Impact of Credit Events on Treasury Securities Prices and Liquidity

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Abstract

In this paper we study the impact of unscheduled international credit events in emerging markets on the prices and liquidity of the U.S. treasury markets. We examine the reaction of the yields of U.S. treasury securities to credit events using a credit-event indicator model with *GARCH* effects and find that the largest price decline occurs in the ten-year treasury notes. For the liquidity effects, we examine the behavior of the components of the bid-ask spread of treasury bonds to credit events. There is an increase in adverse selection cost of thirty-year treasury bonds during such events.

JEL Classification: C22, C32, E43, G15.

Key Words: Treasury securities, credit events, GARCH, bid-ask spread, Generalized Method of Moments (GMM).

Introduction

International financial markets have recently experienced a number of major financial crises in emerging markets. These crises include the Asian crisis in 1997, Russia's default on its sovereign debts in 1998 and the devaluation of the Brazilian real in 1999. There exists a rich literature, which includes approaches that address the following issues inherent to financial crises: fundamentals approach, self-fulfilling process, financial contagion effects, and herding effects (see Kodres and Pristsker (2001)). These studies focus mainly on the effects on the emerging market without linking the effects to financial turmoil in developed markets. Difficult as it may be to detect, the effects of financial turmoil on the financial markets of developed countries, particularly government securities markets, is important not only for merely understanding of the movements of global financial market as a whole, but also there are implications to portfolio management due to the ever increasing important role of government securities market in hedging the risk in portfolios.

Most researchers studying the impact of news on U.S. Treasury market focus on scheduled macroeconomic news releases. Recent studies include Elton and Green (1996, 1998, 1999), Ederrington and Lee (1993), and Fleming (July 1997, 1998, 1999). In their work of 1996 and 1999, Elton and Green examine the effects of 26 economic news

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announcements (including both monthly or weekly news releases) on the three-month bills, the two- and ten-year notes, and the thirty-year bonds, and find 17 of 26 releases to have significant effects on Treasury securities prices. Fleming (1998)'s approach divides ten economic news releases into three categories; labor market information, price level information and aggregate demand, and he finds that surprises in the announcements evoked the sharpest reactions from the intermediate maturities.

In our study we estimate the impact of unscheduled credit events on the U.S. treasury market. Using credit event indicator model with a $GARCH(1,1)$ effects term we find the price effect of credit events is biggest for ten-year treasury notes and weaker for thirty-year bonds and two-year notes, but smallest for five-year notes.

Previous literature examines the treasury market liquidity through quoted bid-ask spread behavior (e.g. Fleming and Remolona (October 1999)) or volume (e.g. Elton and Green (1998) and Fleming (1999)). One exception is Amihud and Mendelson (September 1991) who by comparing yields of treasury bills and treasury notes with matched maturities find the yield is higher for notes, and they claim that it is due to the lower liquidity of the notes. In our study, we try to employ Huang and Stoll (1997) method to estimate the behavior of components of bid-ask spread before, during and after credit events, but we only obtain meaningful results for thirty-year bonds before and after events, while the adverse selection cost is so big that this leads to the inventory holding cost to be minus and this result breaks the bound of assumption. However, when we examine the price effect parameters for credit events, we find that, the more negative the parameter in the price estimation of the effect the credit events has on the treasury market, the bigger the adverse selection cost in the estimation of components of bid ask spread.

The rest of the paper is as follows: In section I we will provide theoretical background on the definition of credit events and from trading characteristics and mechanisms of the U.S. Treasury market we develop our hypothesis. In section II, we describe the events data and GovPX data. We develop estimation procedures and report results for price effect in section III. Then we develop estimations procedures and report and analyze liquidity effects in section IV and reach our conclusion in the last section.

I. Theoretical Background and Hypothesis Development

Defining Credit Events

The unscheduled news announcements in our study are basically credit events. The definition of credit events was first raised by Smithson (1998) and refers to one of the following situations: 1) Bankruptcy, insolvency or payment default, 2) A stipulated price decline for the reference asset, 3) A rating downgrade for the reference asset.

International Swaps and Derivatives Association (ISDA) employs this definition with some amendments in order to account for both firm- and sovereign-level events. The following six credit events are listed by ISDA: 1) Bankruptcy, 2) Obligation Acceleration, 3) Obligation Default, 4) Failure to Pay, 5) Repudiation/Moratorium 6) Restructuring.

The U.S. Treasury Market: Background information and Evolution

Various markets exist for U.S. Treasury securities including the forward or "when-issued" market, the secondary market, and the repurchase market. The secondary market for U.S. Treasury securities is its primarily over-the-counter market. Treasuries are also listed in NYSE and AMEX, but the average trading volume is just US$ 28.6 million per day in 1994 (Fleming (July 1997)). The whole secondary market consists of 1,700 brokers and dealers. Primary dealers are firms acting as counterparties of Federal Reserve Bank of New York (FRBNY) who interacts directly to conduct its open market operations. They include large diversified securities firms, money center banks, and specialized securities firms and are U.S. as well as foreign owned (Fleming (July 1997)). (also see Hirotaka (May 1999))

Trading takes place twenty-two hours a day during the week. Usually trading does not take place from 5:30 p.m. to 7:30 p.m., U.S. daylight saving time. Trading increases to twenty-three hours per day when New York City switches to Eastern-standard time. Although trading takes place nearly around-the-clock, on average, more than 94 percent of trading occurs in New York, with less than 4 percent in London and less than 2 percent in Tokyo. Trading takes place among primary dealers with customers as well as among primary dealers themselves. For the April-to-August 1994 period, dealers traded an average of US$ 125 billion per day with US$ 67 billion with customers and US$ 58.5 billion with other primary dealers, among which US$ 53.5 billion interdealer volume occurred though interdealer brokers and the remainder occurred directly between dealers without intermediary. The source of our data is the interdealer broker market, i.e. the GovPX database that consists of quote and transaction information from five out of six interdealer brokers.

The U.S. Treasury market is a deep and very liquid market. For example, the daily turnover in the U.S. treasury market currently averages about US$ 200 billion per day, a magnitude that is five times greater than turnover on the New York Stock Exchange. Another unique feature of the Treasury market is its issuance of a full range of maturities, from 3-month T-bills to thirty-year treasury bonds. Many other advanced economies have avoided issuing the entire yield curve. Besides the above reasons, the importance of U.S. Treasury market is also in part due to the international role of U.S. dollar as a "safe" currency. This attraction of U.S. Treasury securities results in their following roles:

1) They act as benchmarks for pricing and quotation in the U.S. and international bond markets.

2) They are the important components of the global bond indices used by portfolio managers.

3) They are the major instrument for hedging fixed-income positions in U.S. dollar and international markets;

4) They are the collateral for domestic and international financial transactions;

5) They are the main tools for liquidity management by private sector, especially by banks; they comprised the large share of foreign reserves held by other governments;

6) They are the vehicles for main monetary intervention used by the U.S. Federal Reserve Bank.

7) They are both domestic and international safe-havens.

Given the important role the U.S. treasury market assumes in international context, it is natural to believe that financial crises should have price impacts on the U.S. treasury market. A “stylized fact” is that U.S. Treasury bonds are highly sensitive to credit events during financial crises. For example, on Jan 13, 1999 when Brazil devalued its currency, the yield of thirty-year Treasury bond dropped to its lowest recorded value since it began trading in 1977. This may be attributed to the thirty-year Treasury bond importance as a hedging instrument, which arises from it unique maturity in the global government securities market. This “stylized fact” illustrates the interest in modeling the effects of global credit events on the U.S. Treasury market. The usually very liquid market for U.S. Treasury securities makes these instruments ideal for detecting and classifying events that trigger spillover effects in the level and volatility of financial instruments at specific time points. (also see Fleming (April 2000), Fleming (2001), Fleming and Remolona (December 1997) Fleming and Remolona (October 1999), Fleming and Sarkar (1999))

According to Schineller (March (1997) and October 1997)), an implication of the occurrence of credit events during financial crises in emerging markets is capital flight (flight to quality), which refers to international capital movements from the volatile and illiquid emerging markets to the more stable and liquid developed markets during periods of heightened domestic economic and political uncertainties. Capital flights have been accepted as the characteristics of financial crisis and have been frequently observed since late 1970s and 1980s. They embody themselves in a substantial outflow of domestic resources ranging from 5 to 10 percent of GNP. Wincoop and Yi (2000) found that the overall effect of financial crises on the U.S. GDP was positive, but small. They further claim that much of the capital that reaches the U.S. is in the form of foreign direct investment or portfolio investment from abroad. Treasury securities, especially Treasury notes and bonds play an important role in portfolio management; therefore we expect a positive price impact on treasury securities on the occurrence of credit events during the crisis of the emerging market.

Both the domestic and the international roles the Treasury market assumes enable it to evolve in line with the changes in U.S. domestic monetary policy as well as international trends and events. First, the share of foreign ownership of Treasury market is increasing. In 1960s, foreign ownership of publicly held treasury debt was below 5 percent, but jumped to 15 percent in the early 1970s, where it remained until mid 1980s. Thereafter it began to increase steadily and rose to its current share of 40 percent. By the end of June 2000, excluding treasury debt held by U.S. federal, state and local government accounts (including the Federal Reserve), foreign ownership accounted for 51 percent. These changes are expected due to the greater frequency of financial crises during the 1990’s.

Second, faced with the improved fiscal situation of U.S. and the reduced funding requirement, the U.S. Treasury has altered its issuance policy and begun buying back some debt. The Treasury announced in May 1998 that it would eliminate the issuance of three-year notes. And in response to substantial budget surplus and an effort to maintain the market liquidity, the Treasury reduced the issuance of the five-year notes from monthly to quarterly where the reason is summarized best by the words of the Assistant Secretary for Financial Markets of the U.S. Treasury: "We chose to concentrate on having fewer, larger, issues." In August 1999, the U.S. Treasury announced that it was reducing the issuance frequency of the thirty-year bond from three times a year to twice a year and that it was considering reducing the issuance frequency of one-year bills and two-year notes. The above trends imply a decline of supply of treasury securities especially in the long-end maturities.

Another notable change is the decline in number of market makers in secondary treasury market which is attributable to market consolidation in financial institutions in the late 90s. In 1999, there were 30 primary dealers down from 39 in 1997. And this number further declined to 27 in late 2000. While the fewer number of U.S. Treasury primary dealers may not necessarily imply the market has reduced in size; one obvious consequence is that there are fewer market makers.

The facts above together with the high frequency and large magnitude of financial crisis implies a demand supply imbalance of U.S. government securities, but different magnitude, thus we also expect the price impact will be different on securities with different maturities—with higher impact on the securities with lower supply.

The U.S. Treasury market: Trading Mechanism

The attraction of U.S. government securities comes from both its roles as safety haven and liquidity haven. However, the shrinking supply of treasury market makes it possible the liquidity might be affected before, during and after credit events.

The bid-ask spread is an important aspect of liquidity, and it's widely accepted that the quoted spread consists of the following three components. The order processing cost component (Demsetz (February 1968) and Tinic (February 1972)) represents a fee charged by the market makers for standing ready to match buy and sell orders. The inventory holding costs (Stoll (March 1989) and Ho and Stoll (May 1981)), the charge compensates dealers for holding less diversified portfolios. Finally, the adverse information selection costs (Berry and Howe (September 1994), Copeland and Galai (December 1983), Glosten and Milgrom (1985), and Easley and O'Hara (September 1987)) represent a reward to market makers for taking on the risk of dealing traders who may posses superior information. (also see Mitchell and Mulherin (July 1994))

To estimate bid-ask spread in studying liquidity reaction of treasury market during international financial crisis, we need to understand the trading mechanisms in the interdealer broker treasury market. According to Fleming and Remolona (October 1999), trading in the interdealer broker market is conducted via phone lines. The Treasury market provides the interdealer broker with proprietary electronic screens that post the "best" bid and offered prices as well as the quantities quoted by other dealers. Quotes are "binding" until or unless they are withdrawn. The dealers execute trades by calling brokers, who post the resulting trade prices and quantity on their screens. This characteristic of interdealer trading is similar to NASDAQ, and is in contrast to auction markets, particularly NYSE, in the following ways: First, there is no "*tick rule*." A tick rule limits the bid ask spread to specified minimums or maximums and is more meaningful on the NYSE, which used to be based on a US$1/8 tick size. For the

NASDAQ, the US$1/8 tick is not a rule, and transactions can be negotiated at a price increment as small as US$1/256. In Treasury market, though Treasury notes and bonds are quoted in 32^{nds} of one percent of the par value, but the 32^{nd} can be split into increments as small as 1/128's of one percent.

Second, the order processing cost is higher for interdealer trading. Affleck-Graves, Hedge, and Miller (September 1994) note that specialists on the NYSE consolidate order flows, whereas they are fragmented across dealers of the Treasury markets and according to Lee and Ready (June 1991) floor trading increases competition among market participants. The consequence of these observations is that auction-based exchange trading structure facilitates the matching of buy and sell orders without requiring as much dealer participation in NASDAQ. Therefore, the order processing cost on the NYSE, which represents a fee charged by market makers for standing ready to match buy and sell orders, are lower than that in NASDAQ.

Third, in interdealer market, the inventory holding cost is lower, because multiple dealers are able to share the inventory risk. While on the auction-based market, the specialist needs to absorb a given imbalance in order flow, thereby induce larger inventory risk. Ho and Macris (1985) find that dealers carry larger imbalances collectively. Also Ho and Stoll (September 1983) suggest that the interdealer trading allows for quick reallocation of inventory imbalances across market makers.

The interdealer broker treasury market shares a similar market mechanism with NASDAQ and they have the similar number of market makers. In treasury market, the number of market maker is 30 in 1999, and this is same as the mean number of market maker in NASDAQ (Huang and Stoll (1996)). Among their responsibilities, primary dealers in Treasury market are expected to participate in the auctions, make "reasonably" good markets for trading Treasuries with the FRBNY, and to supply market information to the Federal Reserve Bank. Even though trading with customers is no longer a requirement, but they remain the predominant market makers in U.S. Treasury securities. Besides these roles given, by nature the dealers are motivated by profit, therefore they are analogous to the dealer dominated NASDAQ market, the bid-ask spread they quote also include the three components mentioned above.

The three components are expected to change when there is information asymmetry. Greater information asymmetries among market participants should lead to wider spreads. During financial crises, interdealer market trading activity is affected by information asymmetry from the behavior of foreign investors. The typical information asymmetry model assumes two types of traders: *liquidity traders* and *informed traders* (Copeland and Galai (December 1983) and Glosten and Milgrom (1985)). Informed traders act on private information that is not reflected in the prices, while liquidity traders trade for reasons other than private information and recover their loss through the bid-ask spread. This implies that greater information asymmetry among market participants will lead to wider spreads. The logical extension of this model is to assume that the adverse information selection component will increase. This is detected in stock market in the work of Krinsky and Lee (September 1996), who use NYSE and AMEX data to conduct a standard event study to account for the effect of announcement effect on components of bid ask spread in stock market and detected higher adverse selection cost and lower ordering processing cost and inventory holding cost during predisclosure and event period.

Therefore, we expect the similar components of bid-ask spreads can be detected in the treasury markets and the components in the spread are expect to change in reaction to credit events in a similar way in the stock market.

However, the treasury market is unique by nature that the Treasury securities are traded in large volumes when compared to stock markets and have very small proportional bid-ask spreads, which are only 1/1000 as large as the proportional spreads on the NASDAQ. This makes it relatively difficult to decompose the quoted spread into the three components; the adverse selection cost, the inventory holding cost and the order processing cost-as researchers usually do in the stock markets.

II. Data Description

Credit Events

In order to detect any impact of credit events on U.S. Treasury market we include major international credit events in our application of the ISDA definition to events that lead to financial crisis. This approach differs from Kaminsky and Schmukler (April 1999). In their study of emerging market “jitters” they associate large stock market changes with news good or bad, real or speculative rumors, be they financial or political. The criteria we have chosen do not include all types of events that are associated with a crisis, but we try to capture the representative country- and firm-level events that happened during a crisis.

Our approach is to conduct a comprehensive search for major credit-related news events using the Bloomberg news database. This is the same approach employed by Kaminsky and Schmukler (1999). We conduct our search over a number of individual categories of new events using the following indicators: bankruptcy (BCY), credit ratings (CIR), and foreign exchange (FRX) and combined these with the indictor for a news event from the emerging markets (EMG). The list of countries we search for news events consists of Mexico, Japan, Korea, Hong Kong, Thailand, Indonesia, Malaysia Singapore, Russia, and Brazil. The list of credit events, with their dates of occurrence, is further classified according to the country and the nature of events. The news events from the bankruptcy and credit ratings categories are used to detect the possible presence of a credit event. We also check this list of events with other publications about Asian crisis available, and find the information that is relevant to credit events largely coincides. Our approach enables us to locate credit events times that are accurate to the minute, and then work back to the beginning of the actual half hour interval containing the event time.

In our credit events data selection, we try to avoid including credit events that are not significant enough, since during financial crisis, everyday there are hundreds of facts, updates, speculations and rumors about credit events. To identify the event with significance, we only include credit events that are facts issued by officials or recognized sources, the first reports of the event or relevant events, and only include events that are widely accepted as events that have effects to the local stock market. To achieve this we use some recognized magazines such as Risk annual review column to help us in identifying credit events. We also refer to the chronology of events in Roubini (1998)'s work about the Southeast Asian financial crisis. See "The Crisis in Emerging Markets" in International Monetary Fund (December 1998) for events concerning the Brazilian, Russian, and Southeast Asian crises. We found our search of credit events largely coincide with the current publications.

U.S. Treasury Securities Data

The interdealer broker data is from GovPX dataset, which consolidates and posts real-time quotes and transaction data from five out of six major interdealer brokers. We use "on-the-run" Treasury securities over the period from January 1,1997 to December 31, 1999. By "on-the run" securities we mean securities that are newest issued and also highly liquid. The products we include are thirty-year treasury bonds and treasury notes of all maturities, i.e. two-, five-, and ten-year treasury notes. Three-year notes are excluded as the U. S. Treasury has stopped auctioning these contracts since May 12, 1998. We follow Fleming (July 1997)'s sample cleaning procedures to clean the GovPX data set.

III. Price Effects

A credit-event indicator model with $GARCH$ effects is used to examine the yields of treasury securities under the impact of an event. In our credit-event model, we choose coupon rates of various treasury bonds and notes to account for the coupon effect. Even though there is time to maturity difference, but since we study on-the-run issue of a single product, which is with approximately same maturity, the effect would not have effect on the validity of our results for credit events. To test the effect of liquidity on the yield, we also include volume and proportional quoted spread as explanatory variables separately. The descriptive statistics and estimation results are presented as Table 1.

We incorporate a $GARCH(1,1)$ term in the credit-event indicator model to account for the excess volatility around credit events. $GARCH$ models are used to describe the serially correlated changes in the volatility of a financial time series by allowing the conditional variance to be a function of the squares of the previous observations and past sample variances and/or lagged conditional variances. An appealing characteristic of $GARCH$ models is that they allow for the intuitive feature of market movements that "*big*" surprises (of either sign), increase the uncertainty in the markets and which, in turn, will most likely generate more periods that exhibit other "*big*" surprises such as credit events. $GARCH$ models are defined in terms of their conditional distribution functions as opposed to their unconditional distribution functions. The conditional distribution function is allowed to vary over time as a function of past realized sample disturbance terms. Surveys of the theory, estimation and applications of $GARCH$ models can be found in Bollerslev, Chou, and Kroner (1992), Engle (1995), Gourieroux (1997), and Chapter 21 of Hamilton (1994).

The complete credit-event indicator model with the inclusion of both a $GARCH$ effects term and a liquidity variable is given below:

$$YLD_{i,t} = c_0 + c_1 PRE_t + c_2 EVT_t + c_3 AFT_t + c_4 COUPON_{i,t} + c_5 LIQ_{i,t} + \varepsilon_t \quad (1)$$

where

$$\varepsilon_t = \sigma_t \eta_t, \quad (2)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \quad (3)$$

and

$YLD_{i,t}$: The yield-to-maturity of security i at time t.

PRE_t : The day-before credit event dummy variable; takes value of 1 if day t is the previous day of a credit event.

EVT_t : The day-of credit event dummy variable; takes value of 1 if day t has a credit event.

AFT_t : The day-after credit event dummy variable; takes value of 1 if day t is the next day of a credit event.

$COUPON_{i,t}$: The coupon of securities i. at time t. This variable is zero for three-month treasury bills.

$LIQ_{i,t}$: The liquidity variables where these variables can be the volume or the proportional spread of securities i at time t, respectively.

ε_t : The multiplicative $GARCH(1,1)$ error term driven by a random component η_t that is scaled by time- and sample-dependent factor σ_t

η_t : The error term that is zero mean, unit variance and uncorrelated.

σ_t^2 : The square of the scale factor σ_t for the error term ε_t, which has a $GARCH(1,1)$ model

ω, α, and β : The coefficients of the $GARCH(1,1)$ model that must be estimated.

c_0, c_1, c_2, c_3, c_4, and c_5 : The coefficients of the regression model for $YLD_{i,t}$ that must be estimated.

We follow Bollerslev (1986) in the use of a $GARCH(1,1)$ model to estimate the $GARCH$ error term in equation (1). The $GARCH(1,1)$ model is estimated using straightforward maximum likelihood estimation procedures since their estimators are formulated in terms of the distribution of the one-step-ahead prediction error.

Before we estimated the model in equations (1) to (3), we tested for the presence of a unit root using augmented Dickey-Fuller test statistics. These tests did not reject the null hypothesis at the 10% level. The correlogram suggests that the partial autocorrelation of 0.994 at lag one, which implies an autoregressive model of order one. The results from the estimation of the credit event model without either of the liquidity variables are in Table (2). The estimated coefficients for all three dummy variables PRE_t, EVT_t, and AFT_t are significant at the 1% levels except for five-year notes. The impact magnitude is biggest for ten-year treasury notes, and progressively weaker for the thirty-year treasury bonds, two- and five-year treasury notes.

These results are quite different from the Fleming (1998)'s findings for macroeconomic news releases impact on Treasury securities. He finds that during the news releases, event surprises have the biggest impact on the medium-term notes and have impacts effects that drop lower for thirty-year bond and three-month bill. One apparent explanation is that the implications of unscheduled credit events and scheduled macroeconomic news releases to dealers is different by nature. Using data from 1991 to 1995, Fleming (1998) examines the impact of scheduled macroeconomic news releases on U.S. treasury market. The U.S. scheduled macroeconomic news releases contain domestic labor market information, price level information, aggregate demand information and money market information. The implication to the dealers is that they focus on Fed's actions with respect to the target fund rate, and the periodic adjustments in measured steps to their ultimate target. Therefore, the participants focus on both near-term target rate changes and on the Fed's ultimate target rate over the whole tightening or easing cycle. While the releases contains significantly weaker information to the long-end of yield curve (also see Grossman (November 1981)).

During the period of financial turmoil, losses on riskier assets often provoke flights to quality and liquidity crises, and this usually means a flight to government securities, especially the US Treasuries. This effect was amplified during the period from the middle of 1997 to the beginning of 1999 when a series of credit events happened in Southeast Asia, Russia and Brazil. Facing the uncertainty of the potential for sovereign defaults; investors tighten standards and terms and demand more collateral; financial firms attempted to scale back their exposures in many markets. This adjustment of position taking and hedging often takes places in the deepest markets, government bond, cash and futures markets. When the increased demand comes in line with the shrinking supply, the yields of Treasury securities are driven to record lows. The different impact of the events on various securities reflect the projection of the crisis's effect on the U.S. domestic economy, however with treasury market acting as the largest and deepest safe haven in the world, the impact reflects the demands of securities of adjusting portfolios more.

Two-year treasury notes have the largest trading volume, and based on this measure, it is the most liquid of the Treasury securities traded. Recently the five-year note's issuing frequency was lessened from monthly to quarterly. These reasons, together with the fact that nearly 2/3 investors holding maturity is less than five years, account for the reason that two year notes are considered more favorable than five year notes during extreme market events, and thus have a sharper yield decline. However, the yield decline of two-year notes is smaller than ten-year notes and thirty-year bonds and this cannot attribute to liquidity reason since ten-year notes and thirty-year bonds have smaller transaction volume comparing to two-year notes.

According to the BIS study group's September 2001 research paper, one notable change of investors facing the over expensive government securities is their increasing willingness to move towards more diversified portfolios. Nevertheless, the pace of changing across investors are different, investors following relatively passive and conservative asset management strategies changes their portfolio slowly. Together passive investors, namely pension funds, life insurance companies, mutual funds and government bodies, including central banks, held 65% of U.S. treasury securities in 2000, and this was up from 57% in 1995. The maturity composition of portfolios for the passive investors tends to be towards the long–end of the maturities of treasury securities, thereby the higher concentration of passive investors drive more of the impact towards the ten-year notes and thirty-year bonds. Due to the concentrated fall-off of volume in thirty-year bond contracts, the breakdown of the normally stable relationship between government and non-government bond yields, and the relatively higher liquidity of ten-year notes make the ten-year notes more favorable to investors and thus their transaction prices more sensitive to the event impact.

Including volume as an explanatory variable is due to its significance in explaining price increases; a flight to liquidity favors higher volume with higher prices and lower yields (See the results in Table (3)). But the proportional quoted spread failed to explain the yield level (see the results in Table (4)). This inconsistency leads us to break down the quoted spread and examine the liquidity measures in greater detail. Liquidity effects will be studied in the next section.

IV. Liquidity Effects

The purpose of this section is to investigate the behavior of components of bid ask spread one day before, event day and one day after an event. The method employed is the three-way decomposition model of Huang and Stoll (1997).

In three-way decomposition, the following equation is estimated using generalized method of moments:

$$E\left[Q_{t-1}\middle|Q_{t-2}\right] = (1-2\pi)Q_{t-2}\,, \tag{3}$$

which is the conditional expectation of the trade indicator variable at time t-1, given Q_{t-2}, and

$$\Delta M_t = (\alpha+\beta)\frac{S_{t-1}}{2}Q_{t-1} - \alpha(1-2\pi)\frac{S_{t-2}}{2}Q_{t-2} + \varepsilon_t \tag{4}$$

where

Q_t : The buy-sell trade indicator variable that can takes the value of +1 if the transactions is buyer initiated and occurs above the bid-ask midpoint, the value of -1 if the transactions is seller initiated and occurs below the bid-ask midpoint, and the value of 0 if the transactions occurs below the bid-ask midpoint.

ΔM_t: The log-change quoted midpoint price calculated from the bid-ask quotes that prevail just before a transaction, noting that M_t is the midpoint of the bid-ask spread.

S_t: The proportional quoted spread at time t,

π: The probability of a price reversal, which must be estimated,

ε_t : The error term that is mean zero and uncorrelated and considered the serially uncorrelated public information shock.

α The percentage of the half-spread attributed to adverse selection and a coefficient that must be estimated.

β : The percentage of the half-spread attributed to inventory holding cost and a coefficient that must be estimated.

As in Huang and Stoll (1997), the generalized method of moments (GMM) is used in the estimation of the liquidity effects via the three-way decomposition method. GMM uses the sample moment as estimates of the corresponding population moment, which are assumed to converge in probability to some constant. When fitting a parametric distribution to a set of data, GMM determines the estimators for unknown parameters by equating the corresponding sample moments and population moments. GMM procedures use moment conditions not only to test model specification, but also to define model parameters (in the sense of providing a parameter mapping for a model). Surveys of the theory, estimation and applications of the generalized method of moments can be found in Chapter 17 of Davidson and MacKinnon (1993), Chapter 14 of Hamilton (1994) and Chapters 1-6 of Lee (1996).

Estimation Results for Liquidity Effects

The data sample for the study of liquidity effects for each event includes both the tick-by-tick quoted and transaction prices for one day before the event, the event day and one day after the event. We obtain 71 event days for each period. We follow Fleming (July 1997)'s sample cleaning procedures to clean the GovPX data set. After that we follow Huang and Stoll (1997) to filter data. In order to filter the valid quotes, the analysis is confined to transactions paired with bid and ask quote within five minutes, and the ask quotes must exceed bid quotes. Also note that if many trades occur at the same quotes, the estimated adverse information and inventory effects will be small. This result may be partly spurious if trades are bunched at the bid or ask because large trades are broken up or because the buying or selling programs cause several transactions to occur at an unchanged bid or ask. In Huang and Stoll (1997) they estimate both "bunched" data and data without bunching. We estimated just the bunched data. In the case of Huang and Stoll (1997), the number of observations is reduced to around 40% of the original data after bunching. In GovPX data, after combing, the number of observations in our data set was also reduced to approximately 40 percent. See Table (5) for descriptive statistics of the liquidity effects data.

In our estimation, we choose all the treasury notes and bonds to estimate the liquidity effects, but the results are not meaningful except for thirty-year bonds, therefore we only report the results of thirty-year bonds. This is mainly due to the small magnitude of quoted price changes and bid ask spread. The results from the estimation of the liquidity effects model are in Table (6). The estimation results are comparable to studies on the spread components for dealer markets such as the NASDAQ (see Affleck-Graves, Hedge, and Miller (September 1994)), but is much different from assets trading on the NYSE and AMEX (Huang and Stoll (1996)), or the SIMEX (Kim, Ko and Noh (2001)). The

SIMEX result may be due to the relatively higher order processing cost and lower inventory holding cost that this dealers market has. This difference in the dealer and auction markets can be attributed to the market structure differences we discuss in the earlier sections.

Our estimation results are different from previous literature on stock announcement effect (Krinsky and Lee (September 1996)) in that, during event days, the trading volume is smaller while the magnitude and the volatility of bid ask spread is larger. Our explanation is that as theory indicates, price reactions to public information do not require trading. In Fleming and Remolona (October 1999), They also find a two-stage adjustment process for government securities. In the first stage, price changes followed by bid-ask spread widens dramatically but a reduction of trading volume, while the trading volume surges in the second stage. Dealers evidently widen or withdraw their quotes in response to the inventory risk of sharp price changes. It is also interesting to examine the number of transactions taken at bid and ask sides of the market. Before and during an event, more trading takes place on the ask side, which means dealers are selling more than buying due to the increases of the prices. But the higher prices reduce the overall trading volume. While after the event, more buying side takes place in interdealer broker market in a reaction to the relatively lower magnitude of the price changes, which is detected in the price effect credit-event $GARCH$ model. A surge in trading volume happened in the following day of the event.

V. Conclusion

Using a credit-event indicator model with a $GARCH(1,1)$ term, we find that the evident impact on the prices of U.S. Treasury securities, with biggest effect on ten-year treasury notes and significant for other treasury notes and bonds. The unique characteristics and recent shrinking supply makes impact of events on the price of securities different depending on both their demand and their liquidity.

We then employ the (Huang and Stoll (1997) model to estimate the quoted proportional bid ask spread for thirty-year treasury bonds. We find that the adverse selection cost change mostly in line with the price effect. The higher price effect in the credit-event indicator model with the $GARCH(1,1)$ term, the bigger the adverse selection cost. The estimated result is comparable to another dealers market, NASDAQ.

For further extension, we consider modifications on Huang and Stoll (1997) might help to detect other treasury securities' components of quoted spread, since the quoted spread in treasury market is small and make the estimation difficult. Also more research on impact of events of different nature, such as political uncertainty, IMF agreements, and financial sector news is helpful to understand the reaction of market makers to different news. However, this is difficult to do since the number of events is limited.

VI. References

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Table 1 - Descriptive Statistics for Price Effect

	30 Year Bond			10 Year Note		
	Yield	**Volume**	**Spread**	**Yield**	**Volume**	**Spread**
Mean	6.0140	0.6898	0.00047	5.7461	3.7234	0.00025
Standard Deviation	0.5553	0.5116	0.00060	0.6140	1.5248	0.00020
Skewness	0.0619	0.6231	3.5464	-0.2332	0.1804	1.8405
Kurtosis	2.3089	2.6678	19.5890	2.4292	2.5025	12.3011
Maximum	7.1700	2.4210	0.4531	6.9770	9.0560	0.0625
Minimum	4.7030	0.0050	0.0000	4.1470	0.0070	0.0000
# 0f Observations	750	750	750	750	750	750

	5 Year Note			2 Year Note		
	Yield	**Volume**	**Spread**	**Yield**	**Volume**	**Spread**
Mean	5.6317	5.4739	0.00016	5.5033	6.2420	0.00008
Standard Deviation	0.6292	2.3290	0.00012	0.5453	2.1638	0.00006
Skewness	-0.5219	0.2950	1.7139	-0.7602	0.4994	3.4186
Kurtosis	2.7630	2.5647	9.7562	3.1333	3.6461	29.1991
Maximum	6.8580	13.0020	0.0938	6.5360	14.6380	0.2813
Minimum	3.9390	0.0060	0.0000	3.8520	0.0000	0.0000
# 0f Observations	750	750	750	750	750	750

Table 2-Estimation Results for Price Effect Parameter Set 1

This table presents results for the estimation of price effects using GARCH (1,1) specification equations (1) to (3).
PRE: The day-before the credit event dummy variable; takes value of 1 if day t is the previous day before a credit event;
EVT: The day-of the credit event dummy variable; takes value of 1 if day t has a credit event;
AFT: The day-after the credit event dummy variable; takes value of 1 if day t is the next day after a credit event;
COUPON: The coupon of securities i at time t.

	30 Year Bond	10 Year Note	5 Year Note	2 Year Note
Constant	0.4262*** (-0.0666)	1.0209*** (0.0370)	1.0274*** (0.0284)	0.3791*** (0.0388)
PRE	-0.0749*** (0.0170)	-0.1030*** (0.0190)	-0.0085 (0.0110)	-0.0256** (0.0127)
EVT	-0.0856*** (0.0183)	-0.1203*** (0.0192)	-0.0146* (0.0087)	-0.0462*** (0.0120)
AFT	-0.0732*** (0.0113)	-0.1100*** (0.0088)	-0.0161* (0.0099)	-0.0312*** (0.0136)
COUPON	0.9238*** (0.0110)	0.8252*** (0.0066)	0.8298*** (0.0049)	0.9414*** (0.0070)
Conditional Variance Equation				
Constant	0.0037*** (0.0004)	0.0031*** (0.0005)	0.0015*** (0.0003)	0.0029*** (0.0002)
ARCH(1) Term)	0.8847*** (0.1573)	1.0297*** (0.1688)	1.0656*** (0.1390)	0.9*** (0.1419)
GARCH(1) Term	-0.0044*** (0.0000)	-0.0086** (0.0038)	0.0034 (0.0079)	0.0080 (0.0372)
Adjusted R-squared	0.6216	0.6582	0.7622	0.8781
Log Likelihood	117.4107	130.9950	428.6528	513.9028
Durbin-Watson Stat	0.0424	0.0573	0.0655	0.1459
Akaike Info Criterion	-0.2922	-0.3280	-1.1217	-1.3491
Schwarz Criterion	-0.2428	-0.2787	-1.0725	-1.2998
F-statistic	176.5643	207.0355	344.0323	771.8840

***** indicates significant at the 1% level**
**** indicates significant at the 5% level**
*** indicates significant at the 10% level**
Standard errors are in parentheses

Table 3-Estimation Results for Price Effect Parameter Set 2

This table presents results for the estimation of price effects using GARCH (1,1) specification equations (1) to (3).
PRE: The day-before the credit event dummy variable; takes value of 1 if day t is the previous day before a credit event;
EVT: The day-of the credit event dummy variable; takes value of 1 if day t has a credit event;
AFT: The day-after the credit event dummy variable; takes value of 1 if day t is the next day after a credit event;
COUPON: The coupon of securities i at time t.
VOLUME: Volume of securities i at time t, liquidity variables.

	30 Year Bond	10 Year Note	5 Year Note	2 Year Note
Constant	0.3445*** (0.0819)	1.0117*** (0.0432)	1.0197*** (0.0295)	0.3548*** (0.0358)
PRE	-0.0624*** (0.0161)	-0.1070 (0.0195)	-0.0088 (0.0107)	-0.0263** (0.0118)
EVT	-0.0707*** (0.0179)	-0.1218*** (0.0193)	-0.0165* (0.0089)	-0.045*** (0.0118)
AFT	-0.0544*** (0.0130)	-0.1003*** (0.0107)	-0.0161 (0.0101)	-0.0362*** (0.0117)
COUPON	0.9383*** (0.0143)	0.8307*** (0.0081)	0.8349*** (0.0053)	0.9534*** (0.0063)
VOLUME	-0.042*** (0.0082)	-0.0052* (0.0029)	-0.0035*** (0.0012)	-0.0059*** (0.0010)
Conditional Variance Equation				
Constant	0.0031*** (0.0004)	0.0034*** (0.0005)	0.0016*** (0.0003)	0.0026*** (0.0003)
ARCH(1) Term	0.9815*** (0.1840)	0.9852*** (0.1567)	1.0489*** (0.1369)	0.9311*** (0.1464)
GARCH(1) Term	-0.0033*** (0.0006)	-0.0094** (0.0052)	0.0061 (0.0105)	0.0078 (0.0341)
Adjusted R-squared	0.6075	0.6595	0.7636	0.8794
Log Likelihood	125.0401	131.0446	430.8525	522.0295
Durbin-Watson Stat	0.0398	0.0572	0.0665	0.1537
Akaike Info Criterion	-0.3099	-0.3255	-1.1249	-1.3681
Schwarz Criterion	-0.2544	-0.2700	-1.0695	-1.3126
F-statistic	145.7168	182.3464	303.3359	683.8859

***** indicates significant at the 1% level**
**** indicates significant at the 5% level**
*** indicates significant at the 10% level**
Standard errors are in parentheses

Table 4-Estimation Results for Price Effect Parameter Set 3

This table presents results for the estimation of price effects using GARCH (1,1) specification equations (1) to (3).
PRE: The day-before the credit event dummy variable; takes value of 1 if day t is the previous day before a credit event;
EVT: The day-of the credit event dummy variable; takes value of 1 if day t has a credit event;
AFT: The day-after the credit event dummy variable; takes value of 1 if day t is the next day after a credit event;
COUPON: The coupon of securities i at time t.
SPREAD: Proportional quoted daily closing bid-ask spread, which is a liquidity variable.

	30 Year Bond	10 Year Note	5 Year Note	2 Year Note
Constant	0.369***	0.987***	1.0234***	11.1952***
	(0.0680)	(0.0368)	(0.0291)	(3.0470)
PRE	-0.0723***	-0.1005***	-0.0085	-0.0166
	(0.0177)	(0.0193)	(0.0109)	(0.0128)
EVT	-0.086***	-0.1176***	-0.0151*	-0.0331***
	(0.0188)	(0.0188)	(0.0089)	(0.0119)
AFT	-0.0718***	-0.1074***	-0.0164*	-0.0205
	(0.0112)	(0.0088)	(0.0099)	(0.0142)
COUPON	0.9328***	0.8315***	0.8303***	0.9448***
	(0.0110)	(0.0066)	(0.0049)	(0.0078)
SPREAD	8.4164	-7.0393	6.6267	-141.3468
	(7.9070)	(17.3110)	(22.8459)	(114.7436)
Conditional Variance Equation				
Constant	0.0036***	0.0031***	0.0015***	0.0028***
	(0.0005)	(0.0005)	(0.0003)	(0.0002)
ARCH(1) Term	0.9487***	1.0092***	1.0658***	0.9081***
	(0.1825)	(0.1625)	(0.1395)	(0.1479)
GARCH(1) Term	-0.0040	-0.0095	0.0034	0.0020
	(0.0142)	(0.0067)	(0.0077)	(0.0377)
Adjusted R-squared	0.6200	0.6574	0.7619	0.8775
Log Likelihood	119.3473	131.9797	428.7065	524.1330
Durbin-Watson Stat	0.0427	0.0571	0.0656	0.1445
Akaike Info Criterion	-0.2947	-0.3279	-1.1192	-1.3960
Schwarz Criterion	-0.2392	-0.2725	-1.0638	-1.3399
F-statistic	153.5492	180.6490	300.6269	660.6963

***** indicates significant at the 1% level**
**** indicates significant at the 5% level**
*** indicates significant at the 10% level**
Standard errors are in parentheses

Table 5 - Descriptive Statistics for Liquidity Effects

30 Year Bond	Price Change	Spread	Volume	# Trades on Bid	# Trades on Ask	Total # of Observations
PRE-EVENT						
Mean	5.7800E-06	5.0800E-04	759.28	2596	2668	5264
Std. Dev.	7.2600E-04	4.3100E-04	481.22			
EVENT						
Mean	3.0900E-06	5.1300E-04	721.55	2397	2500	4897
Std. Dev.	6.7100E-04	4.5000E-04	532.17			
AFTER-EVENT						
Mean	7.5900E-06	5.0500E-04	774.89	2759	2697	5456
Std. Dev.	6.6300E-04	4.0200E-04	514.98			

Table 6 - Estimation Results for Liquidity Effects

This table presents the results for liquidity effect using equation (4) and (5).
PI: The probability of a price reversal, which must be estimated;
ADVERSE SELECTION COST: The percentage of the half-spread attributed to adverse selection and a coefficient that must be estimated;
INVENTORY HOLDING COST: The percentage of the half-spread attributed to inventory holding cost and a coefficient that must be estimated.

30 Year Bond	Pre-event	Event	After-event
Pi	0.4567 (0.0072)	0.4617 (0.0075)	0.4536 (0.0068)
Adverse Selection Cost	0.4192 (0.4562)	1.2122 (0.5037)	0.4836 (0.3613)
Inventory Holding Cost	0.1768 (0.4474)	-0.5221 (0.5002)	0.1114 (0.3563)

Standard errors are in parentheses