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Eurocurrency Risk Premia

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ABSTRACT

We develop a model that shows that the Eurocurrency market risk premium is comprised of two components: sovereign risk and credit risk. On the basis of our model, we construct hypotheses that explain the differences in risk both within and across Eurocurrency trading centers. We use daily LIBOR, SIBOR, and TIBOR benchmark rates for several Eurocurrencies to empirically test the hypotheses. Our inter-market test results indicate a strong positive relationship between pairs of risk premia. Differences in inter-market risk premia are explained by differences in: sovereign risk between host countries, and Eurobank credit quality. Our intra-market tests show a weak positive relationship between pairs of risk premia. Differences in intra-market risk premia are explained by differences in: sovereign risk between the countries issuing the underlying currencies, Eurobank credit quality, and domestic bank credit quality.

JEL Classification: *E43, F34, G21*

Keywords: *Eurocurrency market; Risk premium; Sovereign risk; Credit risk*

I. INTRODUCTION

The difference between the offshore Eurocurrency deposit rate and domestic onshore deposit rate for the same currency is frequently positive. Eurobanks, however, are not required to provide deposit insurance or hold reserves against deposits. Consequently, it is frequently argued, they operate at a relative cost advantage to domestic banks, and can thus offer a higher deposit rate to the depositor. Risk differences are less frequently cited as the reason for the difference between offshore and onshore deposit rates. Sovereign risk is always present in offshore deposits and a difference in bank credit quality between offshore and onshore banks may also exist.

Firstly, given common risks and costs, the "law of one price" suggests that all offshore trading centers will offer identical deposit rates for the same Eurocurrency. When this is the case, their risk premia will obviously be identical. Secondly, if one ignores offshore deposit risk and assumes an equal cost advantage in acquiring offshore deposits, the difference between Eurocurrency rates for two different currencies traded within a single Eurocurrency trading center must logically be explainable by the Fisher effect, i.e., a difference in expected inflation rates between the two home countries whose currencies denominate the offshore deposits.

In fact, the pricing convention in the interest rate and currency swap markets ignores intra-market risk differences between Eurocurrencies. For example, the floating leg of a fixed-for-floating yen interest rate swap is usually set at the benchmark 6-month Euroyen rate, whereas the corresponding floating leg of a fixed-for-floating yen currency swap is usually set at the benchmark 6-month Eurodollar rate regardless of the denomination of the underlying currency. The fixed leg of both the yen interest rate swap and the yen currency swap are identically priced for identical maturities. Combining the two results in a yen-floating-for-dollar-floating currency (basis) swaps. Implicitly, this pricing convention only recognizes the difference between expected inflation rates contained in the benchmark Euroyen rate of the interest rate swap and the benchmark Eurodollar rate of the currency swap; any risk differences imbedded in these two rates have been implicitly ignored by identically pricing the fixed legs. An empirical study to determine if the current currency swap market convention of treating intra-market pairs of equal-maturity Eurocurrency time deposits as being equivalent-risk assets would be a contribution to the literature.

In the present study, we argue that the difference between Eurodeposit and domestic deposit rates is based on differences in the risk premia embedded in the respective rates rather than cost advantages. In Section II, we provide a primer on the Eurocurrency market to formally establish the relevant questions. In Section III, we develop a model that defines the excess Eurocurrency market risk premium as comprised of both sovereign and credit risk components. We also develop testable hypotheses for explaining differences in risk within and across Eurocurrency trading centers. In Section IV, we empirically test our hypotheses using daily data for several Eurocurrencies. Section V offers a summary and conclusion.

II. A PRIMER ON THE EUROCURRENCY MARKET

To make loans and investment in securities, commercial banks need first to obtain deposits as a source of funds. A principal source of funds for domestic banks in major banking centers worldwide are negotiable certificates of deposits (CDs). In the U.S., dollar denominated CDs presently account for 19 (27) percent of total resident bank liabilities (deposits). While there is no limit on maximum maturity, CDs typically have maturities less than one year. By comparison, sterling CDs presently account for 6 (7) percent of resident bank liabilities (deposits) in the U.K. In Japan, yen CDs amount to 4 (6) percent of resident bank liabilities (deposits).

International banks seek deposits of foreign currencies in the Eurocurrency market and make loans in foreign currencies. Eurocurrency is a time deposit of money in an international bank in a country technically outside of the jurisdiction of the country that issued the denominating currency. These banks, called Eurobanks, are not always physically located offshore. In the United States, International Bank Facilities (IBF) technically operate as foreign banks for the purpose of accepting foreign currency deposits, including U.S. dollars, from foreign residents and making foreign currency loans to foreign residents, even though they are physically located in the U.S. Moreover, the offshore branch of, say, a U.S. bank, may conduct its Eurocurrency trading in the bank's U.S. offices, and have nothing more than a shell operation offshore.

The size of the Eurocurrency market can be approximated by the amount of external liabilities held by the world's banks. As of December 2006, the Bank for International Settlements (BIS) reported that its group of reporting banks held $24,175.7 billion in external liabilities. Principal trading centers are London (with 22 percent of external deposits), New York (12 percent), Paris (9 percent), Frankfurt (7 percent), the Cayman Islands (7 percent), Zurich (4 percent), Tokyo (3 percent), and Singapore (3 percent)[1]. Of the total, $17,823.6 billion were liabilities to other banks and the remaining $6,352.1 billion were liabilities to non-banks. As these numbers indicate, the bulk of Eurocurrency trading occurs in the interbank market as banks collect larger sums to make Eurocurrency loans. Additionally, some Eurobanks may borrow in the interbank market and immediately re-lend, the reason being simply to expand the size of their balance sheets or to maintain a market presence for when they do need to obtain loanable funds.

The Eurocurrency market represents the foundation of the international money market. Eurocurrency time deposits have maturities that range from overnight to as long as one year[2]. Typical maturities are 1-month, 3-months, 6-months, and 1-year. Currencies traded in the offshore Eurocurrency market are referred to as Euro__; for example, Japanese yen are Euroyen. As of December 2006, the U.S. dollar accounted for 45 percent of external liabilities, the euro accounted for 32 percent, the pound sterling accounted for 8 percent, and the yen accounted for 3 percent, leaving 12 percent for all other Eurocurrencies.

A. LIBOR, SIBOR, TIBOR

Eurobanks making a market in Eurocurrencies establish an interbank offer rate (IBOR) at which they will make loans and an interbank bid rate (IBID) at which they will accept deposits. The spread is very small, typically amounting to no more than 1/8 of one percent. Trading occurs throughout the trading day in each Eurocurrency trading center. However, at 11:00 am every trading day in London (11:00 Greenwich Mean Time (GMT))[3], the British Bankers Association (BBA) fixes the London Interbank

Offered Rate (LIBOR) for the sterling, Canadian dollar, euro, U.S. dollar, Australian dollar, yen, Swiss franc, New Zealand dollar, and Danish krone. BBA LIBOR serves as the primary daily benchmark used by banks, securities houses, and investors to fix the cost of borrowing money in the international money, derivatives, and capital markets around the world. The BBA fixes LIBOR for each Eurocurrency it tracks by averaging the middle two quartiles of rates offered to a panel of Eurobanks active in the London Eurocurrency market. At 11:00 am in Tokyo (2:00 GMT), the Japanese Bankers Association (JBA) fixes the Tokyo Interbank Offered Rate (TIBOR) calculated from rates offered by a panel of banks active in the Japanese money market. Through two separate panels the JBA fixes two TIBOR rates for the yen: one for Euroyen, the offshore market, and the other for Japanese yen traded in the domestic, or onshore, interbank market. Similarly, at 11:00 am in Singapore (3:00 GMT), the Association of Banks in Singapore (ABS) fixes SIBOR for Eurodollars. Additionally, at 11:00 am Central European Time (10:00 GMT)[4], the European Banking Federation (EBF) fixes EURIBOR, the onshore IBOR for euros traded in the interbank market within the euro zone[5].

Since there are two sides to each interbank transaction and most Eurocurrency trading is in the interbank market, it is obvious that one bank's offered rate is the other bank's bid rate. Consequently, the IBOR–IBID spread for Eurocurrencies in the interbank market is somewhat of a misnomer. As Dufey and Giddy (1994) note, no one actually pays the spread unless they lend to and borrow from the same bank.

B. Cost Differentials

Typically, discussions about the competition for deposits between the onshore and offshore money markets note that U.S. domestic deposit rates are lower than comparable maturity Eurodollar deposit rates because domestic time deposits are subject to Federal Reserve Bank reserve requirements and Federal Deposit Insurance Corporation (FDIC) fees and Eurodollar deposits are not. Holding reserves is voluntary for Eurobanks, and while host countries may require deposit insurance on domestic deposits, offshore deposits are unregulated. Consequently, because of these costs, it is argued that domestic banks cannot offer as high of a deposit rate to depositors. Concern with these factors is outdated, however. Since December 1990 reserve requirements on U.S. nonpersonal time deposits has been zero percent[6]. Additionally, FDIC insurance is applicable for only the first $100,000 of deposits. Formerly, the deposit insurance fee was 1/12 of one percent of the deposit amount. Large denomination domestic time deposits ($1,000,000 plus) that correspond to the size of trading common in the Eurocurrency interbank market are obtained via negotiable certificates of deposit. Consequently, the impact of deposit insurance on the effective deposit rate on a $1,000,000 CD was less than one basis point. Moreover, the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1992 instructed the FDIC to implement risk-based deposit insurance premia. After introduction of the FDICIA, insured institutions were assessed between 23 and 31 cents per $100 of deposits as long as the reserve fund was less than the Designated Reserve Ratio (DRR) of 1.25% of insured deposits. The DRR was reached in 1995. As a result, since 1996 about 95 percent of U.S. commercial banks pay nothing for deposit insurance[7]. Thus, cost differences between domestic and Eurodollar deposits can no longer be used to explain dollar deposit rate differentials[8]. Any difference must be related to risk differences.

C. Sovereign Risk and Credit Risk Differentials

The risks from dealing in the Eurocurrency market are different from the domestic market for bank deposits. Eurocurrency deposits always involve a foreign jurisdiction. In the creation of Eurocurrency, the underlying currency never leaves the onshore banking system. For example, Eurodollar deposits, regardless of the location of the Eurobank, involve the U.S. banking system as the location of the underlying dollar deposit. On the maturity date of a Eurodollar time deposit, an international transaction takes place transferring ownership of a deposit of dollars in the U.S banking system from the offshore bank to the depositor. In receiving payment, the Eurodollar depositor is subject to the actions of both the governmental body holding jurisdiction over the offshore bank and the U.S. government, which has the authority to restrict nonresident convertibility. This even applies to IBFs physically located in the United States. Consequently, Eurobanks must offer a premium over domestic rates; otherwise depositors would not bear the sovereign risks of the country in whose jurisdiction the Eurobank operates or the transfer risk of the country whose currency denominates the deposit[9]. Additionally, not all Eurobanks have the same degree of creditworthiness. Less creditworthy Eurobanks in any Eurocurrency trading center would be expected to have to pay more for Eurocurrency deposits[10].

The focus of this study is to analytically define and empirically examine the nature of the Eurocurrency risk premium. In the remainder of this paper we concentrate on answering two questions. 1) Is the risk premium contained in Eurocurrency rates different from one Eurocurrency trading center to another for the same Eurocurrency? 2) Is the risk premium contained in Eurocurrency rates different for different Eurocurrencies within a single Eurocurrency trading center?

III. METHODOLOGY

Of initial interest is whether there is a risk premium in the Eurocurrency market in excess of the risk premium contained in the domestic rate. The interbank offered rate for Eurocurrency i can be stated as:

$$IBOR_i = RP_{IBOR,i} + C_{IBOR,i} + \rho_i + \pi_i \tag{1}$$

where $RP_{IBOR,i}$ denotes the overall Eurocurrency market risk premium associated with sovereign and bank credit risks, $C_{IBOR,i}$ is the cost of acquiring the deposit, ρ_i is the expected real rate of return for currency i, and π_i is the expected inflation rate in currency i. Equation (1) is the well-known Fisher equation with the addition of a risk and a cost term.[11] Similarly, we use the large CD rate with a term-to-maturity equal to the Eurocurrency time deposit as representative of the most competitive domestic deposit rate for currency i:

$$CD_i = RP_{CD,i} + C_{CD,i} + \rho_i + \pi_i \tag{2}$$

where $RP_{CD,i}$ represents the bank credit risk premium in the domestic CD market and $C_{CD,i}$ represents the sum of the cost of deposit acquisition, reserve requirements, and deposit insurance fees. The expected real rate ρ_i and expected inflation premium π_i will be the same in the Eurocurrency market and domestic money market for currency i.
The difference between the two rates:

$$IBOR_i - CD_i = (RP_{IBOR,i} - RP_{CD,i}) + (C_{IBOR,i} - C_{CD,i}) \tag{3}$$

is equal to the difference in risk premia and cost differences. The term $(RP_{IBOR,i} - RP_{CD,i})$ represents the sum of the sovereign risk premium component of the Eurocurrency deposit rate and the difference in credit risk premia between the Eurobank deposit and the domestic bank deposit rates. The term $(C_{IBOR,i} - C_{CD,i})$ should be close to zero because there are no longer any significant opportunity or direct costs associated with reserve requirements and deposit insurance fees of the banking systems covered in this study. Hence, because the effects of the expected real rate and the expected inflation rate on the two deposit rates cancel via the differencing, equation (3) represents the excess risk premium of the Eurodollar deposit relative to the risk premium of the domestic deposit. For most Eurocurrencies, we expect $(RP_{IBOR,i} - RP_{CD,i})$ to be positive. A negative value would indicate a domestic credit risk premium that exceeds the sum of the sovereign risk and credit risk premia in the Eurocurrency market for currency i.

A. Inter-Market Risk Premium-Testable Hypothesis

The interesting inter-market question is whether there is a single Eurocurrency rate regardless of where trading takes place. Consider two Eurocurrency trading centers that trade the same Eurocurrency. The market may perceive that the sovereign risk of one host country exceeds that of the other. Additionally, the credit risk of the Eurobanks in one trading center may exceed that of the banks in the other. As an example, consider the Eurocurrency trading centers of Tokyo and London, which both trade the Euroyen. Using equation (3), the inter-market difference in sovereign/credit risk premia can be stated as:

$$(\text{EY TIBOR} - \text{¥ CD}) - (\text{¥ LIBOR} - \text{¥ CD}) \tag{4a}$$
$$= (RP_{\text{EY TIBOR}} - RP_{\text{¥ CD}}) - (RP_{\text{¥ LIBOR}} - RP_{\text{¥ CD}}) \tag{4b}$$
$$= (\text{EY TIBOR} - \text{¥ LIBOR}) \tag{4c}$$
$$= (RP_{\text{EY TIBOR}} - RP_{\text{¥ LIBOR}}). \tag{4d}$$

If there is a single Eurocurrency rate, the logical null hypothesis is that the inter-market difference expressed by equation (4a) is zero[12]. Covrig, Low, and Melvin (2004) test for a difference in the (EY TIBOR – ¥ LIBOR) spread. Over sub-periods of their sample they find a positive difference known as the “Japan premium” which they attribute to the greater credit risk of the primarily Japanese Eurobanks in the EY TIBOR market compared to the multinational Eurobanks in the ¥ LIBOR market. Equation (4d) suggests that the Japan premium might be due to the combined difference in sovereign risk between Japan and the UK and the difference in credit risk between the Eurobanks dealing in the TIBOR and LIBOR interbank markets.

A regression model for testing whether there is a difference between an inter-market pair of Eurocurrency risk premia that is consistent with equation (4a) is:

$$(\text{EY TIBOR} - \text{¥ CD}) = \beta_0 + \beta_1(\text{¥ LIBOR} - \text{¥ CD}) + e_{\text{EY TIBOR}} \qquad (5)$$

The appropriate joint hypothesis is β_0=0 and β_1=1. An individual estimate of β_0 significantly different from zero suggests that there is a structural difference between the inter-market pair of sovereign/credit risk premia. An individual estimate of β_1 significantly different from unity suggests a lack of accord, or harmonization, between the two risk premia.
From equations (4a) and (4d):

$$(\text{EY TIBOR} - \text{¥ CD}) = (\text{¥ LIBOR} - \text{¥ CD}) + (RP_{\text{EY TIBOR}} - RP_{\text{¥ LIBOR}}) \qquad (6)$$

Based on this reformulation, regression equation (5) can be re-specified to include additional terms designed to show the impact of sovereign and/or bank credit differences. This allows for a more detailed examination of the inter-market difference in risk premia in the Eurocurrency market. The re-specification is:

$$(\text{EY TIBOR} - \text{¥ CD}) = \beta_0 + \beta_1(\text{¥ LIBOR} - \text{¥ CD}) + \beta_2(\text{SovPI}_{\text{UK}} - \text{SovPI}_{\text{Japan}}) + \beta_3(\text{EurBk}_{\text{EY TIBOR}} - \text{EurBk}_{\text{¥ LIBOR}}) + e_{\text{EY TIBOR}} \qquad (7)$$

where SovPI denotes the value of the price index on sovereign bonds from the UK and Japan denominated in a common currency and EurBk is an index measure of Eurobank credit risk.

Ideally, transactions data would be best for empirically testing equation (7). However, as Michaud and Upper (2008, p. 48) recently note, "time series on the rates paid by individual banks…are notoriously hard to obtain… because the interbank market is organized on a bilateral basis, where only the two parties…know the precise terms." Consequently, we use, as do they, the published daily fixings of interbank rates: BBA LIBOR, JBA TIBOR, ABS SIBOR, and EBF EURIBOR. Knowledge of the bank membership of the respective BBA LIBOR, JBA TIBOR, ABS SIBOR, and EBF EURIBOR bank panels allow for a distinct matching of the banks in the panel and their corresponding Moody's credit rating on a particular date. Thus, equation (7) can be tested for an inter-market currency pair by constructing, as we do for each Eurocurrency rate, a time series of LIBOR, TIBOR, SIBOR, EURIBOR rates that is matched on each date with the bank panel's average Moody's credit rating of member banks. The appendix discusses this aspect of our methodology in depth.

The value of SovPI decreases as sovereign yields increase. Consequently, an increase in the yields on Japanese government bonds relative to UK government bonds results in an increase in the value ($\text{SovPI}_{\text{UK}} - \text{SovPI}_{\text{Japan}}$). When SovPI_{UK} and $\text{SovPI}_{\text{Japan}}$ are denominated in a common currency, a change in their difference represents a relative change in sovereign risk between the UK and Japan as reflected in a relative change in the sovereign debt yields of the two countries after currency effects have been removed. Consistent with the null hypothesis for equations (4a), we expect both β_2 and β_3 to be insignificantly different from zero. Given an increasing ($\text{SovPI}_{\text{UK}} - \text{SovPI}_{\text{Japan}}$) differential, a statistically significantly positive estimate of β_2 would be evidence of a larger sovereign risk premium contained in the EY TIBOR rate than in the ¥ LIBOR rate.

We construct an index measure of Eurobank credit risk EurBk for the sets of Eurobanks dealing in the JBA EY TIBOR and BBA ¥ LIBOR Eurocurrency markets. (The appendix offers an example of how we construct an index measure of bank credit risk using Moody's credit ratings.) Given an increasing ($EurBk_{EY\ TIBOR} - EurBk_{¥\ LIBOR}$) spread, a statistically significantly positive estimate of β_3 would be indicative of a Japan premium. In conducting our empirical tests with equation (7), we first orthogonalize all explanatory variables to remove the effect of any multicollinearity among the variables.

B. Intra-Market Risk Premium-Testable Hypothesis

The interesting intra-market question is whether the risk premium contained in Eurocurrency rates for different currencies is the same. For a specific Eurocurrency trading center where multiple Eurocurrencies are traded, a difference in the excess risk premia can exist from one Eurocurrency to the other depending upon the countries issuing the underlying currencies and the market's perceptions of their relative risks. For example, for the London Eurocurrency market and BBA LIBOR, the intra-market difference between sovereign/credit risk premia for Eurocurrencies i and j can be expressed as:

$$(LIBOR_i - CD_i) - (LIBOR_j - CD_j) \tag{8a}$$
$$= (RP_{LIBOR,i} - RP_{CD,i}) - (RP_{LIBOR,j} - RP_{CD,j}) \tag{8b}$$
$$= (RP_{LIBOR,i} - RP_{LIBOR,j}) - (RP_{CD,i} - RP_{CD,j}) \tag{8c}$$

The term ($RP_{LIBOR,i} - RP_{LIBOR,j}$) in equation (8c) represents the difference in sovereign risk premia between the countries issuing underlying currencies i and j plus the difference in the aggregate credit risk premia between the sets of Eurobanks trading Eurocurrencies i and j.[13] The credit risk between the sets of Eurobanks may be different, even though the banks trade in the same Eurocurrency trading center, if Eurobanks of different credit quality comprise each BBA LIBOR panel[14]. The term ($RP_{CD,i} - RP_{CD,j}$) in equation (8c) represents the difference in credit risk premia between the sets of banks acquiring deposits in domestic markets i and j. If the risk premium contained in Eurocurrency rates for different currencies is the same, the logical null hypothesis is that the difference expressed by equation (8a) is zero. Consequently, we expect the two terms in equation (8c) to have the same absolute magnitude.

A regression model for testing whether there is a difference between an intra-market pair of Eurocurrency risk premia that is consistent with equation (8a) is:

$$(LIBOR_i - CD_i) = \gamma_0 + \gamma_1(LIBOR_j - CD_j) + e_i \tag{9}$$

The appropriate joint hypothesis is γ_0=0 and γ_1=1. An individual estimate of γ_0 significantly different from zero suggests that there is a structural difference between the intra-market pair of sovereign/credit risk premia. An individual estimate of γ_1 significantly different from unity suggests a lack of accord, or harmonization, between the two risk premia.

From equations (8a) and (8c):

$$(LIBOR_i - CD_i) = (LIBOR_j - CD_j) + (RP_{LIBOR,i} - RP_{LIBOR,j}) - (RP_{CD,i} - RP_{CD,j}) \quad (10)$$

Based on this reformulation, intra-market regression equation (9) can be re-specified to include additional terms designed to show the impact of sovereign and/or bank credit differences on any observed difference in excess risk premia. The re-specification is:

$$(LIBOR_i - CD_i) = \gamma_0 + \gamma_1(LIBOR_j - CD_j) + \gamma_2(SovPI_j - SovPI_i) + \gamma_3(EurBk_{LIBOR,i} - EurBk_{LIBOR,j}) + \gamma_4(DomBk_i - DomBk_j) + e_i \quad (11)$$

where SovPI denotes the price index on sovereign bonds from countries denominating Eurocurrencies j and i expressed in numeraire currency j, EurBk is an index measure of bank credit risk for the sets of Eurobanks trading Eurocurrencies i and j, and DomBk is an index measure of bank credit risk for the sets of domestic banks dealing in the CD markets in countries i and j. The γ_4 term recognizes that CD rates i and j are determined in two domestic markets.

The value of SovPI decreases as sovereign yields increase. Consequently, an increase in the yields on government bonds issued by country i relative to government bonds issued by country j results in an increase in the value ($SovPI_j - SovPI_i$). When $SovPI_j$ and $SovPI_i$ are both denominated in currency j, a change in their difference represents a relative change in sovereign risk between Country j and Country i as reflected in a relative change in the sovereign debt yields of the two countries after currency effects have been removed. The null hypothesis for equation (8a) would predict γ_2, γ_3 and γ_4 to be insignificantly different from zero. Recall that for the null hypothesis to hold, the two terms in equation (8c) must have the same absolute magnitude. Consequently, if the estimates of γ_2 and/or γ_3 are found to be significantly positive (negative), it would not be unusual to find the estimate of γ_4 to be significantly negative (positive). Prior to conducting our empirical tests with equation (11), we orthogonalize all explanatory variables to remove the effect of any multicollinearity among the variables.

IV. EMPIRICAL RESULTS

A. Data

Much of our data are from DataStream. We are able to obtain 1- and 3-month dollar, euro, sterling, and yen BBA LIBOR, dollar ABS SIBOR rates, and EBF EURIBOR rates. Additionally, we are able to obtain 1- and 3-month Euroyen (EY) and Japanese yen (JY) JBA TIBOR rates. We also obtained corresponding certificate of deposit offer rates for the yen. For the dollar we have secondary market middle CD rates from the St. Louis Fed website. For the sterling we obtained CD rates from the Bank of England website. By necessity we use 1- and 3-month euro commercial paper rates because a well-developed euro CD market does not exist. DataStream's data entry for financial market holidays when the market is closed is the previous day's market price. In conducting our empirical tests, we eliminated these stale prices. If a holiday occurred in any market that resulted in a market closing, we eliminated data items across all other markets because a matched data pair would not exist.

Bartram and Karolyi (2006) document that the introduction of the euro common currency leads to lower market risk exposures in and outside of Europe. Our sample is free from any complicating effects from the introduction of the euro on January 1, 1999. Most of our empirical tests are conducted using data from May 8, 2000 through April 30, 2007, for which we have a complete time series for all data items except euro commercial paper for which our time series begins February 4, 2003. We note that our study period purposely terminates prior to the third quarter of 2007, the commonly accepted beginning of the ongoing subprime credit crisis. As The Wall Street Journal has reported in several articles, since the credit crisis began in the summer of 2007, Eurobanks have been accused of and have been shown to understate the Eurocurrency rates they report to the British Bankers Association for the official LIBOR fixing because they are trying to hide their weakened financial condition and, subsequently, the true rates that they have to pay to borrow in the interbank market. Thus, it would not be meaningful to study Eurocurrency risk premia using data from the credit crisis because they are not functioning normally and true market rates are not being reported[15].

B. Descriptive Statistics

Table 1 presents descriptive statistics for each of the Eurocurrency rate time series and from testing the excess risk premium of equation (3) for each Eurocurrency. Specifically, the table presents sample means, standard deviations, minimum and maximum values, and t-statistics from testing whether the mean rates are statistically significantly different from zero. Initial examination of the table shows that the t-statistics for all Eurocurrencies are large and significant for both 1-month and 3-month maturities. Since the deepest market is for 3-month maturities, we concentrate our discussion there.

Panel A shows that the $ LIBOR market risk premium exceeds the domestic $ CD risk premium by an average of almost 6 basis points (bps) over our study period. The $ SIBOR excess risk premium is slightly larger. Panel B presents the results for the € LIBOR and EURIBOR markets. The table shows that the 3-month € LIBOR market risk premium exceeds the € CP risk premium by an average of almost 2 bps. A slightly larger risk premium exists in the euro zone EURIBOR market. Panel C shows that the 3-month Eurosterling risk premium is slightly greater than 7 bps[16].

Panel D presents the results for ¥ LIBOR, EY TIBOR, and JY TIBOR. Examination of the panel shows that the 3-month ¥ CD rate exceeds the 3-month ¥ LIBOR rate by an average of almost 9 bps. This indicates that over our study period, yen depositors found the credit risk of domestic Japanese banks to be greater than the combined sovereign risk and bank credit risk in the London Euroyen market. This is a result of ongoing domestic banking problems in Japan[17]. Panel D also shows that the 3-month ¥ CD rate exceeds the 3-month EY TIBOR rate by an average of more than 7 bps and the JY TIBOR rate by about the same. More will be said about these latter two markets in subsequent discussion.

Table 1
Eurocurrency descriptive statistics[a]

	Mean	Standard Deviation	Minimum	Maximum	t-statistic
A. Dollar					
1-mth LIBOR	3.2200	1.8008	1.0148	6.5987	73.14
1-mth LIBOR – $ CD	.0469	.0202	-.0035	.4962	95.01
3-mth LIBOR	3.2767	1.8041	.9950	6.6431	74.29
3-mth LIBOR – $ CD	.0592	.0230	-.0374	.3991	105.03
1-mth SIBOR	3.2238	1.8015	1.0148	6.5788	73.20
1-mth SIBOR – $ CD	.0507	.0215	.0000	.4867	96.64
3-mth SIBOR	3.2804	1.8034	.9950	6.6349	74.40
3-mth SIBOR – $ CD	.0628	.0239	-.0588	.3919	107.39
B. Euro					
1-mth LIBOR	2.4473	.5322	1.9945	3.7945	147.15
1-mth LIBOR – € CP	.0163	.0080	-.0147	.0538	65.20
3-mth LIBOR	2.4999	.5687	1.9364	3.9409	140.67
3-mth LIBOR – € CP	.0171	.0085	-.0078	.0439	64.52
1-mth EURIBOR	2.4471	.5316	1.9960	3.7922	147.31
1-mth EURIBOR – € CP	.0162	.0087	-.0164	.0675	59.68
3-mth EURIBOR	2.5005	.5680	1.9381	3.9384	140.86
3-mth EURIBOR – € CP	.0177	.0094	-.0058	.0614	60.12
C. Sterling					
1-mth LIBOR	4.4935	.6758	3.2376	5.9477	271.98
1-mth LIBOR – £ CD	.0648	.0599	-.1800	.3151	44.26
3-mth LIBOR	4.5466	.6862	3.2901	6.0725	270.99
3-mth LIBOR – £ CD	.0709	.0264	-.0846	.2369	109.87
D. Yen					
1-mth LIBOR	.1376	.1731	.0362	1.0235	32.49
1-mth LIBOR – ¥ CD	-.0785	.0401	-.2480	.2516	-80.03
3-mth LIBOR	.1628	.1822	.0455	.7205	36.55
3-mth LIBOR – ¥ CD	-.0885	.0352	-.1928	-.0044	-102.81
1-mth EY TIBOR	.1449	.1580	.0515	.9575	37.52
1-mth EY TIBOR – ¥ CD	-.0711	.0360	-.2448	.0710	-80.67
3-mth EY TIBOR	.1811	.1727	.0608	.6698	42.89
3-mth EY TIBOR – ¥ CD	-.0702	.0309	-.1676	-.0038	-92.98
1-mth JY TIBOR	.1439	.1563	.0516	.9438	37.67
1-mth JY TIBOR – ¥ CD	-.0707	.0362	-.2473	.0522	-81.38
3-mth JY TIBOR	.1801	.1713	.0599	.6649	43.00
3-mth JY TIBOR – ¥ CD	-.0712	.0314	-.1742	-.0027	-92.76

[a]This table presents descriptive statistics for each of the Eurocurrency rate time series and from testing the excess risk premium of equation (3) for each Eurocurrency. The table provides means of annualized percentage rates, standard deviations, minimum and maximum values, and t-statistics from testing whether the means are significantly different from zero. Panels A, C, and D cover the period 05:08:00-04:30:07; Panel B covers the period 02:04:03-04:30:07.

We estimate SovPI as the natural log of the JP Morgan Government Bond Price Index denominated in dollars for Japan, Singapore, the UK, and the U.S. For the euro zone, we average the price indices for Belgium, France, Germany, Italy, the Netherlands, and Spain. The JP Morgan Government Bond Price Index is widely recognized as the premier sovereign debt price index. The value of each price index is set equal to 100 for all countries on May 8, 2000.

Table 2 presents descriptive statistics for the EurBk and DomBk variables in regression equations (7) and/or (9). The table is structured in a similar format to Table 1. EurBk is the average of the Moody's ratings for the Eurobanks comprising the various BBA LIBOR panels, the JBA EY TIBOR panel, the ABS SIBOR panel, where Moody's rating Aaa is assigned an index number of 1, Aa = 2, A = 3, Baa = 4, etc. Consequently, a lower credit quality is associated with a larger Moody's index value. The time series of changes in BBA LIBOR panel membership are available on the BBA website. Changes in JBA TIBOR panel membership and ABS SIBOR panel membership were obtained through direct correspondence with the JBA and ABS. Moody's ratings are obtained from various issues of the annual Euromoney "Bank Atlas".[18] DomBk is the average of the Moody's ratings for all the domestic banks in the JY TIBOR panel, the largest national domestic banks in Japan, the UK, the U.S., the euro zone, and in the EURIBOR panel.[19]

Table 2

EurBk and DomBk descriptive statistics[a]

	Mean	Standard Deviation	Minimum	Maximum
A. EurBk				
€ LIBOR	2.0244	.0619	1.9375	2.1875
¥ LIBOR	2.2777	.0899	2.1875	2.4375
£ LIBOR	1.9369	.0487	1.8750	2.0000
$ LIBOR	2.0524	.0410	2.0000	2.1250
$ SIBOR	2.1850	.0556	2.1538	2.3125
EY TIBOR	3.0700	.1097	2.8462	3.2000
B. DomBk				
Euro Zone	2.0966	.0675	1.9400	2.1500
EURIBOR	2.0966	.0675	1.9400	2.1500
Japan	3.2425	.1286	3.0000	3.4000
JY TIBOR	3.2425	.1286	3.0000	3.4000
United Kingdom	2.0278	.2048	1.8000	2.3000
United States	2.1293	.1029	2.0000	2.3000

[a]This table presents descriptive statistics on the explanatory variables EurBk and DomBk in regression equations (7) or (11). The table provides means, standard deviations, minimum and maximum values. EurBk is the average of the Moody's ratings for the Eurobanks comprising the various BBA LIBOR panels, the JBA EY TIBOR panel, and the ABS SIBOR panel, where Moody's rating Aaa is assigned an index number of 1, Aa = 2, A = 3, Baa = 4, etc. DomBk is the average of the Moody's ratings for the domestic banks in the JBA JY TIBOR panel, the largest national domestic banks in Japan, the UK, the U.S., the euro zone, and in the EURIBOR panel. Moody's ratings are obtained from various issues of the annual Euromoney "Bank Atlas". The period covers 05:08:00-04:30:07.

Table 3
Inter-market regressions[a]

A: ($ SIBOR – $ CD) vs. ($ LIBOR – $ CD)	β_0	β_1	β_2	B_3	F (β_0=0, β_1=1)	Adjusted R^2
1-month	.0054	.9646			293.99	82.55%
	9.77	-3.26				
	.0054	.9646	-.0574	-.0411	166.08	84.04%
	10.21	-3.41	-8.38	-9.40		
3-month	.0055	.9691			304.55	87.07%
	9.47	-3.39				
	.0055	.9691	.0031	-.0353	163.22	87.53%
	9.65	-3.45	.46	-8.00		
B: (EURIBOR – € CP) vs. (€ LIBOR – € CP)						
1-month	-.0008	1.0422			1.91	92.14%
	-4.58	4.43				
	-.0008	1.0422	-.0034	.0066	11.39	92.59%
	-4.71	4.56	-.83	7.90		
3-month	-.0008	1.0761			55.75	94.42%
	-4.84	4.43				
	-.0008	1.0761	.0014	.0054	77.62	94.67%
	-4.96	9.52	.37	7.06		
C: (EY TIBOR – ¥ CD) vs. (¥ LIBOR – ¥ CD)						
1-month	-.0130	.7410			193.95	67.93%
	-11.82	-20.82				
	-.0130	.7410	-.0940	.0971	592.12	82.36%
	-15.93	-28.06	-22.41	29.44		
3-month	-.0044	.7430			1704.77	71.79%
	-4.07	-29.46				
	-.0044	.7430	-.0472	.0864	2215.56	83.44%
	-5.32	-22.58	-13.94	31.36		
D: (JY TIBOR – ¥ CD) vs. (¥ LIBOR – ¥ CD)						
1-month	-.0153	.7237			131.15	64.15%
	-13.13	-20.89				
	-.0153	.7237	-.0916	.1019	540.39	80.73%
	-17.90	-28.49	-20.73	31.78		
3-month	-.0058	.7389			1358.72	68.70%
	-4.98	-21.42				
	-.0058	.7389	-.0442	.0834	1692.16	80.67%
	-6.33	-27.26	-11.88	29.93		

[a]This table presents the empirical results from testing regression equations (5) and (7). For each regression, the table provides regression coefficient estimates, their t-statistics (second row), the F value from testing the joint hypothesis (β_0=0 and β_1=1), and the adjusted coefficient of determination. The t-statistic on β_1 is calculated relative to unity. The critical two-tailed .05 t-statistic values are +/- 1.96 and the .95 critical F value is 3.07.

C. Inter-Market Tests

For each inter-market currency pair, Table 3 presents the empirical results from testing regression equations (5) and (7). For each regression, the table provides regression coefficient estimates, their t-statistics (second row), the F value from testing the joint hypothesis (β_0=0 and β_1=1), and the adjusted coefficient of determination. The t-statistic on β_1 is calculated relative to unity.

Initial examination of Table 3 shows that F values are statistically significant for both regression equations (5) and (7) for all inter-market Eurocurrency pairs except EURIBOR/€ LIBOR when using 1-month data; thus, the joint null hypothesis (β_0=0 and β_1=1) is rejected in all but one case. The second item of interest is that the adjusted coefficients of determination are all quite high. Additionally, for each currency pair, the adjusted coefficient of determination is modestly higher for regression (7) in comparison to regression (5). These observations suggest confining our discussion to an analysis of the individual coefficient estimates.

Panel A of Table 3 presents the results for regressions (5) and (7) for $ SIBOR/$ LIBOR. When using 1-month data, for regression (5), β_0 is individually significantly positive and β_1 is significantly less than unity at the two-tailed five percent level, indicating a structural difference and a lack of harmony in the relationship between the $ SIBOR and $ LIBOR excess risk premia. For regression (7), contrary to expectation, β_2 is significantly negative, indicating that the $ SIBOR/$ LIBOR risk premium spread decreases with an increase in Singapore/UK sovereign risk differences. Additionally, β_3 is significantly negative, indicating that an increase in the relative credit risk between the panels of Eurobanks that are polled to fix $ SIBOR and $ LIBOR rates has a negative impact on risk premium differences. When using 3-month data, the coefficient β_0 is individually significantly positive and β_1 is significantly less than unity in both regressions. In regression (7), β_2 is insignificantly positive and β_3 is significantly negative.[20]

The EURIBOR/€ LIBOR results are presented in Panel B of Table 3. Recall that EURIBOR is the interbank offered rate for euros among euro zone banks. Thus, in essence it is a domestic rate. Consequently, the β_3 term is a hybrid term defined as ($DomBk_{EURIBOR}$ - $EurBk_{€\ LIBOR}$). Examination of the 1-month results shows that β_0 is individually significantly negative and that β_1 is significantly greater than unity in both regressions (5) and (7), indicating a structural difference and some lack of harmony between the EURIBOR and € LIBOR risk premia. In regression (7), β_2 is insignificantly negative and β_3 is significantly positive. When using 3-month data β_0 is individually significantly negative and β_1 is significantly greater than unity in both regressions. In regression (7), β_2 is insignificantly positive and β_3 is significantly positive. To help interpret these results, we note that the UK and most, but not all, euro zone countries have Aaa Moody's and AAA Standard and Poor's (S & P) sovereign credit ratings.[21] Additionally, Table 2 shows that the average credit quality of € LIBOR panel Eurobanks is collectively slightly superior to that of the euro zone banks trading in the EURIBOR market. Consequently, one would expect to find positive but not necessarily significant β_2 and β_3 coefficients, indicating that the EURIBOR risk premium increases relative to the € LIBOR risk premium with increases in relative sovereign risk and lower bank credit quality. This supposition is consistent with the

BBA website statement explaining that "…differences in perception about the credit quality of the 16 large banks comprising the BBA [€ LIBOR] Panel and the banks on the EURIBOR Panel, some of which are comparatively small…" might exist in the wholesale market[22]. The 3-month results are more consistent with this statement than are the 1-months results. Nevertheless, the significantly positive β_3 coefficient estimates are consistent with the existence of a "euro zone" premium.

Panel C of Table 3 presents the EY TIBOR/¥ LIBOR regression results. We only discuss 3-month results since the 1-month results are similar. Examination of the panel shows that β_0 is significantly negative and β_1 is positive but significantly less than unity in both regressions (5) and (7). This indicates a structural difference and a lack of harmony between EY TIBOR and ¥ LIBOR risk premia. For regression (7), β_2 is significantly negative and β_3 is significantly positive. The positive β_3 is consistent with a Japan premium, as documented by Covrig, Low, and Melvin (2004) using a different methodology. Moreover, Table 2 shows that the average credit quality of EY TIBOR Eurobanks is lower than the average credit quality of ¥ LIBOR Eurobanks. The significantly negative β_2 estimate is puzzling and difficult to explain. It is inconsistent with the current Moody's (S & P) sovereign rating of Aa1 (AA-) for Japan versus an Aaa (AAA) rating for the United Kingdom.

Panel D presents the JY TIBOR/¥ LIBOR results. These regressions are analogous to the corresponding EURIBOR/€ LIBOR regressions in Panel B because JY TIBOR is a domestic interbank rate. The β_3 term is a hybrid term defined as ($DomBk_{JY\ TIBOR} - EurBk_{¥\ LIBOR}$). Nevertheless, examination of Panel D shows that the results are very similar to the EY TIBOR/¥ LIBOR results in Panel C.

Overall, the results presented in Table 3 are quite strong. The adjusted coefficient of determination values is all quite high. Nevertheless, structural differences and a lack of perfect harmony exist between all pairs of inter-market risk premia. In the Singapore and London Eurodollar markets, the difference between excess risk premia is shown to decrease with an increase in the relative credit risk between the panels of Eurobanks that are polled to fix \$ SIBOR and \$ LIBOR rates. However, in the EURIBOR and € LIBOR markets, the difference in risk premia is more reasonably shown to increase with an increase in the difference in bank credit quality. The difference in EY TIBOR/¥ LIBOR risk premia is largely explained by the difference in sovereign risk between Japan and the UK and a Japan premium. An identical story explains the difference in risk premia between the domestic JY TIBOR market and the ¥ LIBOR Euromarket.

D. Intra-Market Tests

Table 4 presents the empirical results from testing regression equations (9) and (11) when (\$ LIBOR - \$ CD) is the primary explanatory variable. This is fitting since Eurodollars are the predominant Eurocurrency. The organization of the table is similar to Table 3.

Initial examination of Table 4 shows that the F values are all statistically significant for both regressions (9) and (11) when using 1- or 3-month data, indicating that the joint hypothesis of (γ_0=0 and γ_1=1) is rejected for each intra-market Eurocurrency pair. The second item of interest in Table 4 is that the adjusted coefficients of determination are low in comparison to the magnitude of the values in

Table 3. Nevertheless, for each currency pair, the adjusted coefficient of determination for regression equation (11) is comparatively larger than for regression equation (9). These observations again suggest confining our discussion to an analysis of the individual coefficient estimates.

Panel A of Table 4 presents the results for regression equations (9) and (11) for £ LIBOR/$ LIBOR. The results are qualitatively the same whether using 1- or 3-month data. Examination of the panel shows that for both regressions, γ_0 is significantly positive and γ_1 is positive but significantly less than unity. This indicates a structural difference and a lack of harmony between the intra-market pair of sovereign/credit risk premia for the two Eurocurrencies. For regression (11), γ_2 and γ_4 are significantly positive, indicating that the £ LIBOR/$ LIBOR risk premium spread increases with both an increase in UK/U.S. sovereign risk differences and an increase in credit risk differences between the UK/U.S. banks acquiring deposits in the domestic markets. The coefficient γ_3 is significantly negative, indicating that the £ LIBOR/$ LIBOR risk premium spread decreases with an increase in credit risk differences between the sets of £/$ LIBOR panel Eurobanks.

Table 4
Intra-market regressions[a]

A: (£ LIBOR – £ CD) vs. ($ LIBOR – $ CD)	γ_0	γ_1	γ_2	γ_3	γ_4	F (γ_0=0, γ_1=1)	Adjusted R^2
1-month	.0465	.3890				149.58	1.67%
	12.67	-8.51					
	.0465	.3890	.1826	-.5421	.0300	127.71	13.94%
	13.55	-9.09	7.08	-13.38	3.49		
3-month	.0422	.4848				341.23	17.88%
	26.19	-20.31					
	.0422	.4848	.1858	-.3544	.0128	621.36	46.23%
	32.37	-25.10	19.45	-22.11	4.16		
B: (€ LIBOR – € CP) vs. ($ LIBOR – $ CD)							
1-month	.0064	.2220				4884.69	13.04%
	7.70	-43.58					
	.0064	.2220	.0506	.1435	-.0041	11026.04	34.21%
	8.85	-50.10	9.62	15.41	-1.47		
3-month	.0047	.2510				5892.94	16.96%
	5.32	-43.27					
	.0047	.2510	.0621	.1610	.0048	13975.48	41.47%
	6.33	-51.53	11.75	17.04	1.65		
C: (¥ LIBOR – ¥ CD) vs. ($ LIBOR – $ CD)							
1-month	-.0896	.2379				13698.64	1.38%
	-36.40	-15.82					
	-.0896	.2379	.0608	.1553	.0471	9288.54	10.55%
	-38.23	-16.61	3.50	11.47	5.52		
3-month	-.1096	.3558				23993.90	5.37%
	-47.48	-17.73					
	-.1096	.3558	.0275	-.0036	.0700	16538.96	10.07%
	-48.71	-18.19	1.73	-.28	9.35		

[a]This table presents the empirical results from testing regression equations (9) and (11). For each regression, the table provides regression coefficient estimates, their t-statistics (second row), the F value from testing the joint hypothesis (γ_0=0 and γ_1=1), and the adjusted coefficient of determination. The t-statistic on γ_1 is calculated relative to unity. The critical two-tailed .05 t-statistic values are +/- 1.96 and the .95 critical F value is 3.07.

The € LIBOR/$ LIBOR results are presented in Panel B. The 1-month and 3-month results are very similar. Examination of the panel shows that γ_0 is significantly positive and γ_1 is positive but significantly less than unity for both regressions (9) and (11), indicating a structural difference and a lack of harmony between the € LIBOR and $ LIBOR risk premia. For regression (11), the coefficients γ_2 and γ_3 are significantly positive, indicating that the spread between € LIBOR and $ LIBOR risk premia increases with both an increase in sovereign risk differences and an increase in credit quality differences between the sets of €/$ LIBOR panel Eurobanks. The coefficient γ_4 is insignificantly negative (positive) with 1-month (3-month) data.

The ¥ LIBOR/$ LIBOR results are presented in Panel C. Examination of the panel shows that with 1-month and 3-month data γ_0 is significantly negative and γ_1 is positive but significantly less than unity in both regressions (9) and (11). This indicates a structural difference and a lack of harmony between ¥ LIBOR and $ LIBOR risk premia. For regression (11), γ_2 and γ_3 are significantly positive with 1-month data. This indicates that the ¥ LIBOR/$ LIBOR risk premium spread increases with both an increase in Japanese/U.S. sovereign risk differences and an increase in the difference in credit quality between the sets of ¥/$ LIBOR panel Eurobanks. The coefficient γ_4 is significantly positive, indicating that ¥ LIBOR/$ LIBOR spread increases with an increase in credit risk differences between the Japanese/U.S. banks acquiring domestic deposits. With 3-month data, γ_2 and γ_3 are insignificant and γ_4 is significantly positive.

Regardless of the currency pair, a significant structural difference and a lack of harmony exists between intra-market Eurocurrency risk premia. Nevertheless, our results show that the spread between pairs of intra-market Eurocurrency risk premia are based on risk differences. Specifically, the £ LIBOR/$ LIBOR spread increases with increases in both sovereign risk differences and UK/U.S. domestic bank credit risk differences, and decreases with increases in Eurobank credit risk differences. The € LIBOR /$ LIBOR spread increases with increases in sovereign risk differences and Eurobank credit risk differences. The ¥ LIBOR/$ LIBOR spread increases with an increase in Japanese/U.S. domestic bank credit risk differences.

V. SUMMARY AND CONCLUSION

This study explores the nature of the difference between Eurocurrency and domestic interest rates in the same currency and the difference in rates between two Eurocurrencies. We argue that the difference between Eurodeposit and domestic deposit rates is based on differences in the risk premia embedded in the respective rates rather than cost differences. We specify a model that defines the excess Eurocurrency market risk premium as comprised of both sovereign and credit risk components. Additionally, we develop hypotheses for explaining differences in risk within and across Eurocurrency trading centers. We empirically test our hypotheses using LIBOR, SIBOR, and TIBOR benchmark rates for several Eurocurrencies. Our inter-market test results are quite strong and intuitively explainable. They indicate a positive relationship between pairs of risk premia. Where inter-market differences in excess risk premia exist, they are explained by a difference in sovereign risk and a difference in bank credit quality. This allows us to draw the conclusion that there is not a single worldwide Eurocurrency market for a specific underlying currency. Rather risk is priced uniquely in each Eurocurrency trading center for each underlying currency based upon the sovereign risk of the host country and the creditworthiness of the Eurobanks dealing in the trading center.

The intra-market test results are not as strong. In general, we find significant structural differences and a lack of harmony between pairs of risk premia for different Eurocurrencies traded within the same Eurocurrency trading center. Nonetheless, a weak positive relationship exists between intra-market risk premia. Differences in pairs of intra-market risk premia are explained by a difference in sovereign risk between the countries issuing the underlying currencies and a difference in Eurobank and domestic bank credit quality. We conclude that an observed difference between Eurocurrency rates for different currencies cannot always be explained by the Fisher effect—significant risk differences may exist. Consequently, the currency swap market convention of treating intra-market pairs of equal-maturity Eurocurrency time deposits as being equivalent risk assets needs to be reconsidered.

ENDNOTES

1. More precisely, the percentages represent the portion of external liabilities in the entire country of which the cities cited are located.
2. Bartolini, Hilton and Prati (2005) find integration between the Federal Funds market and the overnight Eurodollar market. They ignore differences in risk premia between the two rates.
3. During British Summer Time, the 11:00 am fixing corresponds to 10:00 GMT.
4. During Central European Summer Time, the 11:00 am fixing corresponds to 9:00 GMT.
5. There are currently 16 banks each in the BBA panels for USD, GBP, JPY, and EUR LIBOR. While there is some overlap in membership, the banks that comprise these panels are not identical for any two panels. There are currently 16 (15) banks in the JBA EY (JY) TIBOR panel. There are currently 14 banks in the ABS USD SIBOR panel. There are over 45 banks in the EURIBOR panel.
6. By comparison, the reserve requirement in Japan on negotiable certificates of deposit is a modest 0.05 of one percent. In the UK, a cash ratio deposit of 0.15 of one percent is required on certificates of deposits, with interbank holdings exempt.
7. See Martin (2003) for a detailed discussion of the FDIC deposit insurance procedure.
8. By comparison, negotiable certificates of deposit are not covered by deposit insurance in Japan. In the UK, deposit insurance premia are levied on financial institutions at a maximum of 0.30 of one percent of deposits as insurance reserves are needed; deposits are covered up to a maximum of £20,000 ($39,186 at year-end 2006).
9. Dufey and Giddy (1984) present a qualitative analysis of sovereign risk.

10. Peria and Schmukler (2001) find that depositors punish banks for risky behavior by withdrawing deposits and by requiring higher interest rates.
11. Interest rates (R) are expressed as ln(1 + R) to facilitate mathematical manipulation.
12. Equations (4b) and (4c) implicitly assume that the difference in the cost terms from equation (3), $(C_{EY\ TIBOR} - C_{¥\ CD}) - (C_{¥\ LIBOR} - C_{¥\ CD}) = (C_{EY\ TIBOR} - C_{¥\ LIBOR}) = 0$. This is a reasonable assumption since there are no reserve requirements or deposit insurance fees in either Eurocurrency market. The same assumption is reasonable for all inter-market pairs of Eurocurrencies.
13. Equations (8b) and (8c) implicitly assume that the difference in the cost terms from equation (3), $(C_{LIBOR,i} - C_{CD,i}) - (C_{LIBOR,j} - C_{CD,j}) = 0$. Since there are no reserve requirements or deposit insurance fees for either Eurocurrency i or j, $(C_{LIBOR,i} - C_{LIBOR,j}) = 0$. It is also reasonable to assume that $(C_{CD,j} - C_{CD,i})$ is approximately zero. Recall from Section II that deposit insurance fees are not a concern in any domestic CD market covered by this study. Moreover, the largest difference in reserve requirements is zero for the $ CD market and .15 of one percent for the £ CD market. Therefore, the cost effect of a difference in reserve requirements will be less than one basis point for CD rates on the order of 6 percent.
14. Peek and Rosengren (2001) reason that the Japanese banking crisis required all Japanese banks to pay a Japan premium, including those in the $ LIBOR and ¥ LIBOR markets. They find a Japan premium by comparing individual quotes between higher and lower quality Japanese banks that are members of the BBA $ LIBOR and ¥ LIBOR panels.
15. For example, see The Wall Street Journal article by Carrick Mollenkamp titled "Bankers Cast Doubt on Key Rate During Crisis" (April 16, 2008, p. A1) and the article by Carrick Mollenkamp and Mark Whitehouse titled "Study Casts Doubt on Key Rate" (May 29, 2008, p. A1).
16. Eurosterling, sterling CD, and JY TIBOR rates are quoted according to an actual/365 day-count basis whereas the convention is to quote all other Eurocurrency and domestic money market rates according to an actual/360 day-count basis. Therefore, these rates are adjusted by a factor of 360/365 to make them comparable.
17. Table 2 shows that the average Moody's credit quality rating for Japanese domestic banks is lower than for UK, U.S., and euro zone banks.
18. Our sovereign risk variable SovPI is based on the JP Morgan Government Bond Price Index because a Moody's sovereign credit risk rating for a country seldom changes. For our purpose, the unsettled question of whether rating changes lead or lag bond price changes is not relevant. Moody's assigns a country rating for foreign currency deposits that serves as a ceiling for foreign currency bank deposits within the country; consequently, it is important to orthogonalize the explanatory variables.
19. Since the domestic banks that comprise the JY TIBOR panel will be the same banks that actively trade in the domestic CD market, DomBk for Japan and JY TIBOR are the same. Similarly, since many of the dozens of banks that comprise the EURIBOR panel also trade in the euro commercial paper market, DomBk for the euro zone and EURIBOR are the same.

20. In conducting our tests, risk premia were calculated and regressions were run based on matching variables by calendar date. To examine the robustness of our results, we also structured the $ SIBOR/$ LIBOR and EY (JY) TIBOR/¥ LIBOR regressions by lagging the LIBOR variable one day to recognize time zone differences when markets did not overlap in terms of hours of operation. This approach was suggested by Covrig, Low and Melvin (2004). In general, the results were not as strong when we made these changes.
21. Belgium and Spain have Aa (AA) Moody's (S & P) sovereign ratings.
22. Refer to www.bba.org.uk.

APPENDIX

This appendix elaborates on our methodology of constructing a time series of BBA LIBOR, JBA TIBOR, ABS SIBOR, and EBF EURIBOR rates that are matched on each date with the corresponding bank panel's average Moody's credit rating of member banks. To illustrate, Appendix Table A1 lists the 16 banks that comprise the BBA dollar LIBOR panel in September 2005. The table shows the Moody's deposit credit rating for each bank, the index number assigned to each credit rating (Aaa = 1, Aa = 2, etc.), and the reported 3-month borrowing rate. The daily fixing is obtained by eliminating the highest and lowest quartiles and averaging the two middle quartiles, rounded to five decimal places, from a rank ordering of the 16 individual bank borrowing rates. For September 1 the fixing is 3.855 percent and for September 2 it is 3.761 percent.

The rates shown in bold **font** in the table are included in the two middle quartiles of eight banks. Note that the membership of all eight banks comprising the middle two quartiles can be uniquely determined for September 2 but not for September 1. For September 1, only two banks uniquely appear in the middle two quartiles, the remaining six banks include three each from the six banks reporting a borrowing rate of 3.85 percent and the six banks reporting a borrowing rate of 3.86 percent. Consequently, it is not always possible to precisely determine the average Moody's credit rating associated with a daily fixing. For example, for September 2, using the index values we assign to Moody's credit ratings, the average index credit rating for the eight banks included in the daily fixing is shown to be precisely 2.0. However, since the eight banks included in the fixing on September 1 cannot be uniquely determined, the average index credit rating can be as low as 1.75 and as high as 2.25, depending on which banks are assumed to comprise the middle two quartiles.

If Moody's credit ratings have validity, one would expect higher borrowing rates to be associated with a lower Moody's rating. However, if there is noise in the borrowing rates (or Moody's ratings), on any particular date, a rank ordering of the individual borrowing rates might not align with a precise ordering of the Moody's ratings. Examination of Appendix Table A1 shows this to be the case for both September 1 and 2. For example, on September 1, both Lloyds (Aaa) and Westdeutsche Landesbank (A1) report a borrowing rate of 3.86 percent. Additionally, Rabobank (Aaa) reports a borrowing rate of 3.855 percent, whereas Deutsche Bank (Aa3) reports a lower rate of 3.845 percent.

In general, our methodology relies on there not being any systematic biases in the data and those, in general, lower Moody's ratings will be associated with a higher borrowing rate. However, since the precise eight banks comprising the middle two quartiles cannot always be determined, we match the daily rate fixing with the average index credit rating computed over all 16 banks in the panel. This method avoids matching a daily rate fixing with an extreme average credit rating specific to an arbitrary set of eight banks. As can be seen from the table, the average index credit rating we match to the rate fixings for both September 1 and September 2, 2005, is 2.0625.

Table A1

BBA bank panel membership and individual percentage rates reported for fixing 3-month dollar LIBOR[a]

Bank	**September 1, 2005**	**September 2, 2005**
Bank of America (Aa1=2)	3.850	3.780
Bank of Tokyo-Mitsubishi (A1=3)	3.860	3.770
Barclays (Aa1=2)	3.870	**3.760**
Citibank (Aa1=2)	3.850	**3.760**
CSFB (Aa3=2)	3.850	**3.760**
Deutsche Bank (Aa3=2)	3.845	3.730
HBOS (Aa2=2)	3.850	**3.760**
HSBC (Aa2=2)	3.850	3.770
JPMorgan Chase (Aa2=2)	3.860	3.750
Lloyds (Aaa=1)	3.860	**3.760**
Norinchukin Bank (A1=3)	3.860	3.770
Rabobank (Aaa=1)	**3.855**	3.740
Royal Bank of Canada (Aa2=2)	3.850	3.755
Royal Bank of Scotland (Aa1=2)	3.860	**3.760**
UBS (Aa2=2)	**3.855**	**3.768**
Westdeutsche Landesbank (A1=3)	3.860	**3.760**
BBA Dollar LIBOR Fixing (%)	3.855	3.761
Average Moody's Index Rating-Full Panel of 16	2.0625	2.0625
Average Moody's Index Rating-Fixing 8	1.7500-2.2500	2.0000

[a]Of the 16 banks that comprise the BBA dollar LIBOR panel, the daily fixing is obtained by eliminating the highest and lowest quartiles and averaging the two middle quartiles, rounded to five decimal places, of a rank ordering of the individual bank borrowing rates. The rates shown in bold **font** are included in the two middle quartiles of eight banks. The membership of the eight banks comprising the middle two quartiles can be uniquely determined for September 2. For September 1, only two banks uniquely appear in the middle two quartiles; the remaining six banks include three each from the six banks reporting a borrowing rate of 3.85 percent and the six banks reporting a borrowing rate of 3.86 percent.

REFERENCES

Bartolini, L., S. Hilton, and A. Prati, 2005, "Money Market Integration," *Federal Reserve Bank of New York Staff Report no. 227.*

Bartram, S., and G. Karolyi, 2006, "The Impact of the Introduction of Euro on Foreign Exchange Rate Risk Exposures," *Journal of Empirical Finance*, 13, 519-549.

Covrig, V., B. Low, and M. Melvin, 2004, "A Yen is not a Yen: TIBOR/LIBOR and the Determinants of the Japan Premium," *Journal of Financial and Quantitative Analysis*, 39, 193-208.

Dufey, G., and I. Giddy, 1984, "Eurocurrency Deposit Risk," *Journal of Banking and Finance*, 8, 567-589.

Dufey, G., and I. Giddy, 1994, *The International Money Market*, Prentice Hall: Englewood Cliffs, NJ.

Martin, A., 2003, "A Guide to Deposit Insurance Reform," *Kansas City Federal Reserve Bank Economic Review*, First Quarter, 29-54.

Michaud, F.-L., and C. Upper, 2008, "What Drives Interbank Rates? Evidence from the LIBOR Panel," *BIS Quarterly Review*, March, 47-58.

Peek, J., and E.S. Rosengren, 2001, "Determinants of the Japan Premium: Actions Speak Louder than Words," *Journal of International Economics*, 53, 283-305.

Peria, M.S.M., and S.L. Schmukler, 2001, "Do Depositors Punish Banks for Bad Behavior? Market Discipline, Deposit Insurance, and Banking Crises," *Journal of Finance*, 56, 1029-1051.