish 3-month inter-bank rate by the UK 3-month inter-bank rate.

(3) *90-day Government Paper Rate*

The analysis of the 90-day Government paper rates is brief for two reasons. First, the Exchequer Bill rate is only available monthly – the assumption imposed, therefore, is that this rate persists for the three subsequent weeks – and, secondly, as pointed out in a recent Central Bank Report (1975, p. 87), the Exchequer Bill rate is set, in fact, by reference to short-term UK rates.

The Kendall Z-statistic for the two 90-day rates suggests the absence of a trend, although the individual spectra do suggest autocorrelation in the two series. This apparent inconsistency could be explained by a small positive value of the autocorrelation coefficient or, alternatively, by a negative autocorrelation coefficient giving rise to an oscillatory series. This explanation is supported by the similarity of the results obtained from a cross-spectral analysis of the original series and their first differences.

The coherence at both low and high frequencies indicates that long run cyclical components and very short run cyclical components move together in the two series. The estimated coherence is very close to zero for most of the intervening frequencies. The phase diagram is interesting in that it is the only phase diagram investigated for which the 95 per cent confidence interval *does not* include zero phase angle of some frequency. The lag in time units is in the region of two to three weeks for long-run cyclical components (i.e., periodicities greater than 12 weeks) and is almost exactly four weeks for long-run trend. Clearly, both the trend phase lag of 4 weeks and the very low value for coherence in the 2.4 to 6 weeks periodicity range is reflective of the fact that the issue rate on Exchequer Bills is available only monthly and is set by reference to the Treasury Bill rate.

(4) *Bank Deposit Rates*

It was noted in Section II that, while, generally, deposit rates of Irish and UK banks move together, discrepancies can arise and these are not always of the same sign. (In the following, we focus on the Associated Bank interest rate on deposits of £5,000 to £25,000 and the London Clearing Bank interest rate on deposits of £10,000 to £25,000.) For the period studied, i.e., from the second half of 1973 through 1976, the cumulative change in the Irish deposit rate was 0.5 percentage points more than in the UK. Since, at the start of the period, the UK rate was a good deal higher than the Irish one, it was to be expected that the gap would be closed somewhat. It is interesting to note that, during the period studied, there were 23 changes in the UK rate, while the number of changes in the Irish rate was just in excess of half of this, 13. This could be explained by the requirement that, before altering their rates, Irish banks consult with the Central Bank, as well as a desire, on the part of Irish banks, to minimise the administrative costs of changing interest rates by delaying such changes until a series of anticipated adjustments in UK rates have taken place.

In the case of 6 of the 13 changes in the Irish rate, there was more than one previous change in the UK rate since the immediately preceding change in the Irish rate, although in only two instances were there more than two such changes in the UK rate. If we consider only the final alteration in the UK rate between changes in the Irish rate, the average lag in the adjustment of the Irish rate works out at less than two weeks. If we consider all changes in UK rates (except for one instance where a large change in the UK rate was reversed shortly afterwards), the average lag in the adjustment of the Irish rate to the UK rate is just less than 5 weeks.

It was noted earlier that, because of the limited variability of the deposit-rate series, the robustness of cross-spectral analysis may be reduced somewhat. In the event, the cross-spectral analysis corroborates the informal evidence outlined in the previous paragraph.

The coherence diagram (see Figure 5) indicates that only the low frequency components corresponding to periodicities of 12 weeks and greater are significantly correlated. There is a large peak (.47) in the coherence of approximately the 3 week periodicity but it falls short of the 95 per cent lower confidence bound. Thus, there appears to be some degree of independent variability in the Associated Banks' deposit rate for periodicities of up to 10 weeks with convergence between changes in the Irish rate and the UK rate being achieved for periodicities of greater than 12 weeks, i.e., in the long-run. Fitting a 95 per cent confidence interval for the gain over the frequency components for which coherence is significant, indicates that it is not significantly different from unity suggesting that the total variation in the UK rate is eventually transmitted to the Irish rate in the long-run.

It can be shown (see Jenkins and Watts (1968), p. 350) that the sampling error of the estimated phase spectrum at a given frequency is inversely related to the (true) coherence between the series at that frequency. Since the estimated coherence is consistent, it follows that the phase spectrum (see Figure 6) cannot be accurately interpreted for frequency components greater

Figure 5. Coherence between UK and Irish Bank Deposit Rates (N=201, M=35)

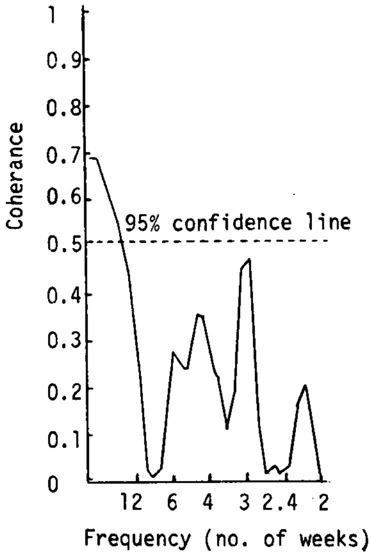
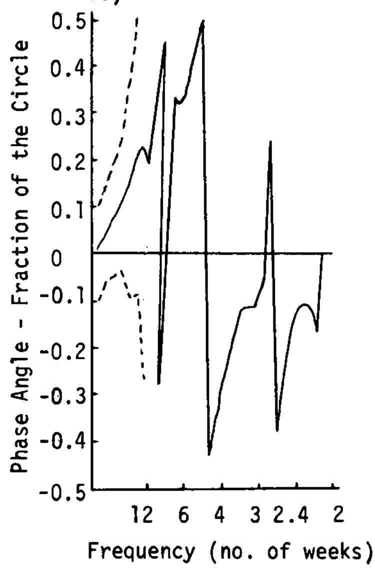


Figure 6. Phase Spectrum of UK and Irish Bank Deposit Rates (N=201, M=35)



than six in the present case (see Figure 5). For periodicities of 12 weeks and greater, corresponding to the long-run relationship between the two series, the phase diagram suggests a pure delay of two to three weeks in the adjustment of the Irish rate to the UK rate. Note that the 95 per cent confidence interval for the phase (fitted for the low frequencies) includes the zero phase angle. Such a relationship corresponds closely to that suggested by inspection of the two interest rate series noted above.

(5) *Prime Lending Rates*

It can be seen from the graphs in Section II that the behaviour of prime lending rates mirrors fairly closely that of the deposit rates; the Irish rate follows the general pattern of UK rates, although divergences of up to about two percentage points have been experienced. The Irish rate is customarily about one percentage point below the UK rate. Over the years 1973 to 1976, there were 14 changes in the Irish, compared with 22 changes in the UK, prime lending rate, while the cumulative changes over the period are 3 and a half percentage points and 4 and a half percentage points, respectively. As in the case of the deposit rates, a change in the Irish rate is preceded occasionally by a number of changes in the UK rate. The data indicate that changes in the UK rate (ignoring those that are fairly quickly followed by another change in UK rate with no adjustment in the Irish rate) are followed by changes in the Irish rate with a lag of slightly more than two weeks.

In the cross-spectral analysis, the coherence and phase spectra for the prime lending rates virtually replicate those for the deposit rates. The frequency domain regression coefficient or "gain" does not differ significantly from unity for those low frequency components for which it may be safely interpreted, indicating, as with the deposit rates, that the full variability of the UK rate is reflected in the Irish rate. This result is, of course, consistent with an approximate constant discrepancy between the levels of the two rates as mentioned above.

IV SUMMARY AND CONCLUSIONS

In this paper, we have endeavoured to examine the degree of financial integration between Irish and UK financial markets by analysing movements in several sets of weekly interest rates in the two countries. To our knowledge, no other formal studies in this area have been published. However, several non-technical studies of the Irish monetary system have appeared that consider, *inter alia,* the high degree of financial integration between Ireland and the UK. A comprehensive and up-to-date study is the paper entitled 'Financial Institutions and Monetary Policy' (Central Bank, 1975). Effectively, this brings up to date the Money Market Report of 1969 (Central Bank, 1969). Both of these papers acknowledge the limited ability to regulate domestic interest rates. In the former, it is noted that: 'Although small differentials can exist in bank interest rates, it is not possible, without heavy outflows, for any substantial divergence to persist because of the free mobility of funds between the two areas. Consequently, bank interest rates have generally been kept at a level competitive with rates prevailing in the UK and elsewhere' (Central Bank, 1975, p. 84). In their comprehensive surveys, both Dowling (1974) and Gibson (1977) concur in this view.

In the present paper, we have applied formal statistical methods in an analysis of interest rate movements in Ireland and the UK. The results for the 3-month inter-bank rates suggest virtually perfect integration with respect to this market with complete adjustment of the Irish to the UK rate within one week. The correspondence of 7-day inter-bank rates is not quite as tight; although it is apparent that, normally, the two rates are identical in the two countries, the statistical analysis showed that very short-term discrepancies between rates can occur which may be attributed to the divergences evident in 1974 and is the result of the effects of the secondary banking crisis and the 50 per cent requirement on capital inflows at that time which gave rise to differential risk premia. The correspondence between the Exchequer Bill and UK Treasury Bill rate was found to be extremely high. (It was only possible to obtain data for the former once monthly; the statistical analysis reflects this and indicates that the Irish rate adjusts to the UK rate with a lag of three to four weeks). With regard to commercial bank deposit and lending rates, it was found that the longer run variations in UK rates are exactly mirrored in Irish rates. However, shorter-run fluctuations are not significantly correlated, indicating a small element of autonomous variation in the Irish bank deposit and lending rates.

From the point of view of an independent monetary policy, a necessary element is the existence of some asset whose yield can be controlled by the monetary authorities independently of the corresponding UK yield. The evidence on the inter-bank rates and 90-day Government yields presented above would point to an equivalently high degree of arbitrage between yields on Government paper that might be used as open-market instruments. This suggests that the scope for autonomous monetary policy in Ireland as an instrument of stabilisation policy is very constrained by virtue of the high degree of integration of Irish and UK financial markets.

DATA SOURCES

Associated Bank Deposit Rates: Friday figures used.
London Clearing Bank Deposit Rates: Friday figures used as published in *Financial Times.*
Exchequer Bill Rate: compiled monthly.
UK Treasury Bill Rate: The average rate of discount after the weekly tender; the rate is expressed as a yield per cent per annum. Source: *Bank of England Quarterly Bulletin.*
Associated Bank Prime Lending Rate: Overdraft Rate.
London Clearing Bank Prime Lending Rate: Friday figures used as published in *Financial Times* (Where two rates are quoted, lower rates are used.)
Irish Inter-Bank Rates – 7-day and 3-month: as quoted by money brokers (mid-rates).
UK 7-day Inter-Bank Rate: as published in *Financial Times* (mid-rates).
UK 3-month Inter-Bank Rate: as published in *Bank of England Quarterly Bulletin.*
Irish Building Societies' Share Account and Mortgage Loan Rates: representative rates as announced by the Irish Building Societies Association.
UK Building Societies' Share Account and Mortgage Loan Rates: as published in 'Financial Statistics', HMSO.

Unless otherwise specified, the series are compiled and are available in the Central Bank.

REFERENCES

BRANSON, WILLIAM H., 1976. "Portfolio Equilibrium and Monetary Policy with Foreign and Non-Traded Assets", in *Recent Issues in International Monetary Economics* E. Claasen and P. Salin (eds.) Amsterdam: North-Holland.

CENTRAL BANK, 1969. *"Committee on the Functions, Operation and Development of a Money Market in Ireland"*, Report.

CENTRAL BANK, 1975. "Financial Institutions and Monetary Policy", *Annual Report.*

CHOW, GREGORY C., 1975. *Analysis and Control of Dynamic Economic Systems,* New York: John Wiley.

DOWLING, BRENDAN R., 1974. "The Development of the Financial Sector in Ireland 1949–72", *Journal of the Statistical and Social Inquiry Society of Ireland.* Vol. XXIII, Part 1.

FISHMAN, GEORGE S., 1969. *Spectral Methods in Econometrics,* Cambridge Mass.: Harvard University Press.

FRENKEL, J. and R. M. LEVICH, 1977. "Transactions Costs and Interest Arbitrage", *Journal of Political Economy,* Vol. 85, No. 6.

GIBSON, NORMAN J., 1977. "The Banking System", in *Economic Activity in Ireland – A Study of Two Open Economies,* N. J. Gibson and J. E. Spencer, (eds.) Dublin: Gill and Macmillan.

GRANGER, C. W. J., 1969. "Investigating Causal Relations by Econometric Models and Cross-spectral Methods", *Econometrica,* Vol. 37, No. 3.

HARVEY, A. C., 1975. "Spectral Analysis in Economics", *The Statistician,* March.

HODJERA, ZORAN, 1973. "International Short Term Capital Movements: A Survey of Theory and Empirical Analysis", *IMF Staff Papers,* Vol. 20, No. 3.

JENKINS, G. M. and DONALD G. WATTS, 1968. *Spectral Analysis and its Applications,* San Francisco: Holden-Day.

KENDALL, M. G., 1973. *Time-Series,* London: Charles Griffin.

LOGUE, D. E., M. A. SALANT and R. J. SWEENEY, 1976. "International Integration of Financial Markets: Survey, Synthesis and Results", in *Eurocurrencies and the International Monetary System* (C. H. Stem, J. H. Makin and D. E. Logue eds.), American Enterprise Institute for Public Policy Research.

PORSIUS, PIETER, 1977. "Spectral Analysis of the Structure of Interest Rates in the Netherlands", *Journal of Monetary Economics,* Vol. 3, No. 2.