# The Transmission of Shocks to LIBOR Risk Spreads and Nominal Risk-Free Rates

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**Abstract**

In this study, effects of shocks to international money market conditions, as measured by the three-month London Interbank Offer Rates (LIBOR) for five financially integrated economies (United States, the euro zone countries, Great Britain, Japan, and Canada) are examined. The sample period runs from January 4, 1999, through December 31, 2010. A five-equation vector autoregressive (VAR) model is developed using daily risk spreads between each country's LIBOR and its nominal risk-free rate. Also, effects of the risk spreads on the respective nominal risk-free rates are identified in a separate VAR system. Based on the risk-spread VAR, effects of exogenous shocks are examined. Single-country impulse tests show that the feed-through effects on the other countries are surprisingly limited for these integrated countries. Only when a shock is applied concurrently to all five risk spreads can effects on the magnitude noted in 2008 and 2009 be replicated, suggesting that all LIBOR rates were affected by a contemporaneous shock. Finally, a proportion of the shock to the risk-spread feed has an inverse effect on each country's nominal risk-free rate, reflecting the effect of the flow of funds from risky assets to safe assets in a time of increased risk and vice versa.

## I. Introduction

The spread between the London Interbank Offer Rate (LIBOR) and the Treasury bill rate of a corresponding maturity is considered an international measure of risk and liquidity. This can be calculated for any country, and this study uses five such spreads. Since these incorporate both risk and liquidity risk in the interbank market for respective currencies, it is always positive. This measure is closely related to the LIBOR risk spread which is the difference between the 3-month Eurodollar futures contract and the three-month Treasury bill contract.

The LIBOR risk spread is reported in Figure 1 on a monthly average basis for the 1971–2010 period. Each of the periods in which the spread widened can be traced to specific events. For example, the period from 1979 through 1988 can be traced to the evolution of the risk in dollar-based loans to "Less Developed Countries (LDC)." For example, the widening spread from roughly 1979 through 1983 represented the market recognition of the riskiness of LDC lending. The narrowing spread from 1984 through 1987 represented the systematic elimination of this risk through charge-offs and loan sales. The latest episode (2008–2009) can be attributed to the sub-prime mortgage crisis in general, the failure of Lehman Brothers, and the ensuing liquidity crisis in banking.

If each of these episodes is considered a shock, the obvious question is the degree to which a shock that boosts dollar-based LIBOR and originates in the United States is transmitted to countries with which the U.S. is financially integrated. To address this question, this paper assesses the linkage in the risk spreads between the London Interbank Offer Rate (LIBOR) and nominal risk-free rate (both at the three-month maturity) for five financially integrated countries. These linkages are then used to assess the international transmission of shocks. The paper also

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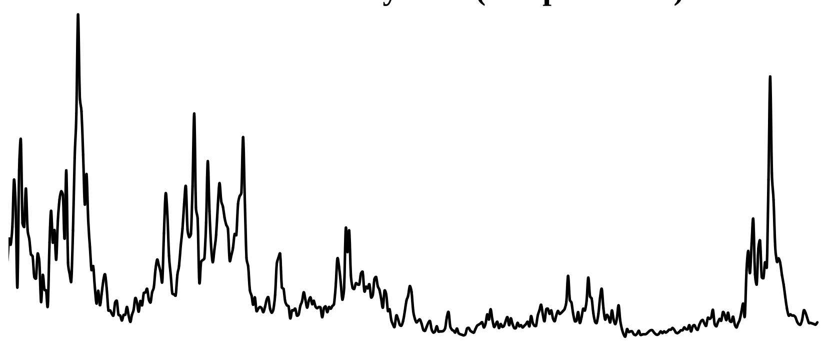
assesses the extent to which shifts in risk spreads affect nominal risk-free rates. That is, as shifts in risk spreads affect the appetite for risky assets, funds flow from risky assets to risk-free assets and vice versa. Thus, events that have a traumatic effect on risk spreads should also have an opposite effect on nominal risk-free rates.

**Figure 1: Spread between 3-month LIBOR and 3-month Treasury Bills (Coupon Basis)**



The paper begins with the literature review, followed by a discussion of the data and data manipulation methodology. The estimation methodology is explained, and the results are discussed and compared with DePrince and Morris (2009). The paper ends with a note on the significance of the findings.

## II. Literature Review

In many studies that examine shocks, it is the transmission of a monetary shock that is studied. The monetary shock is expressed as either a one-time change in money growth or in the federal-funds rate. Ehrmann and Fratzscher (2009) examine the transmission of monetary policy shocks to 50 worldwide equity markets looking at both advanced and emerging market economies. They use a precisely identified structural shock known to have substantial effects on financial models as well as international macroeconomic effects. They addressed the strength of transmission of U.S. monetary policy shocks to global equity markets. In their findings many differences in transmission strengths were observed. They further examine the macroeconomic policy differences and degree of financial integration to identify the underpinnings of these transmission strength differences across countries.

Mumtaz and Surico (2009) extend the work of Bernanke, Bovin, and Eliasz (2005) to the open economy as they examine the extent to which limited information sets plays in small-scale VARs. They focus on the growing importance of the inclusion of relevant information when the analysis moves from a closed economy to an open economy and attribute the puzzles found in the literature to the selection of information used in the analysis. They mention the Global VAR approach used by Dees, di Mauro, Smith, and Pesaran (2007) as an interesting alternative to use when examining the impact of shocks that originate in specific countries.

In this study, a multi-variable vector autoregressive (VAR) model is used to capture interdependencies among the risk spreads. This is a well-used technique, and many studies have used this econometric technique to address the effects of monetary policy and exchange rates including Sims (1992), Eichenbaum and Evans (1995), Grilli and Roubini (1995), Cushman and Zha (1997), Clarida and Gertler (1997), and Kim and Roubini (2000). Of these studies, Sims (1992) addresses the price puzzle by identifying monetary policy shocks with interest rate shocks in order to obtain positive (negative) output and money supply responses that are consistent with expansionary (contractionary) policy implementation. Eichenbaum and Evans (1995) examine the impact of an innovation (shock) on U.S. interest rates and the relative impact on exchange-rate movements in the other G-7 countries, while Sims (1992) and Grilli and Roubini (1995) examine the interest-rate innovations in the G-7 countries in order to assess exchange rate movements relative to the U.S. dollar.

The frequency used in the VAR studies varies based on the focus of the study. Since financial data is available on a daily basis, this study is based on high-frequency data, applying innovations or shocks to the daily risk spreads associated with the currencies under examination. Typically, however, it is more common for VAR studies to be based on data with lower frequencies due to data availability or the underlying assumptions of informational delays (Kim and Roubini 2000). For example, the use of quarterly data by Sims and Zha (1995) is important in the identification of the structural VAR in their analysis, whereas the structural VAR identifications of Kim and Roubini (2000) and Kim (2005) following the same general assumptions of Sims and Zha (1995) are based on the use of monthly data, leading them to alter the model's underlying assumptions.

In this analysis, the endogenous variables in the VAR are treated symmetrically. This treatment allows for the endogenous variables to be explained by their lags and the lags of the other endogenous variables. Sims (1980) advocates this econometric technique to avoid the "incredible identification restrictions" associated with structural VARs while still obtaining resultant economic relationships. Using high-frequency interest-rate data, daily Libor rates, in the implementation of this econometric technique is done to avoid the "pervasive orthagonalization problem" caused by co-movement of rates (Cocharane and Piazzesi 2002).

A study of the transmission of monetary shocks is not the intention of this study. In this model, a shock external to the system is the event, so the error term in each of the endogenous variables is the vehicle through which the shock is introduced.

Thus, the research question is whether (1) a shock that originates in the U.S. moves around the globe as represented in the risk spread VAR model, and a shock in the U.S. accounts for the global rise in LIBOR risk premiums in 2008–2009, or (2) all countries experienced a simultaneous exogenous shock that led to a global rise in the risk/liquidity premiums incorporated into the LIBOR rates.

## III. The Model and Estimation Methodology

Based on the introductory comments, the underlying research hypothesis is that events (shocks) in one country are transmitted to other countries that are financially integrated. Here it is assumed that the shock would affect the risk spread (*Risk Spread*), or premium above the nominal risk-free rate, and it may have an indirect effect on the nominal risk-free rate (*Nominal RF Rate*) in each of the countries.

LIBOR risk spreads are subject to the default, liquidity, and other risks of financial institutions (Jagannathan, Kaplin, and Sun 2003). Using this approach, the model of the LIBOR risk spread may be represented by

$$Risk\ Spread = F\left(CR_t\ LR_t, OC, v_t\right) \qquad (1)$$

where
$CR$ = Credit risk,
$LR$ = Liquidity risk,
$OR$ = Other risks, and
$v$ = Error term

In order to test the research hypothesis, it is assumed that each of the explanatory terms responds to shock with persistence. Therefore, the entire risk-spread structure can be approximated by a Vector Autogressive Model (VAR). Additionally, there is a separate VAR model for each country within the financially integrated environment. Thus, the VAR has *n* equations, one for each of the *n* countries in the study. Each of the endogenous variable risk spreads (*Risk Spread)* will have 1 through *m* lags in each equation. The system is denoted by:

$$\Delta\left(Risk\ Spread_{j,t}\right) = \beta_{0,j} + \sum_{j=1}^{n}\sum_{k=1}^{m}\beta_{k,j}\Delta\left(Risk\ Spread_{j,t-k}\right) + \mu_{j,t} \qquad (2)$$

Where

$$Risk\ Spread_{j,t} = LIBOR_{j,t} - Nominal\ RF\ Rate_{j,t}$$

and $j$ = 1, …, *n* and represents the *n* countries, and
$k$ = 1, …, *m* and represents the *m* lags on each of the *n* countries within the system.

During the test phase, the estimation results for each country’s *Risk Spread* can be shocked by pinging its stochastic innovation term by a given amount—say, for example, one percentage point—and the VAR system will show the feed through to the other currencies.

Next, the nominal risk-free rate depends in turn upon relative supply and demand for funds. Since this is typically measured by a short-term Treasury rate, the demand for funds by that sector depends upon the need for funds at that maturity as well as a random term. Thus, the demand for funds depends upon the nominal risk-free rate (the real risk-free rate plus expected inflation), relative conditions in competing sectors, and the usual random element. Relative conditions in other sectors reflect relative credit and liquidity considerations, relative information costs, and relative uncertainty. The system can be solved for the nominal risk-free rate as a function of the need for funds, relative conditions in other sectors, and a random term. On the assumption that this reduced-form equation can be approximated by a VAR, the nominal risk-free rate of each country may be expressed as

$$\Delta\left(Noninal\ Risk\ Free\ Rate_{j,t}\right) = \beta_{0,j} + \sum_{j=1}^{n}\sum_{k=1}^{m}\beta_{k,j}\Delta\left(Noninal\ Risk\ Free\ Rate_{j,t-k}\right) + \sum_{j=1}^{n}\delta_j Relative\ Conditions_{j,t} + \mu_{j,t} \tag{3}$$

where $j$ = 1, …, $n$ and represents the $n$ countries,
$k$ = 1,…, $m$ and represents the $m$ lags on each of the $n$ countries within the

Relative conditions are approximated, in turn, by the change in the LIBOR risk spread or

$$Relative\ Conditions_{j,t} = \Delta\left(Risk\ Spread_{j,t}\right) \tag{4}$$

Thus, shifts in the risk spread have an indirect effect upon the nominal risk-free rate. This is the expected outcome in a world of two assets in which one becomes relatively riskier (and vice versa). If short-term lending is perceived to rise in risk, relative to the risk-free sector, the resulting movement of funds from the riskier sector to the safer sector leads to a rise in the lending rate in the riskier sector and a fall in the rate in the risk-free sector.

## IV. The Data

LIBOR data and data on the nominal risk-free rates (approximated by the three-month Treasury or government rate for each country) were obtained from the Bloomberg database. The focus is on the post-euro period, which extends from January 4, 1999, through December 31, 2010. Industrialized (financially integrated) countries used in the study include the United States, the United Kingdom, the euro-zone countries, Canada, and Japan.[1] Daily observations are used in this study, organized into five-day weeks. Observations for holidays were set equal to the observation on the day preceding the holiday.

## V. Estimation Results

### a. Screening Results

The first step was to assess the stationarity of the day-to-day changes in the risk spread and the nominal risk-free rate at the three-month maturity. Using the Augmented Dickey-Fuller method, the null hypothesis (the presence of a unit root implying a non-stationary series) was rejected with near certainty for the first difference of the risk spreads and the nominal risk-free rates. Thus, the first difference of the risk spreads and the nominal risk-free rates can properly be used in the estimation phase.

Next, the appropriate number of lags was addressed. Lag-length test results varied, depending on the specific test. Since results were ambiguous, it was decided that a week (five

[1] Data for Swiss and Australian LIBOR are available, but data for their Treasury yields are not available through Bloomberg. Hence, the study is limited to the five countries for which both data sets are available.

business days) would be an appropriate lag structure. While arbitrary, a business week does have a certain intuitive appeal.

### b. Model Results

Table I reports estimation results using Equation 2 for the five-variable VAR system for the daily changes in the LIBOR risk spreads. Table II reports results for the nominal risk-free rate (Equation 3). Both are at the three-month maturity. To help the reader visualize the results, the lags on the "own" rate in each of the five estimated equations are boxed in both models.

Readers can see that the adjusted $R^2$ is low for each of the LIBOR risk spread equations (Table I, Equation 2). In a sense, this should not be surprising, since changes in interest rates are often viewed as following a random-walk process. Nonetheless, the test of the null hypothesis (i.e., that the independent variables have no influence on the dependent variables) is rejected with near certainty using the F-test for each of the five countries. From reviewing results for each equation, it is evident that the most significant variables are the own rate, though the significant lags vary among countries. The cross-country coefficients vary in importance; however, several are significant at the 95-percent level in each country. These lags determine, in turn, the extent to which a shock in one country propagates across the other four countries. Finally, the diagnostic evaluation of the lags is favorable. The inverted AR roots of the polynomials associated with the five functions reported in Table I all lie within the unit circle. This implies that impulse simulation will be damped in all cases—a highly desirable outcome.

Table II reports results for Equation 3 which explains the daily changes in the nominal risk-free rate at the three-month maturity for all five currencies. In addition to lags on the daily changes in the five risk-free rates, it includes the LIBOR risk spread for each of the five countries as exogenous variables. Results for endogenous variables are roughly similar to results for five LIBOR risk spreads in Table I for Equation 2. Most of the statistically important lags are those of the own rate. As in Equation 2, cross-country lags have scattered importance, but several are significant at least at the five-percent level.

Turning to the exogenous variables in Equation 3, the risk spreads are designed to capture effects of asset flows between riskier and safer assets as the financial environment evolves. Signs, as expected, are negative, implying that an increase in risk (an increase in the LIBOR risk spread) is reflected in a movement of funds from the risky asset to the safe asset. This increases the supply of funds for the safe asset and reduces the supply of funds for the risky asset. These results confirm that, other things being equal, as the risk spread rises, the yield on safe assets falls, and vice versa. Coefficients on the own risk spread ranges from a high of 92 percent in the euro zone to a low of 43 percent in the U.K.

## VI. Shock Test Phase: The Risk Spreads

### a. Introduction

In this phase, a 100-basis-point shock is applied to the day-to-day change in each LIBOR spread. The change occurs in Period 1, and subsequent effects on the own LIBOR spread and the cross LIBOR spreads begin in Period 2. The shocks are applied to each spread separately, the day-to-day effects on each on the five LIBOR spreads are reported over a 15-day period, and the

**Table I: Estimation Results for Equation 2**
Daily Changes in LIBOR Risk Spreads (LIBOR less nominal risk-free rates)

| | US | EU | JPY | UK | CAN |
|---|---|---|---|---|---|
| US(-1) | 0.046 | 0.002 | -0.003 | 0.006 | 0.175 |
| | (2.388) | (0.123) | (-0.608) | (0.233) | (12.151) |
| US(-2) | 0.048 | 0.012 | 0.007 | 0.079 | 0.029 |
| | (2.481) | (0.762) | (1.626) | (2.832) | (2.005) |
| US(-3) | -0.021 | 0.020 | 0.015 | 0.050 | 0.051 |
| | (-1.108) | (1.316) | (3.384) | (1.809) | (3.521) |
| US(-4) | -0.120 | -0.024 | 0.014 | 0.015 | -0.015 |
| | (-6.307) | (-1.583) | (3.278) | (0.547) | (-1.041) |
| US(-5) | -0.028 | 0.009 | -0.001 | 0.031 | 0.032 |
| | (-1.446) | (0.592) | (-0.318) | (1.139) | (2.250) |
| EU(-1) | 0.120 | -0.071 | 0.016 | 0.088 | 0.004 |
| | (4.821) | (-3.637) | (2.899) | (2.449) | (0.231) |
| EU(-2) | 0.121 | -0.176 | 0.010 | -0.544 | 0.021 |
| | (4.907) | (-9.074) | (1.801) | (-15.333) | (1.153) |
| EU(-3) | 0.103 | -0.126 | 0.009 | 0.144 | 0.045 |
| | (4.057) | (-6.275) | (1.502) | (3.927) | (2.347) |
| EU(-4) | 0.111 | -0.149 | 0.005 | -0.016 | 0.069 |
| | (4.377) | (-7.414) | (0.888) | (-0.444) | (3.583) |
| EU(-5) | 0.038 | 0.027 | -0.004 | 0.353 | 0.004 |
| | (1.499) | (1.339) | (-0.639) | (9.638) | (0.199) |
| JP(-1) | -0.187 | -0.025 | -0.207 | -0.259 | 0.044 |
| | (-2.34) | (-0.401) | (-11.496) | (-2.243) | (0.733) |
| JP(-2) | 0.012 | 0.041 | -0.004 | 0.012 | 0.054 |
| | (0.147) | (0.639) | (-0.213) | (0.105) | (0.894) |
| JP(-3) | -0.014 | 0.060 | -0.078 | -0.134 | 0.041 |
| | (-0.172) | (0.957) | (-4.320) | (-1.164) | (0.678) |
| JP(-4) | -0.230 | -0.137 | -0.145 | 0.077 | 0.091 |
| | (-2.875) | (-2.179) | (-8.091) | (0.670) | (1.514) |
| JP(-5) | -0.017 | 0.130 | -0.040 | 0.206 | 0.183 |
| | (-0.216) | (2.079) | (-2.254) | (1.807) | (3.075) |
| UK(-1) | 0.038 | 0.010 | -0.018 | 0.003 | 0.062 |
| | (2.824) | (0.967) | (-5.918) | (0.169) | (6.213) |
| UK(-2) | 0.059 | 0.081 | -0.008 | 0.083 | -0.056 |
| | (4.403) | (7.659) | (-2.520) | (4.319) | (-5.525) |
| UK(-3) | 0.023 | 0.067 | -0.003 | 0.014 | -0.018 |
| | (1.710) | (6.338) | (-1.139) | (0.711) | (-1.748) |
| UK(-4) | -0.053 | 0.002 | -0.005 | 0.030 | -0.015 |
| | (-3.993) | (0.152) | (-1.811) | (1.563) | (-1.499) |
| UK(-5) | -0.044 | 0.003 | 0.008 | -0.068 | -0.138 |
| | (-3.338) | (0.298) | (2.575) | (-3.548) | (-13.857) |

| | | | | | |
|---|---|---|---|---|---|
| CD(-1) | -0.113 | 0.193 | 0.012 | 0.198 | -0.121 |
| | (-4.587) | (9.933) | (2.213) | (5.595) | (-6.559) |
| CD(-2) | -0.092 | 0.055 | 0.009 | 0.084 | -0.053 |
| | (-3.669) | (2.770) | (1.516) | (2.313) | (-2.786) |
| CD(-3) | 0.008 | 0.134 | 0.004 | 0.265 | 0.004 |
| | (0.302) | (6.761) | (0.645) | (7.327) | (0.215) |
| CD(-4) | 0.172 | 0.061 | 0.003 | 0.083 | 0.050 |
| | (6.841) | (3.072) | (0.497) | (2.296) | (2.637) |
| CD(-5) | 0.110 | -0.038 | -0.001 | -0.118 | 0.084 |
| | (4.450) | (-1.944) | (-0.106) | (-3.316) | (4.541) |
| C | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (-0.194) | (0.267) | (-0.414) | (-0.009) | (-0.001) |
| Summary Statistics | | | | | |
| Adj. R-squared | 0.091 | 0.123 | 0.081 | 0.157 | 0.162 |
| F-statistic | 13.507 | 18.464 | 11.978 | 24.324 | 25.071 |

**Table II: Estimation Results for Equation 3**
Daily Changes in nominal risk free-rate

| | US | EU | JPY | UK | CD |
|---|---|---|---|---|---|
| US(-1) | 0.124 | 0.028 | -0.002 | -0.013 | 0.049 |
| | (13.953) | (4.718) | (-0.705) | (-1.141) | (6.424) |
| US(-2) | -0.006 | 0.002 | -0.002 | -0.007 | -0.008 |
| | (-0.627) | (0.350) | (-0.884) | (-0.581) | (-1.095) |
| US(-3) | 0.015 | 0.014 | 0.001 | 0.008 | 0.021 |
| | (1.644) | (2.302) | (0.383) | (0.735) | (2.804) |
| US(-4) | 0.006 | -0.008 | 0.005 | 0.012 | -0.017 |
| | (0.721) | (-1.261) | (1.903) | (1.066) | (-2.205) |
| US(-5) | 0.029 | 0.007 | 0.007 | -0.025 | 0.021 |
| | (3.273) | (1.127) | (2.522) | (-2.215) | (2.755) |
| EU(-1) | 0.010 | 0.032 | 0.004 | 0.012 | 0.022 |
| | (0.878) | (4.248) | (1.286) | (0.860) | (2.375) |
| EU(-2) | -0.029 | 0.005 | 0.001 | -0.043 | 0.003 |
| | (-2.571) | (0.606) | (0.235) | (-2.893) | (0.286) |
| EU(-3) | -0.035 | -0.021 | 0.004 | -0.016 | -0.037 |
| | (-3.118) | (-2.742) | (1.196) | (-1.114) | (-3.873) |
| EU(-4) | 0.012 | 0.021 | -0.005 | -0.007 | 0.016 |
| | (1.051) | (2.695) | (-1.389) | (-0.471) | (1.704) |
| EU(-5) | -0.045 | 0.009 | -0.004 | 0.002 | -0.040 |
| | (-3.963) | (1.176) | (-1.077) | (0.117) | (-4.115) |
| JP(-1) | 0.158 | 0.047 | 0.196 | 0.361 | 0.037 |
| | (3.548) | (1.555) | (14.448) | (6.254) | (0.985) |
| JP(-2) | 0.068 | 0.046 | 0.089 | -0.027 | 0.048 |
| | (1.601) | (1.585) | (6.821) | (-0.479) | (1.327) |
| JP(-3) | 0.160 | 0.023 | -0.009 | 0.333 | 0.064 |

| | | | | | |
|---|---|---|---|---|---|
| | (3.733) | (0.791) | (-0.671) | (5.952) | (1.754) |
| JP(-4) | 0.096 | -0.004 | 0.001 | 0.101 | 0.054 |
| | (2.248) | (-0.149) | (0.039) | (1.819) | (1.493) |
| JP(-5) | 0.150 | 0.061 | -0.015 | 0.156 | 0.042 |
| | (3.524) | (2.107) | (-1.172) | (2.824) | (1.166) |
| UK(-1) | -0.044 | -0.013 | -0.011 | 0.091 | -0.012 |
| | (-4.554) | (-1.921) | (-3.652) | (7.144) | (-1.420) |
| UK(-2) | -0.018 | 0.012 | 0.009 | 0.063 | 0.029 |
| | (-1.797) | (1.733) | (3.066) | (4.864) | (3.481) |
| UK(-3) | -0.009 | 0.015 | 0.002 | 0.004 | -0.006 |
| | (-0.912) | (2.258) | (0.544) | (0.348) | (-0.684) |
| UK(-4) | -0.011 | -0.002 | 0.004 | -0.037 | -0.035 |
| | (-1.190) | (-0.345) | (1.256) | (-2.959) | (-4.217) |
| UK(-5) | -0.005 | 0.011 | 0.009 | -0.128 | -0.092 |
| | (-0.497) | (1.66) | (3.129) | (-10.121) | (-11.036) |
| CD(-1) | 0.007 | 0.020 | 0.005 | 0.139 | 0.106 |
| | (0.556) | (2.530) | (1.490) | (8.991) | (10.490) |
| CD(-2) | 0.048 | -0.011 | 0.002 | -0.019 | -0.016 |
| | (4.026) | (-1.328) | (0.573) | (-1.197) | (-1.581) |
| CD(-3) | 0.074 | -0.002 | -0.003 | 0.017 | 0.059 |
| | (6.173) | (-0.206) | (-0.867) | (1.072) | (5.789) |
| CD(-4) | 0.005 | 0.025 | -0.005 | -0.015 | 0.016 |
| | (0.425) | (3.114) | (-1.398) | (-0.946) | (1.556) |
| CD(-5) | -0.055 | 0.000 | -0.004 | 0.089 | 0.002 |
| | (-4.652) | (0.015) | (-1.163) | (5.820) | (0.236) |
| C | -0.001 | -0.001 | 0.000 | -0.001 | -0.001 |
| | (-2.851) | (-1.644) | (-0.275) | (-2.281) | (-2.747) |

**Table II: Estimation Results for Equation 3 (continued)**

Daily Changes in nominal risk free rate

| Exogenous Variable Risk Spreads | | | | | |
|---|---|---|---|---|---|
| | US | EU | JPY | UK | CD |
| US | -0.842 | 0.041 | 0.011 | 0.039 | 0.009 |
| | (-102.203) | (7.385) | (4.320) | (3.608) | (1.305) |
| EU | 0.058 | -0.921 | 0.001 | -0.135 | 0.038 |
| | (5.487) | (-127.795) | (0.433) | (-9.804) | (4.252) |
| JPY | 0.170 | 0.200 | -0.546 | 0.084 | 0.170 |
| | (4.96) | (8.606) | (-52.101) | (1.893) | (5.818) |
| UK | 0.022 | 0.006 | -0.001 | -0.432 | -0.023 |
| | (3.869) | (1.398) | (-0.538) | (-57.182) | (-4.703) |
| CD | 0.113 | 0.049 | 0.008 | -0.081 | -0.735 |
| | (10.503) | (6.744) | (2.514) | (-5.798) | (-80.369) |
| Summary Statistics | | | | | |
| Adj. R-squared | 0.798 | 0.877 | 0.496 | 0.667 | 0.758 |
| F-statistic | 412.325 | 741.235 | 103.512 | 209.142 | 327.221 |

cumulative effect of each shock on each of the LIBOR spreads over the 15-day period are reported at the bottom each column. The 15-day horizon is admittedly arbitrary; however, a quick examination of Tables III-VII shows that effects dissipate over this period. Table VIII reports results for a simultaneous 100-basis-point shock to the daily changes in all five LIBOR spreads.

## b. Shock to Dollar LIBOR Spread

While day-to-day effects differ among the five LIBOR risk spreads in Table I, the 100-basis-point shock to the day-to-day change in the dollar LIBOR risk spread leads to a cumulative effect of nearly 1.0 percentage points to the U.S. LIBOR rate spread as the shock moves through the systems of lag effects. It is interesting that the cumulative effects to the other four currencies are muted. The largest feed-through effect is felt on the U.K. risk spread (32 basis points [bp]),

**Table III: Effect of 100 BP Shock to U.S. LIBOR Spread**

| Period | D(US) | D(EU) | D(JPY) | D(UK) | D(CAN) |
|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 |
| 2 | 0.0458 | 0.0019 | -0.0026 | 0.0064 | 0.1753 |
| 3 | 0.0314 | 0.0455 | 0.0096 | 0.1150 | 0.0163 |
| 4 | -0.0272 | 0.0312 | 0.0133 | 0.0735 | 0.0541 |
| 5 | -0.1106 | 0.0121 | 0.0127 | 0.0635 | -0.0229 |
| 6 | 0.0049 | 0.0225 | -0.0037 | 0.0439 | 0.0240 |
| 7 | 0.0240 | -0.0011 | -0.0033 | -0.0015 | 0.0130 |
| 8 | 0.0146 | 0.0018 | -0.0040 | 0.0026 | -0.0129 |
| 9 | 0.0152 | 0 | -0.0024 | 0.0138 | 0.0021 |
| 10 | 0.0057 | 0.0025 | 0.0015 | 0.0099 | -0.0052 |
| 11 | 0.0040 | -0.0013 | 0.0012 | 0.0022 | -0.0022 |
| 12 | -0.0003 | -0.0003 | 0.0008 | -0.0023 | 0.0019 |
| 13 | -0.0033 | 0.0009 | 0.0005 | 0.0026 | -0.0022 |
| 14 | -0.0033 | -0.0015 | -0.0002 | -0.0022 | -0.0018 |
| 15 | -0.0024 | 0.0002 | -0.0002 | 0.0005 | -0.0020 |
| 15-Day Cumulative | 0.9984 | 0.1142 | 0.0232 | 0.3279 | 0.2376 |

**Table IV: Effect of 100 BP Shock to Euro LIBOR Spread**

| Period | D(US) | D(EUR) | D(JPY) | D(UK) | D(CAN) |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 | 0 |
| 2 | 0.1197 | -0.0713 | 0.0162 | 0.0877 | 0.0043 |
| 3 | 0.1176 | -0.1698 | 0.0037 | -0.5530 | 0.0477 |
| 4 | 0.0636 | -0.0883 | 0.0146 | 0.1929 | 0.0226 |
| 5 | 0.0458 | -0.1285 | 0.0007 | 0.0333 | 0.1197 |
| 6 | -0.0481 | 0.0924 | -0.0063 | 0.4303 | -0.0101 |
| 7 | -0.0073 | 0.0831 | -0.0031 | 0.0601 | -0.0009 |
| 8 | 0.0277 | 0.0520 | -0.0086 | -0.0078 | 0.0528 |
| 9 | 0.0240 | 0.0363 | 0.0039 | -0.0367 | -0.0346 |
| 10 | 0.0181 | -0.0425 | 0.0008 | -0.0653 | 0.0139 |
| 11 | -0.0043 | -0.0145 | 0.0064 | 0.0008 | -0.0514 |
| 12 | 0.0099 | -0.0188 | 0.0009 | 0.0310 | 0.0081 |
| 13 | -0.0012 | -0.0037 | -0.0014 | 0.0086 | 0.0118 |
| 14 | -0.0066 | 0.0138 | -0.0012 | 0.0211 | -0.0019 |
| 15 | -0.0091 | 0.0033 | -0.0017 | -0.0101 | 0.0061 |
| 15-Day Cumulative | 0.3497 | 0.7433 | 0.0248 | 0.1930 | 0.1881 |

**Table V: Effect of 100 BP Shock to Japanese LIBOR Spread**

| Period | D(US) | D(EUR) | D(JPY) | D(UK) | D(CAN) |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 0 |
| 2 | -0.1872 | -0.0253 | -0.2069 | -0.2587 | 0.0441 |
| 3 | 0.0243 | 0.0533 | 0.0441 | 0.0702 | -0.0092 |
| 4 | -0.0447 | 0.0299 | -0.0859 | -0.1638 | 0.0476 |
| 5 | -0.2118 | -0.1567 | -0.1095 | 0.1120 | 0.0500 |
| 6 | 0.0543 | 0.1733 | 0.0070 | 0.1785 | 0.1354 |
| 7 | -0.0016 | -0.0133 | 0.0041 | 0.1048 | -0.0193 |
| 8 | 0.0599 | 0.0325 | 0.0142 | -0.0569 | -0.0285 |
| 9 | 0.0853 | 0.0447 | 0.0124 | 0.0685 | 0.0073 |
| 10 | 0.0431 | -0.0470 | 0.0029 | -0.1062 | 0.0015 |
| 11 | 0.0059 | -0.0056 | 0.0001 | 0.0201 | -0.0059 |
| 12 | -0.0207 | -0.0066 | 0.0004 | 0.0194 | 0.0016 |
| 13 | -0.0200 | -0.0024 | -0.0022 | 0.0259 | 0.0111 |
| 14 | -0.0105 | 0.0156 | 0 | 0.0185 | -0.0111 |
| 15 | 0.0012 | 0.0011 | -0.0018 | -0.0068 | 0.0118 |
| 15-Day Cumulative | -0.2225 | 0.0936 | 0.6790 | 0.0254 | 0.2363 |

| Table VI: Effect of 100 BP Shock to U.K. LIBOR Spread | | | | | |
|---|---|---|---|---|---|
| Period | D(US) | D(EUR) | D(JPY) | D(UK) | D(CAN) |
| 1 | 0 | 0 | 0 | 1 | 0 |
| 2 | 0.0376 | 0.0102 | -0.0177 | 0.0032 | 0.0622 |
| 3 | 0.0583 | 0.0928 | -0.0032 | 0.1014 | -0.0572 |
| 4 | 0.0449 | 0.0525 | -0.0030 | 0.0148 | 0.0029 |
| 5 | -0.0175 | -0.0051 | -0.0019 | 0.0162 | -0.0037 |
| 6 | -0.0136 | -0.0123 | 0.0131 | -0.0847 | -0.1318 |
| 7 | 0.0070 | -0.0506 | -0.0003 | -0.0264 | 0.0153 |
| 8 | -0.0109 | -0.0077 | 0.0007 | 0.0183 | -0.0069 |
| 9 | -0.0120 | -0.0116 | -0.0024 | 0.0025 | -0.0013 |
| 10 | -0.0285 | 0.0016 | -0.0021 | -0.0155 | -0.0127 |
| 11 | -0.0152 | 0.0146 | -0.0009 | 0.0206 | -0.0065 |
| 12 | -0.0002 | -0.0048 | -0.0007 | -0.0254 | 0.0027 |
| 13 | 0.0003 | -0.0021 | 0.0004 | -0.0158 | -0.0085 |
| 14 | 0.0024 | -0.0052 | 0.0002 | -0.0084 | -0.0007 |
| 15 | -0.0006 | -0.0041 | 0 | -0.0004 | 0.0018 |
| 15-Day Cumulative | 0.0519 | 0.0682 | -0.0178 | 1.0005 | -0.1442 |

| Table VII: Effect of 100 BP Shock to Canada LIBOR Spread | | | | | |
|---|---|---|---|---|---|
| Period | D(US) | D(EUR) | D(JPY) | D(UK) | D(CAN) |
| 1 | 0 | 0 | 0 | 0 | 1 |
| 2 | -0.1126 | 0.1925 | 0.0122 | 0.1980 | -0.1212 |
| 3 | -0.0554 | 0.0193 | 0.0045 | 0.0734 | -0.0440 |
| 4 | 0.0551 | 0.0994 | -0.0001 | 0.1498 | 0.0014 |
| 5 | 0.2253 | 0.0266 | -0.0016 | 0.0714 | 0.0657 |
| 6 | 0.1475 | -0.0695 | -0.0058 | -0.1568 | 0.1193 |
| 7 | -0.0105 | 0.0391 | 0.0057 | 0.1194 | -0.0336 |
| 8 | -0.0192 | 0.0008 | 0.0041 | 0.0858 | 0.0158 |
| 9 | -0.0192 | 0.0201 | 0.0040 | 0.0520 | -0.0143 |
| 10 | 0.0173 | 0.0175 | 0.0009 | 0.0133 | -0.0013 |
| 11 | 0.0174 | -0.0084 | -0.0040 | -0.0283 | 0.0349 |
| 12 | -0.0047 | 0.0084 | 0.0004 | 0.0128 | -0.0220 |
| 13 | -0.0028 | -0.0085 | -0.0001 | -0.0012 | -0.0058 |
| 14 | -0.0024 | 0.0001 | 0.0007 | 0.0073 | -0.0058 |
| 15 | 0.0059 | 0.0010 | 0.0004 | 0.0061 | 0.0005 |
| 15-Day Cumulative | 0.2417 | 0.3385 | 0.0212 | 0.6032 | 0.9896 |

**Table VIII: Effect of 100 BP Shock to All LIBOR Spreads**

| Period | D(US) | D(EUR) | D(JPY) | D(UK) | D(CAN) |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | -0.0967 | 0.1079 | -0.1988 | 0.0367 | 0.1648 |
| 3 | 0.1762 | 0.0411 | 0.0587 | -0.1930 | -0.0463 |
| 4 | 0.0917 | 0.1246 | -0.0610 | 0.2672 | 0.1286 |
| 5 | -0.0688 | -0.2516 | -0.0997 | 0.2964 | 0.2088 |
| 6 | 0.1449 | 0.2063 | 0.0044 | 0.4111 | 0.1368 |
| 7 | 0.0116 | 0.0572 | 0.0031 | 0.2565 | -0.0255 |
| 8 | 0.0721 | 0.0794 | 0.0064 | 0.0421 | 0.0203 |
| 9 | 0.0934 | 0.0896 | 0.0155 | 0.1001 | -0.0408 |
| 10 | 0.0556 | -0.0679 | 0.0041 | -0.1638 | -0.0037 |
| 11 | 0.0077 | -0.0152 | 0.0028 | 0.0155 | -0.0311 |
| 12 | -0.0160 | -0.0220 | 0.0018 | 0.0355 | -0.0077 |
| 13 | -0.0270 | -0.0158 | -0.0029 | 0.0201 | 0.0063 |
| 14 | -0.0203 | 0.0228 | -0.0005 | 0.0362 | -0.0213 |
| 15 | -0.0050 | 0.0015 | -0.0033 | -0.0106 | 0.0181 |
| 15-Day Cumulative | 1.4192 | 1.3578 | 0.7304 | 2.1498 | 1.5074 |

followed by the Canada spread (24 bp) and the euro-zone spread (11 bp). Effects on the Japanese risk spread are minimal, consistent with the findings of U.S. monetary policy shocks (Ehrmann & Fratzscher 2009).

In looking at events in the second half of 2008 and the first half of 2009, these results suggest that a shock to the U.S. alone has a limited effect as effects move through time and across countries. In other words, the global turmoil may not be explained solely by effects of the U.S. LIBOR spread. Rather, it is more likely that exogenous shocks hit all economies roughly simultaneously. This stands in contrast to the popular notion that the problem began in the U.S. and was transmitted outward from the U.S. to other countries. Results for single-country shocks discussed below tend to support this conclusion.

### c. Shock to Euro-Zone LIBOR Risk Spreads

Results of a one-time shock to the euro-zone risk spread are reported in Table IV. As with Japan (see next section), there is a slight offset to the 100 bp shock over the 15-day test period, with cumulative effects of only 74 bp on the euro-zone LIBOR. Feed-through effects to the other currencies vary, with the U.S. at 35 bp and the U.K. and Canada at 19 bp.

### d. Shock to Japanese LIBOR Spread

Results of a one-time shock to the Japanese LIBOR risk spread are reported in Table V and show a cumulative effect of 68 bp. In other words, effects of the shock are partly reversed over the subsequent three weeks. Again, there are muted feed-through effects to other currencies. The Canadian risk spread experienced a cumulative rise of 24 bp. Thus, while the Japanese seem to successfully isolate themselves from shocks originating in Canada (see subsequent sections for results of the Canadian shock), the same cannot be said for the ability of Canada to isolate itself from shocks originating in Japan. In contrast, the 100 bp shock to the Japanese risk spread leads to a cumulative decline of 22 bp in the U.S. risk spread. While seemingly a surprising outcome, it suggests that problems in Japan lead to a flight to quality from Japan to the U.S., putting a downward pressure on U.S. risk spreads. On balance, results for Japan are not surprising, since short-term rates were basically flatlined over the sample period.

### e. Shock to U.K. LIBOR Risk Spread

Results of a one-time shock to the U.K. LIBOR risk spread are reported in Table VI. Results are similar to the shock to the U.S. LIBOR risk spread. The cumulative effect on the U.K. risk spread is roughly one percentage point, with very muted effects on the U.S. and euro-zone spreads of roughly 5 to 6 bp each. Effects are minimal on the Japanese risk spread (-2 pb) and surprisingly negative on Canada (-14 bp).

### f. Shock to Canadian LIBOR Risk Spread

Results of a one-time shock to the Canadian LIBOR risk spread are reported in Table VII. The cumulative effect on the Canadian risk spread is in the vicinity of one percentage point. Some feed-through effects are observed on the U.S. and the euro-zone risk spreads (24 and 34 bp, respectively), but there is a sizeable effect on the U.K. risk spread (60 bp), and effects on the Japanese risk spread are minimal.

### g. On Balance

Of the five LIBOR risk spreads, the dollar, the U.K. and the Canadian spreads are around one percentage point, while the Japanese and the euro-zone spreads respond with a cumulative effect of roughly 70 to 75 pb. In terms of feed-through effects, the largest was the effect of a Canadian shock on the U.K. (60 pb). A number of modest bilateral effects were noted in the preceding paragraphs, but Japan stands out as the only country that has successfully isolated itself from shocks originating in the other four countries. The U.S., in turn, shows an inverse relationship between a shock in Japan and resulting cross-country effects in the U.S.

## VII. Simultaneous Global Shocks

The muted feed-through effect of shocks in any single currency to other currencies is an interesting finding and suggests that the magnitude of the current turmoil must have been the result of a simultaneous shock to the daily changes in all five LIBOR risk spreads. To assess this possibility, a 100 bp shock was simultaneously applied to all five risk spreads. Results are reported in Table VIII. Cumulative effects are smallest for Japan at 73 bp, which is consistent with its isolation from single-country shocks noted above. The weak cumulative-impulse response of the Japanese risk spread may seem surprising, but it probably reflects the low rates and the lack of effect of global markets in the Japanese LIBOR over the same period. The cumulative effect is largest for the U.K. (215 bp), which is probably attributable to feed-through effects from Canadian and U.S. shock. Cumulative effects for the U.S., Canada, and the euro zone are all in the 135-150 bp range. On balance, these results support the view that the shock was global in nature, affecting all countries simultaneously.

## VIII. Shocks to Risk Spreads and the Implication for the Nominal Risk-Free Rate

Equation 2 is based on the separation of the LIBOR risk spread from the nominal LIBOR. Equation 2 in isolation presumes that shocks to the risk spread affect LIBOR but not the nominal risk-free rate. At the same time, a strong negative correlation was found between the LIBOR risk spreads and the nominal risk-free rates. This negative influence is captured in Equation 3 (Table II), which shows significant negative effects of daily changes in LIBOR risk spreads on daily changes in the respective nominal risk-free rates.

While a significant effect on the nominal risk-free rates from shifts in risk premiums were identified in Equation 3, effects of shock on the nominal risk-free rates were not assessed. The main purpose of this paper was to assess the effect of shocks on risk spreads. Nonetheless, Equation 3 shows that shocks to the LIBOR risk spreads have a feed-through effect on the nominal risk-free rates. Feed-through effects range from a high of .92 for the euro zone (92 percent of the change in the risk spread feeds through to a decline in the nominal risk-free rate) to a low of a 43-percent fall in the nominal risk-free rate for the U.K.

These negative coefficients are consistent with the view that flights to safety (or movement from LIBOR to a risk-free-rate asset) leads to an increase in the supply of funds in the risk-free market and a reduction of the supply of funds to the risky market. As a result, the nominal risk-free rates would fall in response to increased risk and fall in response to reduced risk in the LIBOR market. Thus, while it would be interesting, an extension of the simulations to include the nominal risk-free rates would not have extended the results in a meaningful manner. However, it is evident that the cumulative effect on each of the LIBOR risk spreads would inversely impact the nominal risk-free rates by the proportion equal to the coefficient on the own-rate LIBOR risk spread in each of the functions in Table II (Equation 3), a pattern reflective of the shift in the supply of funds from a risky market to a risk-free market.

## IX. Summary

The main purpose of this study was accomplished. A VAR model of risk spreads can be developed to assess the international transmission of financial shocks. This model led to two findings. First, there is a muted feed-through effect of a shock to any single-risk spread to the risk spread of other countries. Second, global turmoil, such as that experienced in the second half of 2008 and the first half of 2009, was probably the result of exogenous shocks through the world and not a problem in the U.S. that was transmitted to the rest of the world. Thus, markets responded globally to consecutive shocks around the globe that then went through a multiplier effect as effects accumulated across time and across countries. This does raise the question of the origin of massive contemporaneous shocks around the globe. Nonetheless, it does show that the U.S. was not a singular source of the jump in LIBOR rates in the second half of 2008. Finally, the full model confirmed the inverse impact on the risk-free rates as risk spreads widen (or narrow). This inverse effect is due to the movement of funds from (to) short-term risky assets to (from) the risk-free assets when risk inherent in the risky assets rises (falls).

## References

Bemanke, B. S., J. Boivin, and P. Eliasz. (2005) "Measuring Monetary Policy: A Factor Augmented Vector Autoregressive (FAVAR) Approach." *Quarterly Journal of Economics,* 120,387-422.

Clarida, Richard, and Mark Gertler. 1997. "How the Bundesbank conducts monetary policy." In: Romer, C., Romer, D. (Eds.), Reducing Inflation. University of Chicago Press, Chicago.

Cochrane, John H., and Monika Piazzesi. 2002. "The Fed and interest rates – A high frequency identification." *American Economic Review* 92(2): 90-95.

Cushman, David, and Tao Zha. 1997. "Identifying monetary policy in a small open economy under flexible exchange rates." *Journal of Monetary Economics* 39: 433-448.

Dees, S., F. di Mauro, V. Smith, and H. Pesaran. (2007) "Exploring the International Linkages of the Euro Area: A Global VAR Analysis." *Journal of Applied Econometrics,* 22, 1-38.

DePrince, Albert E., and Pamela D. Morris. 2009. **"**An Assessment of the International Transmission of Financial Shocks on Money Market Conditions." 36th Annual Meeting. Academy of Economics and Finance. Pennsacola Beach, FL.

Eichenbaum, Martin, and Charles Evans. 1995. "Some empirical evidence on the effects of monetary policy shocks on exchange rates." *Quarterly Journal of Economics* 110: 975-1010.

Ehrmann, Michael and Marcel Fratzscher. 2009. "Global Financial Transmission of Monetary Policy Shocks." *Oxford Bulletin of Economics and Statistics* 71(6): 739-759.Grilli, Vittorio, and Nouriel Roubini. 1995. "Liquidity and exchange rates: Puzzling evidence from the G-7 countries." Working paper. Yale University, CT.

Jagannathan, Ravi, Andrew Kaplin, and Steve Sun. 2003 "An evaluation of multi-factor CIR models using LIBOR, swap rates, cap and swaption prices." *Journal of Econometrics* 116**:** 113–146.

Kim, Soyoung. 2005. *"*Monetary policy, foreign exchange policy, and delayed overshooting." *Journal of Money, Credit, and Banking* 37(4): 775-782.

Kim, Soyoung, and Nouriel Roubini. 2000. "Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach." *Journal of Monetary Economics* 45(3): 561-586.

Mumtaz, Haroon and Paolo Surico. 2009. "The Transmission of International Shocks: A Factor-Augmented VAR Approach," *Journal of Money, Credit and Banking* 41 (1 Supplement): 71-100.Sims, Christopher A. 1992. "Interpreting the macroeconomic time series facts: The effects of monetary policy." *European Economic Review* 36: 975-1000.

____. 1980. "Macroeconomics and Reality." *Econometrica* 48: 1-48.

Sims, Christopher A., and Tao Zha. 1995. "Does monetary policy generate recessions?: Using less aggregate price data to identify monetary policy." Working Paper, Yale University.