DBJ Discussion Paper Series, No.1210

What Determines CDS Prices?
Evidence from the Estimation of Protection Demand and Supply

Daisuke Miyakawa
(Development Bank of Japan)
And
Shuji Watanabe
(Nihon University)

December 2012

What Determines CDS Prices?
Evidence from the Estimation of Protection Demand and Supply[*]

December 2012

Daisuke Miyakawa[†] **and Shuji Watanabe**[‡]
Development Bank of Japan and Nihon University

Abstract

This paper examines the determinants of Credit Default Swap (CDS) premiums by applying a limited dependent variable simultaneous equation system to a unique set of time-series data for the Japanese credit market. The estimation results indicate that CDS premiums decrease as a result of an increase in the supply of protection due, for example, to fewer opportunities for investment in other assets (e.g., loans). We also find that premiums increase when the demand for protection increases due, for example, to larger short cover needs. Further, the quantitative impact of factors accounting for the supply and demand of protection is likely to be misestimated unless the simultaneous determination of supply and demand is taken into account. This indicates that it is necessary to include demand and supply factors to understand fluctuations in CDS premiums.

Key words: Credit Default Swap; Demand and Supply; Simultaneous Equation; Credit Link Note
JEL Classification: G12, C34, C36,

[*] We thank would like to thank Tatsuyoshi Okimoto (Hitotsubashi University), Takayoshi Kitaoka (Meiji University), Kentaro Akashi (Gakushuin University), Hiroaki Yamauchi (MTEC), Masazumi Hattori (Bank of Japan), Toyoichiro Shirota (Bank of Japan), Robert Dekle (University of Southern California), and seminar participants at the Research Institute of Capital Formation, the Development Bank of Japan (RICF-DBJ), the Japan Society of Monetary Economics 2012 spring meeting, the Nippon Finance Association 2012 annual meeting, and the Bank of Japan Institute of Monetary and Economic Studies Seminar for helpful suggestion. We are also grateful to Takeshi Moriya for excellent research assistance.
[†] Corresponding Author, Associate Senior Economist, Research Institute of Capital Formation, Development Bank of Japan, 1-9-3 Otemachi Chiyoda-ku, Tokyo, 100-0004 Japan. Phone: +81-3-3244-1917. E-mail: damiyak@dbj.jp.
[‡] Professor, College of Economics, Nihon University, 1-3-2 Misaki-cho, Chiyoda-ku, Tokyo 102-8360 Japan. E-mail: watanabe.shuji@nihon-u.ac.jp.

1. Introduction

Credit default swaps (CDS) are a type of credit derivatives written against the default of a specific firm, security, country, or a basket of these. They function as an insurance against default events and have been widely used as a hedging tool as well as a speculation tool in recent years. However, during the recent financial crisis, substantial turmoil in CDS markets could be observed. Indexes of CDS spreads (i.e., the premium paid for protection) in the United States, Europe, and Japan show large jumps from early 2008 onward in response to the financial crisis triggered by the malfunctioning of U.S. credit markets, which was accompanied by a sharp decline in the prices of securitized products based on various underlying assets.

Given the growing presence of CDSs in financial markets and such large fluctuations in CDS premiums, many academic researchers and practitioners have been trying to establish the determinants of such premiums. The list of candidates includes macro and micro credit factors (e.g., stock prices and bond prices) directly affecting the default probability of the entities referenced by CDSs as well as factors relatively specific to credit markets (e.g., counter-party risk, market segmentation, illiquidity). Thanks to the research effort into the mechanisms governing CDS markets, the role of the various determinants is now largely understood. However, an issue that has received surprisingly little attention in this context so far is the role played by the demand for and supply of protection through CDSs. Against this background, the aim of the present paper is to examine the determinants of CDS premiums explicitly taking such demand and supply into account.

The empirical strategy employed in the large majority of extant studies has been to regress the CDS premium on various covariates representing factors accounting for credit and liquidity in a single equation (e.g., Huang et al. 2003; Blanco et al. 2005; Scheicher 2008; Ericsson et al. 2009). In other words, CDS premiums have been considered as a measure of the default risk and assumed not be affected by the demand for and supply of CDSs. In contrast, the present study explicitly introduces the notion of demand and supply, which has been widely considered as a key determinant of prices in other financial markets such as stock, government and corporate bond, and foreign exchange markets. Specifically, we examine how the interaction of the demand for and supply of protection affects an index of CDS premiums in the Japanese credit market.

While it is relatively easy to measure the price of protection using indexes of premiums in CDS markets (e.g., the various indexes provided by Markit Group Ltd. such as the iTraxx Japan for the Japanese credit market), the quantity of CDS transactions is more difficult to observe. It is particularly difficult to obtain information on the volume of each transaction, mainly due to the lack of a central clearing system. This is the biggest reason making it difficult to study the demand for and supply of protection. We should note, however, that most of the transactions among market makers, which account for the majority of transactions, are offset in a relatively short period by transactions in the opposite direction. This reflects the intention of market makers to "square" their positions as soon as possible.[1] Our empirical strategy in this paper is to take advantage of this feature and exclusively focus on the flow in trades for "outright" protection, which account for positions held for a long period. We use the issuance volume of credit linked notes (CLNs), which are securitized products written against CDSs, as a proxy for the trade flow in outright protection. Due to the lack of a secondary market and high transaction costs, the standard investment strategy for CLNs is "buy-and-hold," which assures that the trade for protection associated with the CLN investments tends to be held for a long period, mostly until their maturity.

An additional technical problem originating from the use of CLN data is that we observe a large number of zero amounts of CLN issuance. This is partly because most of the CLNs are tailor-made and incur time and costs to deliver. Moreover, investors in CLN are relatively limited. To deal with such truncated data, we employ a simultaneous equation Tobit model of the type first proposed by Nelson and Olson (1978) and refined by Amemiya (1979).

Our estimation shows that not considering the simultaneous equation system likely results in substantial misestimation of the impact of changes in the exogenous shift variables for the protection supply and demand curves. This could be interpreted as a sign of simultaneity bias in the reduced form regression. Our estimation also shows that the impact of some factors on CDS premiums could not be identified when we do not properly take the truncated sample into account. These results imply that, to examine the determinants of CDS spreads, it is necessary to explicitly consider demand and supply as well as the potential bias originating from the limited dependent variable (i.e., the truncated data on transaction volumes).

The remainder of the paper is organized as follows. The next section provides an overview of the basic structure of CDSs and the related securitized products markets. Section 3 briefly surveys the literature on the determinants of CDS premiums. Section 4 then describes the data and the empirical framework used for our analysis, while Section 5 discusses the results. Section 6 concludes and highlights remaining issues.

2. Basics of Credit Default Swap Markets and Credit Linked Notes

Figure 1 provides a conceptual depiction of the CDS market. Transactions in CDSs, that is, the selling and buying of protection, can take place between (i) outright protection sellers and market makers, (ii) outright protection buyers and market makers, and (iii) among market makers themselves. Almost all the transactions are executed as over-the-counter (OTC) transactions and

[1] That transactions are typically largely offset within brief periods is illustrated by the following quotes from a recent Bloomberg article: "JPMorgan purchased single-name contracts protecting $147.3 billion of debt and sold $142.4 billion related to the so-called GIIPS nations of Greece, Ireland, Italy, Portugal and Spain." Moreover: "JPMorgan said 'master netting agreements' reduced the notional amount of protection purchased to $18.5 billion and the amount sold to $13.7 billion." (Source: Bloomberg.com, February 29, 2012, "Goldman Mirrors JPMorgan Mirrors Goldman on Swap Exposure to European Debt," sic).

cannot be easily tracked.[2] Since most of the transactions among market makers are squared in short periods, however, the transaction volume in CDS markets which affects the CDS premium is likely to be mainly affected by transactions in outright protection, which are proxied by the issuance volume of CLNs.

CLNs are securities that resemble bonds and provide fixed coupon payments to their holders.[3] Figure 2 illustrates how CLNs and CDSs are linked. The right-hand side shows transactions in CDSs, which take place between securities firms and outright protection buyers. Securities firms play the role of sellers of protection against some default event and receive a premium in return. Outright buyers buy the protection and use it, for example, to hedge the credit risk in their portfolio or to buy protection with a speculative motive.[4] Next, the left-hand side shows transactions in CLNs, which are originated by the securities companies and sold to outright protection sellers, who receive the coupon on the CLNs, which is based on the premium associated with the CDSs and the return on the invested principal. In this sense, the demand for and supply of CLNs are accompanied by protection selling and buying, respectively. The coupon payment may be contingent on a default event relating to a specific company, or a range of companies. Moreover, the contingency may be designed in a variety of ways.[5,6] An important feature is that the CLN investment positions are in general held for a long period due to the lack of a secondary market for CLNs and high transaction costs. This is the reason why it is appropriate for our analysis to measure outright transactions in CDSs based on CLN issuance data.

A graphic representation of what our empirical study seeks to examine is presented in Figure 3. In the diagram, the volume of CDS transactions, proxied by the issuance of CLNs, is plotted on the horizontal axis, while the price, proxied by the iTraxx Japan index for CDS premiums, is plotted on the vertical axis. Suppose that protection sellers (i.e., CLN investors = outright protection sellers) have a large capacity for investing in CLNs and outright protection buyers do not show large demand for protection. Under such circumstances, the spread would be tight, since the supply of protection is large, while the demand for protection is limited. However, if, for example, the perceived risk of investing in CLNs increased, the protection seller curve would shift upward (i.e., t=1), since the appetite for CLN investment becomes smaller. Similarly, the protection buyer

---

2 That being said, data on individual CDS transactions is increasingly being disclosed (e.g., by the Depository Trust & Clearing Corporation (DTCC)), but the amount of data accumulated on such transactions to date is insufficient for analytical purposes. For Japan, the BOJ has been releasing data on CDS transaction volumes aggregated for each six-month period.

3 Synthetic collateralized debt obligations (CDOs) are included in the CLNs considered in this paper. Note also that some CLNs have floating coupon payments, but the number of such cases is limited.

4 Investors may buy CDSs for speculative purposes rather than for protection. In this case, they aim to make a profit by buying CDSs when premiums are low and selling them when premiums are high.

5 Most CLNs are sold in units of 2 billion yen and are highly customized to suit each investor’s preferences.

6 As a typical example, the coupon payment to investors in CLNs categorized as first-to-default (FTD) is terminated and only part of the principal of the CLNs is paid back to investors when one of the firms referenced by the CLN contract defaults. The rise of CLNs in the Japanese credit market is largely driven by the issuance of such FTD-type CLNs.

curve would shift up when, for example, the demand for protection increases due to a larger need for risk hedging (i.e., t=1).[7] We conjecture that the sharp rise in CDS spreads during the recent financial crisis actually emerged due to such shifts in both protection selling and buying.

There have been many investors in Japan who require products with higher risks and higher returns than offered by traditional investment assets (e.g., Japanese government bond). Over the last decade, securities firms have been providing various securitized products such as mortgage backed securities (MBS) and CLNs to investors with a high risk-return appetite. This rising demand for securitized products has led securities firms to sell protection in CDS markets to procure the underlying assets for securitized products. One of our main conjectures is that such demand pressure in the securitized products markets, which works as supply pressure in the CDS market, plays a central role in the determination of premiums in the CDS market.

3. Related Literature

The pricing implications of imbalances in supply and demand have received considerable attention in theoretical studies on CDS markets (e.g., Bollen and Whaley 2004; Brunnermeier and Pedersen 2009; Garleanu et al. 2009). However, when it comes to empirical studies on CDS pricing, despite their substantial number (e.g., Huang et al. 2003; Longstaff et al. 2005; Ericsson et al. 2009; Scheicher 2008), there are hardly any that explicitly that take into account the notion of supply and demand. A notable exception is the study by Tang and Yan (2011), which employs the difference between the number of bids and offers as a proxy for imbalances in supply and demand. They show that such imbalances have a statistically significant and sizable impact on CDS spreads. Similar to the approach taken in this paper, they attempt to take into account the simultaneous determination of CDS prices and transaction volumes by using two-stage least squares estimation. The present study takes the analysis a step further and explicitly examines shifts in the protection seller and buyer curve and the impact of such shifts on CDS spreads – something that is not discussed in Tang and Yan's (2011) study.

While the impact of supply and demand imbalances in CDS markets has remained largely unexplored, this is not the case for other financial markets. Starting from the pioneering study by Kraus and Stoll (1972), numerous studies, such as Chordia et al. (2002), Chordia and Subramanyam (2004), Coval and Stafford (2007), Sarkar and Schwartz (2009), and Hendershott and Menkveld (2012) have examined and confirmed the impact of supply and demand and on stock prices. Similarly, Greenwood and Vayanos (2010) and Krishnamurthy and Vissing-Jorgenson (2012) have examined the role of supply and demand in the determination of government bond prices, while Ellul et al. (2011) did the same for corporate bond prices. Against this background, the role of supply and

[7] We will provide more details on the mechanisms further below.

demand in the determination of CDS prices remains an important gap in the literature, which the present study seeks to fill.

4. Data and Empirical Framework

4.1. Data and Hypotheses

This section provides a description of the data we use for our empirical analysis and sets out our hypotheses. We begin by describing our data. As our variable representing CDS premiums, we use the Markit iTraxx Japan (*iTraxx_P*) index. This is an index of the CDS premium in the Japanese credit market and consists of a basket of five-year CDSs for 50 investment-grade Japanese firms with the highest market liquidity.[8] This index, which is updated daily, is computed from the spreads reported by licensed market makers.

In contrast with the ready availability of such price data, data on the quantity of CDS transactions is difficult to obtain due to the lack of a centralized clearing system. Therefore, we instead use data on the issuance of CLNs (*CLN_ISSUE_Q*) from January 2002 to March 2011, which we collected from information released by Rating and Investment Information Inc. (R&I). Specifically, the data on CLN issuance that we use for our empirical analysis consist of roughly 400 issuances worth almost 1.1 trillion yen. We exclude two large issuances, that by Bank of Tokyo Mitsubishi UFJ in 2006 and that by Mizuho Corporate Bank in 2009, as outliers.[9] We construct weekly frequency data and compute the moving average of *CLN_ISSUE_Q*, since the impact of CLN issuance on the CDS market is presumably not limited to the exact date of issuance but also extends to adjacent periods. This could be the case when, for example, the timing of the CDS transactions associated with the origination of CLNs are spread around the date of CLN issuance. Note that there are still a large number of zeros for *CLN_ISSUE_Q* in our dataset after taking the moving average. For consistency with the quantity data, we therefore transform the daily iTraxx Japan data into weekly data by taking the average for each week.

As detailed in the next subsection, we model price determination in the CDS market as an equilibrium between protection selling and buying. Specifically, we consider traditional investors in the Japanese credit market such as Japanese domestic banks and various institutional investors as outright protection sellers. To measure their risk-taking capacity, we use the level of the Nikkei 225 Stock Index (*NKY_AVG*). In order to take the average investment return on alternatives to investments in CLNs into account, we use the five-year yield on Japanese government bonds (*JGB_5Y*). Another variable we include is the average change in credit ratings of existing CLNs. To

---

[8] The reasons that we focus on the Markit iTraxx Japan index rather than the CDS premium for each of the 50 firms are twofold. First, it is difficult to map the information on CLN issuance for each CLN issue to the referenced individual firms. Second, the Markit iTraxx Japan index is traded in the market as an individual investment tool.

[9] These two synthetic CDOs were issued for risk hedging against the banks' loan portfolios.

precisely measure the impact of rating changes, we multiply the issuance amount of each CLN by the concurrent change in the rating of the CLN, the latter of which takes one (minus one) when the CLN is downgraded (upgraded) by one notch.[10] We conjecture that a larger value of this variable (*RATING_CHANGE*) is associated with a higher credit risk of the CLN portfolio, which leads protection sellers to require a higher premium and to be more cautious about any additional investment. Protection sellers' investment attitude may also be related to the availability of loan investments. Suppose banks face a very low level of loan demand and need to find alternative investment opportunities. In this case, such investors may be willing to sell protection at a relatively low premium. To take this conjecture into account, we use the aggregate-level loan-to-deposit ratio of commercial banks (*LOAN_DEPOSIT*) reported by the Bank of Japan as another exogenous shifter of the protection seller curve. The hypothesis we test for these variables is as follows:

Hypothesis 1: The upward-sloping protection seller curve shifts upward (i.e., protection sellers are willing to sell less protection at the same premium as before) when NKY_AVR decreases (investors' risk-taking capacity decreases), JGB_5Y increases (the returns on other investments increase), RATING_CHANGE increases (the risk of holding CLNs increases), and/or LOAN_DEPOSIT increases (business opportunities in commercial banks' main business improve).

We assume that speculative investors such as hedge funds and investment banks are the buyers of outright protection. As factors shifting the protection buyer curve, we use the difference between three-month dollar Libor (London inter-bank offered rate) and the three-month yield of U.S. treasury bills (*LIBOR_TREASUR3M*), which we regard as a measure of the marginal funding cost of financial institutions and which can be seen as a measure of risk in financial markets. We conjecture that higher risk in the future as measured by a higher *LIBOR_TREASUR3M* leads speculative investors to buy protection, which results in an upward shift of the protection buyer curve.

We also measure the change in the potential losses or gains from CLN purchased at time s as of the current period t (*MARK_TO_MKT*). For simplicity, we assume that the maturity of all CLNs is 5 years, which means that all of the existing CLNs have been issued during the five years preceding t.[11] Since a CLN issued at time s matures five years after s, semi-annual coupon payments are made at time $s+k/2$ $(k=1,2,\cdots,10)$. We denote the number of coupon payments on a CLN issued at time s during the period t to $s+5$ by $X(s,t)$. Thus, *MARK_TO_MKT* is expressed as the product of (i) the principal of the CLN issued at s (A_s), (ii) the price change between the issuance date s and t (P_s-P_t), and (iii) $X(s,t)$.[12] Since the existing CLNs at time t

[10] An upgrade by one notch means, for example, a change from A to A+.
[11] We focus on the potential losses and gains on CLNs with a maturity of 5 years, since these are the most actively traded CLNs in the CDS market.
[12] For simplicity, we further assume that 1year consists of 52 weeks.

were issued during the period from $t-5$ to t, we aggregate this measure over these periods to construct *MARK_TO_MKT*.[13]

As *MARK_TO_MKT* becomes negative, the potential losses for CLN holders become larger (i.e., if the CLNs issued at time s have a very low coupon rate, investors incur large losses at time t). We conjecture that the protection buyer curve shifts up as this value falls. This would be the case when securities firms, which are assumed to square their positions, buy more protection because their sell-position against outright protection buyers is incurring losses. Such losses require securities firms to provide additional collateral to the outright protection buyers in order to fulfill the CDS contract (i.e., the counter-party risk increases for the original outright buyer). However, the securities firms are not allowed to use the principal of the CLNs they received when the CLNs were issued. Rather, the securities firms are required to hold the principal as collateral in case an actual credit event occurs and the firm referenced by the CLNs defaults. In order to obtain funds they can use as additional collateral, securities firms can buy protection (i.e., short cover) and obtain the collateral from the new protection seller in the transaction. In addition, the securities firms may want to procure the protection in advance to prepare for the selling request from original outright protection buyers. In any case, the existence of such "new" protection buyers generates an upward shift of the protection buyer curve. The hypothesis relating to the protection buyer curve can thus be stated as follows:

Hypothesis 2: The downward-sloping protection buyer curve shifts upward (i.e., protection buyers are willing to buy more protection for the same protection fee) when LIBOR_TREASUR3M increases (protection buyers have a stronger speculative motive for buying protection) and/or MARK_TO_MKT decreases (protection buyers have a stronger short-cover motive).

A full list of the variables we use in our estimation, their definitions, and summary statistics is provided in Table 1. Further, Table 2 presents the correlation coefficients between the various variables. Our observations cover the period from August 2004 to April 2011, spanning a total of 348 weeks.

4.2. Empirical Framework

Our goal in this paper is to estimate the supply and demand functions of protection with non-truncated price data (P: *iTraxx_P*) and truncated quantity data (Q^*: *CLN_ISSUE_Q*). For this purpose, we consider a two-equations model consisting of equations $(1-1)$ and $(1-2)$, where the first equation represents the seller function and the second represents the buyer function. As we

[13] Given the large variation of $(P_s - P_t)$, we apply a monotonic transformation to $(P_s - P_t)$ by using the product of (i) the sign of $(P_s - P_t)$ and (ii) the square root of the absolute value of $(P_s - P_t)$, instead of simply using $(P_s - P_t)$.

detailed above, Q^* is truncated at zero. Q^* takes a positive value when CLNs are issued in the week, and zero otherwise. Specifically, the model looks as follows:

$$P = \gamma_1 Q^* + X_1\beta_1 + u_1 \qquad (1-1)$$
$$Q^* = \gamma_2 P + X_2\beta_2 + u_2 \qquad (1-2)$$
$$\text{if } Q = Q^* > 0, \textit{otherwise } Q^* = 0$$

Here, X_1 represents the exogenous shift variables for the protection seller curve (i.e., *NKY_AVR*, *JGB_5Y*, *RATING_CHANGE*, and *LOAN_DEPOSIT*), while X_2 represents the exogenous shifters for the protection buyer curve (i.e., *LIBOR_TREASUR3M* and *MARK_TO_MKT*). This system is identical to the model proposed by Nelson and Olson (1978) and refined by Amemiya (1979). Note that if we did not need to take into account the limited dependent variable Q^*, we could simply run the usual two-stage least squares estimation for the simultaneous equation system. However, in order to deal with the fact that CLN issuance often takes a zero value, we need to use the model above.

As explained in detail by Nelson and Olson (1978) and Amemiya (1979), the predicted values of the endogenous variables are estimated using OLS or MLE in the first-stage regression. The parameters (Π_1, Π_2) in the reduced-form equations $(2-1)$ and $(2-2)$, which represent the coefficients associated with all the exogenous variables X, are estimated from this first-stage regression as follows:[14]

$$P = X\Pi_1 + v_1 \qquad (2-1)$$
$$Q^* = X\Pi_2 + v_2 \qquad (2-2)$$
$$\text{if } Q = Q^* > 0, \textit{otherwise } Q^* = 0$$

where

$$\text{Variance} - \text{Covariance matrix of } (v_1, v_2) = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}$$

As in Amemiya (1979), the results of the first-stage regression $(\hat{\Pi}_1, \hat{\Pi}_2)$, where $\hat{\Pi}_1$ and $\hat{\Pi}_2$ are respectively the OLS and Tobit MLE estimates, are used to estimate the structural parameters $(\gamma_1, \gamma_2, \beta_1, \beta_2)$. Note that $u_1 = v_1 - \gamma_1 v_2$ and $u_2 = v_2 - \gamma_2 v_1$ need to be satisfied so that $(1-1)$ and $(1-2)$ are identified from $(2-1)$ and $(2-2)$. Substituting the results from $(2-2)$ into $(1-1)$ yields the following expression, which provides us with $\hat{\alpha}_1$ through standard OLS estimation:

[14] A similar issue is discussed in the paper by Keshk (2003), which explains the Stata command for simultaneous equation probit models.

$$
\begin{aligned}
P &= \gamma_1 X\Pi_2 + \gamma_1 v_2 + X_1\beta_1 + u_1 \\
&= \gamma_1 X\widehat{\Pi}_2 + X_1\beta_1 + v_1 - \gamma_1 X(\widehat{\Pi}_2 - \Pi_2) \\
&= X[\widehat{\Pi}_2, J_1]\begin{bmatrix}\gamma_1\\ \beta_1\end{bmatrix} + w_1 \equiv X\widehat{H}\alpha_1 + w_1 \qquad (3)
\end{aligned}
$$

Where

$XJ_1 = X_1,\ \ w_1 = v_1 - \gamma_1 X(\widehat{\Pi}_2 - \Pi_2),$

$\widehat{H} = [\widehat{\Pi}_2, J_1],\ \ \alpha_1 = \begin{bmatrix}\gamma_1\\ \beta_1\end{bmatrix}$

Here, we can compute $\widehat{\alpha}_1 - \alpha_1$ as follows:

$$
\widehat{\alpha}_1 - \alpha_1 = \begin{bmatrix}\widehat{\gamma}_1 - \gamma_1\\ \widehat{\beta}_1 - \beta_1\end{bmatrix} = (\widehat{H}'X'X\widehat{H})^{-1}\widehat{H}'X'w_1
$$

This allows us to further compute the variance-covariance matrix of $\widehat{\alpha}_1$:

$$
V(\widehat{\alpha}_1) = (\sigma_1^2 - 2\gamma_1\sigma_{12})(\widehat{H}'X'X\widehat{H})^{-1} + \gamma_1^2\ (\widehat{H}'X'X\widehat{H})^{-1}\widehat{H}'X'XV(\widehat{\Pi}_2)X'X\widehat{H}(\widehat{H}'X'X\widehat{H})^{-1}
$$

Given the relationship between $\widehat{\Pi}_2$ and w_1, we can use the following formula proposed by Amemiya (1979) with regard to $V(w_1)$ to compute $V(\widehat{\alpha}_1)$, which we need to correctly evaluate $\widehat{\alpha}_1$:

$$
V(w_1) = V(v_1) - \gamma_1 E\left[(\widehat{\Pi}_2 - \Pi_2)'X'v_1\right] - \gamma_1 E[v_1'X(\widehat{\Pi}_2 - \Pi_2)] + \gamma_1^2\ XV(\widehat{\Pi}_2)X'
$$

$$
X'V(w_1)X = (\sigma_1^2 - 2\gamma_1\sigma_{12})X'X + \gamma_1^2\ X'XV(\widehat{\Pi}_2)X'X
$$

From the same manipulation of $(2-1)$ and $(1-2)$, we can derive an expression similar to (3):

$$
Q^* = X[\widehat{\Pi}_1, J_2]\begin{bmatrix}\gamma_2\\ \beta_2\end{bmatrix} + w_2 \equiv X\widehat{G}\alpha_2 + w_2 \qquad (4)
$$

where

$XJ_2 = X_2,\ w_2 = v_2 - \gamma_2 X(\widehat{\Pi}_1 - \Pi_1),$

$\widehat{G} = [\widehat{\Pi}_1, J_2],\ \alpha_2 = \begin{bmatrix}\gamma_2\\ \beta_2\end{bmatrix}$

As demonstrated by Amemiya (1979), $\widehat{\theta}_2 \equiv (\widehat{\alpha}_2, \widehat{\sigma}_2^2) = \mathrm{argmax}\, L(\widehat{\Pi}_1, \alpha_2, \sigma_2^2)$ is estimated by linearizing the normal equation (4), assuming that (v_1, v_2) follow the normal distribution $N(0, v)$, and constructing the likelihood function for the Tobit estimation. We obtain the following result:

$$\hat{\theta}_2 - \theta_2 \equiv \begin{bmatrix} \hat{\alpha}_2 \\ \hat{\sigma}_2^2 \end{bmatrix} - \begin{bmatrix} \alpha_2 \\ \sigma_2^2 \end{bmatrix} =^{A} - \left[E \frac{\partial^2 \log L}{\partial \theta_2 \, \partial \theta_2{}'} \right]^{-1} \left[\frac{\partial \log L}{\partial \theta_2} + E \frac{\partial^2 \log L}{\partial \theta_2 \, \partial H_1{}'} \cdot \left(\hat{\Pi}_1 - \Pi_1 \right) \right]$$

where

$\hat{\Pi}_1 - \Pi_1 = (X'X)^{-1} X' v_1$

$=^{A}$ means both sides of the equation have the same asymptotic distribution.

Given that the following relationship holds, we can compute $V(\hat{\alpha}_2)$:

$$\begin{bmatrix} \Pi_2 \\ \sigma_2^2 \end{bmatrix} = \begin{bmatrix} G & 0 \\ 0' & 1 \end{bmatrix} \begin{bmatrix} \alpha_2 \\ \sigma_2^2 \end{bmatrix}$$

$$V(\hat{\alpha}_2) = \left(G' V(\hat{\Pi}_2)^{-1} G \right)^{-1}$$

$$+ (\gamma_2^2 \sigma_1^2 - 2\gamma_2 \sigma_{12}) \left(G' V(\hat{\Pi}_2)^{-1} G \right)^{-1} G' V(\hat{\Pi}_2)^{-1} (X'X)^{-1} V(\hat{\Pi}_2)^{-1} G \left(G' V(\hat{\Pi}_2)^{-1} G \right)^{-1}$$

In this context, it is worth noting that the instrumental variable Tobit model proposed by Smith and Blundell (1986) and Newey (1987), which considers the following limited information simultaneous equations system with one structural equation (i.e., one endogenous variable) in $(5-1)$ and $(5-2)$, produces the same estimators, but the standard errors are different:

$$P = \gamma_1 Q^* + X_1 \beta_1 + u \qquad (5-1)$$

$$Q^* = X_1 \Pi_1 + X_2 \Pi_1 + v \qquad (5-2)$$

In the next section, we present the estimated coefficients of the simultaneous equation system constructed above, for which statistical inference is made by using the variance-covariance matrix computed as above. We also show the results for the model represented by $(5-1)$ and $(5-2)$ for comparison.

5. Estimation Results

5.1. Baseline Estimation Results

The baseline results of our empirical analysis are presented in Table 3. The columns on the left show the results for the first-stage regression, while those on the right show those for the second-stage regression. The first-stage estimation regressing *CLN_ISSUE_Q* on all the exogenous variables is provided in the upper part on the left-hand side. The results of this estimation are used to estimate the seller curve in the second stage, which is shown in the upper part on the right. Similarly, the first-stage estimation regressing *iTraxx_P* on all the exogenous variables is presented in the lower part on the left-hand side and the results are used to estimate the buyer curve in the second stage. The results are shown in the lower part on the right-hand side. For the second-stage regression, both standard errors based on the variance-covariance matrix computed as in Amemiya (1979) and non-corrected standard errors used for the model represented by $(5-1)$ and $(5-2)$ are shown. The non-corrected standard errors underestimate the true standard errors because they do not reflect the errors from the first-stage estimation.

Let us take a look at the results. First, the upper and lower parts on the right-hand side show that the protection seller curve has a significant positive slope (1.5175), while the protection buyer curve has a significant negative slope (-1/0.5482), which is consistent with our conjecture.[15] Second, the protection seller curve shifts down (i.e., protection sellers are willing to sell more protection at the same premium as before) when general economic conditions improve (i.e., *NKY_AVG* is higher). Third, as the yield on Japanese government bonds decreases (i.e., *JGB_5Y* falls), protection sellers attempt to sell more protection. The latter result implies that Japanese government bonds are an alternative investment asset to CLNs. Fourth, such a downward shift of the protection seller curve can be also observed when opportunities for loan investments by banks decrease (*LOAN_DEPOST* falls). When banks find it difficult to invest the deposits they take into traditional loan assets, they tend to use the funds to buy, for example, CLNs, as discussed above. Fifth, protection sellers also tend to sell more protection when the risk of CLN portfolios is lower (i.e., *RATING_CHANGE* is lower).

The lower part of the second-stage estimation represents the estimated protection buyer curve. The negative-sloping buyer curve shifts upward when the speculative motive becomes stronger (i.e., *LIBOR_TREASUR3M* increases) and/or the short-cover motive becomes more significant (i.e., *MARK_TO_MKT* decreases).

Figure 4 depicts the protection seller and buyer curves for five sub-periods using the estimated coefficients from Table 3 and the values for the exogenous variables for the five sub-periods. As can be seeing in panels (a) and (b) of Figure 4, the two curves intersect at relatively low levels of *iTraxx_P* – below 100 basis points – during the early part of our observation period. The intersection shifts up somewhat in the run-up to the collapse of Lehman Brothers in September 2008 (Figure 4(c)) and then jumps to 300 basis points and more in the wake of the collapse of Lehman Brothers (Figure 4 (d)). Interestingly, the price dynamics prior to the collapse of Lehman Brothers are mainly driven by a shift in the protection seller curve. On the other hand, shifts in both the protection seller and buyer curves led to the sharp rise in *iTraxx_P* after the Lehman collapse, which confirms our conjecture that both sides contributed to the sharp rise in CDS premiums.

[15] Note that, in this estimation, we set *CLN_ISSUE_Q* as the dependent variable and, in order to compare these slopes, we need to take the inverse of the estimate.

5.2. Two Sources of Potential Bias

In this subsection, we examine the two potential biases originating from (i) ignoring simultaneity and (ii) ignoring the limited dependent variable. First, the right-hand side of Table 4 shows the estimated coefficients when we ignore the simultaneous equation system. In this estimation, the price (quantity) is regressed on the quantity (price) and all other exogenous variables simply using the OLS (Tobit) specification instead of employing two-stage estimation. The estimation based on the incorrectly specified *iTraxx_P* model (i.e., the upper part on the right-hand side) yields, for example, an insignificant coefficient on *LOAN_DEPOSIT*. The impact of the two variables *NKY_AVG* and *JGB5Y*, which was found to be significant in the baseline estimation, also becomes insignificant in this estimation. These results mean that it is necessary to consider both demand and supply to examine the determinants of CDS premiums.

Second, to investigate the role of another source of bias, namely that resulting from ignoring the limited dependent variable, we implement linear instrumental variable estimations for *iTraxx_P* and *CLN_ISSUE_Q*, the results of which are shown in Table 5. Given that the purpose of this exercise is to examine the bias associated with ignoring that *CLN_ISSUE_Q* is truncated, the estimation is implemented using regular two-stage least square estimation instead of the model in $(1-1)$ and $(1-2)$. The results indicate that the signs of the coefficients are consistent with those of the baseline estimation. To investigate whether the economic impact of each of the exogenous variables is similar in the two estimations, we compute the change in the predicted value of *iTraxx_P* when each variable increases by one standard deviation. The results are shown in Table 6.[16] The column labeled "Baseline" shows the results for the baseline estimation, while that labeled "Ignoring LDV" shows those when ignoring that *CLN_ISSUE_Q* is truncated. The impacts of the shift variables for the protection seller curve (i.e., *NKY_AVG*, *JGB5Y*, *RATING_CHANGE*, and *LOAN_DEPOST*) are almost twice as high in the case of the incorrectly specified model. This implies that we would overestimate the impact of these variables if we do not correctly take into account the truncation of *CLN_ISSUE_Q*.

As another comparison between the correctly and incorrectly specified models, the center column in Table 6 also shows the computed magnitude of each covariate in the estimation of the "single" equation, which ignores the simultaneity. The fact that the loan-to-deposit ratio is not significant in the incorrectly specified single equation model suggests that the quantitative impact of a change in the loan-to-deposit ratio would be measured incorrectly if we do not take the simultaneous equation system into account. Figures 5 and 6 compare the observed price and quantity dynamics with the model prediction. The figures show that our model predicts the price and quantity dynamics reasonably well.

[16] The results in Table 6 are obtained by solving the simultaneous equation system.

6. Conclusion

This paper examined the determinants of CDS premiums by employing a simultaneous equation system consisting of the demand for and supply of protection. The results suggest that CDS premiums rise when the protection supply curve shifts upward, which may occur when investors' risk-taking capacity decreases, the returns on alternative investment assets increases, average credit ratings of existing CLNs in the market deteriorate, and/or business opportunities in commercial banks' main business improve; CDS premiums also rise when the protection demand curve shifts upward, which may occur when the speculative motive and/or the short-cover motive become stronger. The analysis also showed, however, that the quantitative impact of these factors would be misestimated unless the simultaneous determination of supply and demand as well as the limited dependent variable are taken into account. These results mean that, to understand fluctuations in CDS premiums, it is necessary to explicitly consider demand and supply factors just as in the case of prices of other financial assets, as well as the truncated data on transaction quantities.

The research presented in this study could be expanded in a number of directions. One such direction would be to extend our analysis to the determinants of single name CDS spreads through a panel estimation framework. In order to measure the outright demand for protection with regard to exposure to individual firms, however, we need to collect more comprehensive transaction data. Second, a further, potentially interesting extension would be to apply the model in this paper to explicitly analyze the determinants of the spreads of corporate bonds. Third, an important remaining issue would be to analyze transactions among market makers, which in this paper are assumed to play a neutral role. We believe all of these extensions would provide further insights to gain a better understanding of pricing in the CDS market.

References

Amemiya, T., 1979. The Estimation of a Simultaneous Equation Tobit Model. International Economic Review 20, 169–181.

Blanco, R., Brennan, S., Marsh, I. W., 2005. An Empirical Analysis of the Dynamic Relation Between Investment-Grade Bonds and Credit Default Swaps. Journal of Finance 60, 2255–2281.

Bollen, N. P., Whaley, R. E., 2004. Does Net Buying Pressure Affect the Shape of Implied Volatility Functions? Journal of Finance 59, 711–754.

Brunnermeier, M. K., Pedersen, L. H., 2009. Market Liquidity and Funding Liquidity. Review of Financial Studies 22, 2201–2238.

Chordia, T., Roll, R., Subrahmanyam, A., 2002. Order Imbalance, Liquidity, and Market Returns. Journal of Financial Economics 65, 111–130.

Chordia, T., Subrahmanyam, A., 2004. Order Imbalance and Individual Stock Returns: Theory and Evidence. Journal of Financial Economics 72, 485–518.

Coval, J.A., Stafford, E., 2007. Asset Fire Sales (and Purchases) in Equity Markets. Journal of Financial Economics 86, 479–512.

Ellul, A., Jotikasthira, P., Lundblad, C. T., 2011. Regulatory Pressure and Fire Sales in the Corporate Bond Market. Journal of Financial Economics 101, 596–620.

Ericsson, J., Jacobs, K., Oviedo, R. A., 2009. The Determinants of Credit Default Swap Premia. Journal of Financial and Quantitative Analysis 44, 109–132.

Garleanu, N., Pedersen, L. H., Poteshman, A. M., 2009. Demand-Based Option Pricing, Review of Financial Studies 22, 4259–4299.

Greenwood, R., Vayanos, D., 2010. Price Pressure in the Government Bond Market. American Economic Review Papers & Proceedings 100, 585–590.

Hendershott, T., Menkveld, A. J., 2012. Price Pressures. Working Paper.

Huang, Y., Neftci, S., Jersey, I., 2003. What Drives Swap Spreads, Credit or Liquidity? ISMA Centre Discussion Papers in Finance 2003-2005, University of Reading.

Keshk, O. M. G., 2003. CDSIMEQ: A Program to Implement Two-Stage Probit Least Squares. The Stata Journal 3, 157–167.

Kraus, A., Stoll, H. R., 1972. Price Impacts of Block Trading on the New York Stock Exchange. Journal of Finance 27, 569–588.

Krishnamurthy, A., Vissing-Jorgenson, A., 2012. The Aggregate Demand for Treasury Debt. Journal of Political Economy 120, 233–267.

Longstaff, F., Mithal, S., Neis, E., 2005. Corporate Yield Spreads: Default Risk or Liquidity? New Evidence from the Credit Default Swap Market. Journal of Finance 60, 2213–2253.

Nelson, F., Olson, L., 1978. Specification and Estimation of a Simultaneous Equation Model with Limited Dependent Variables. International Economic Review 19, 695–705.

Newey, W. K., 1987. Efficient Estimation of Limited Dependent Variable Models with Endogenous Explanatory Variables. Journal of Econometrics 36, 231–250.

Sarkar, A., Schwartz, R.A., 2009. Market Sidedness: Insights into Motives for Trade Initiation. Journal of Finance 64, 375–423.

Scheicher, M., 2008. How Has CDO Market Pricing Changed During the Turmoil? Evidence from CDS Index Tranches. European Central Bank Working Paper Series No. 910.

Smith, R. J., Blundell, R. W., 1986. An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply. Econometrica 54, 679–685.

Tang, D. Y., Yan, H., 2011. What Moves CDS Spreads? Working Paper.

Figure 1: CDS Market

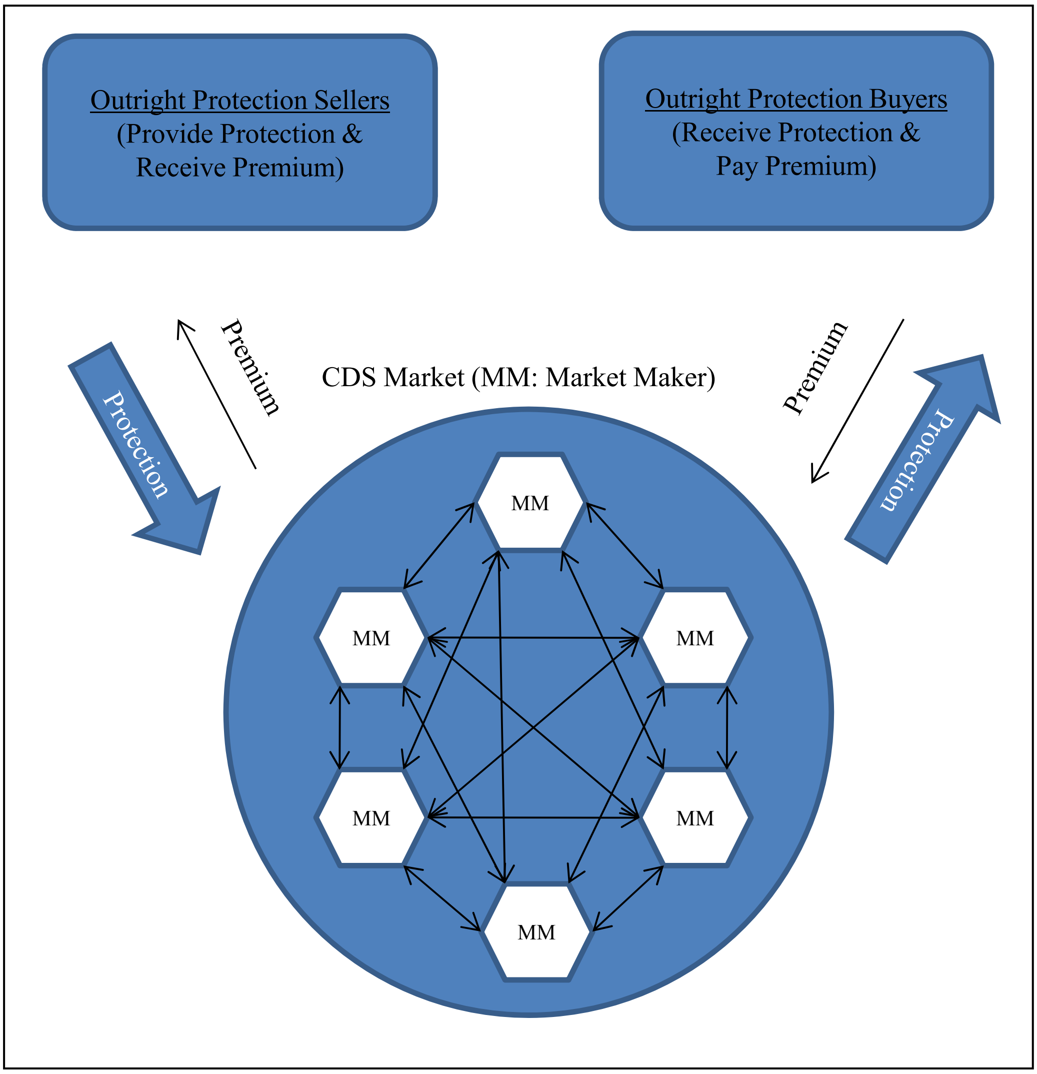


Figure 2: CDS and CLN Markets

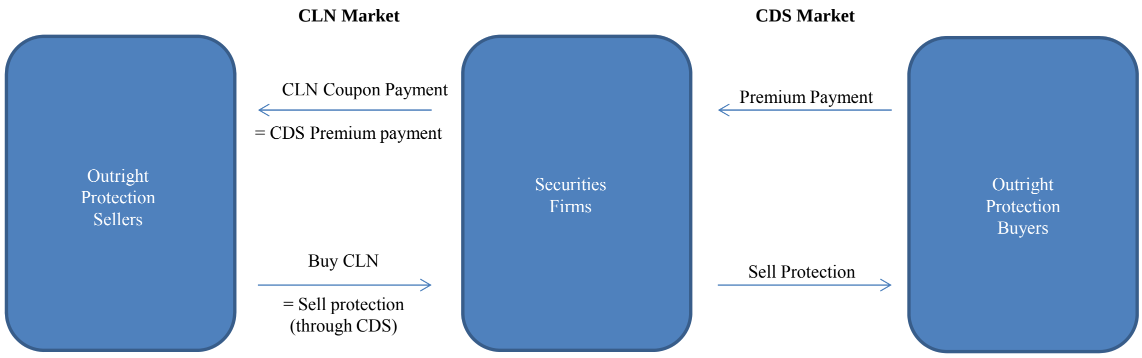
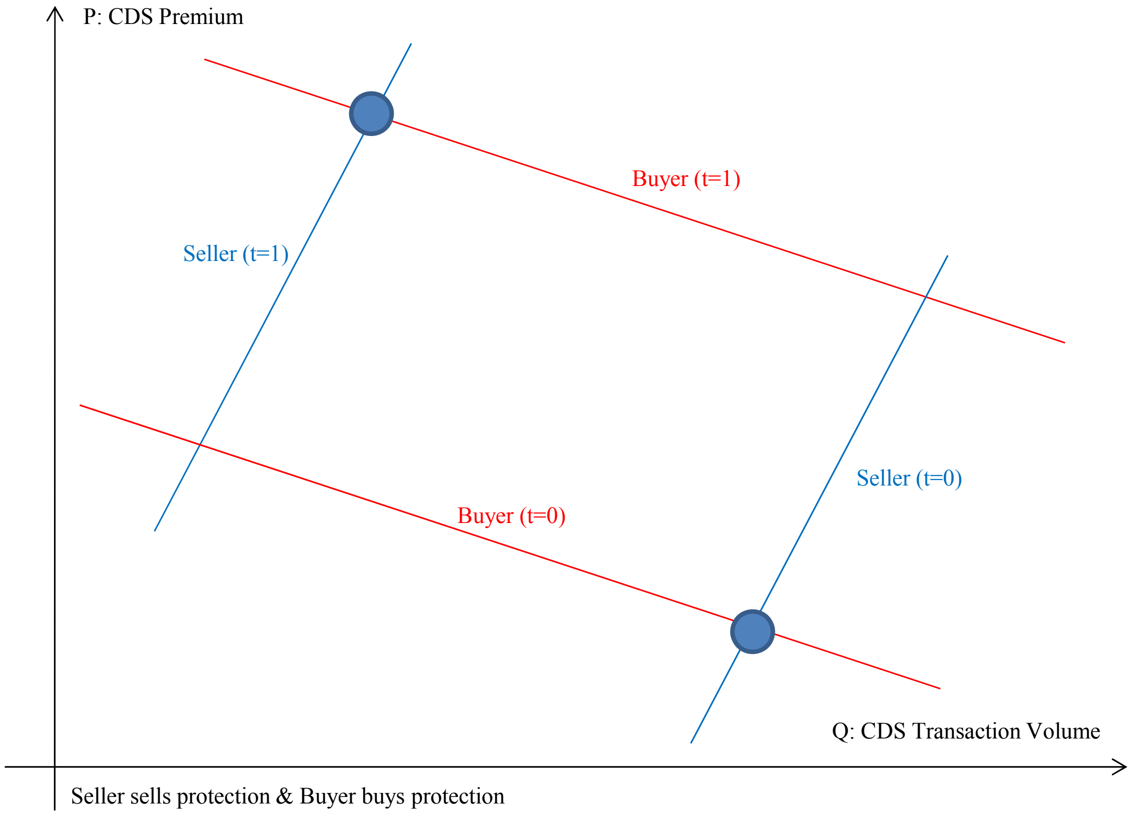


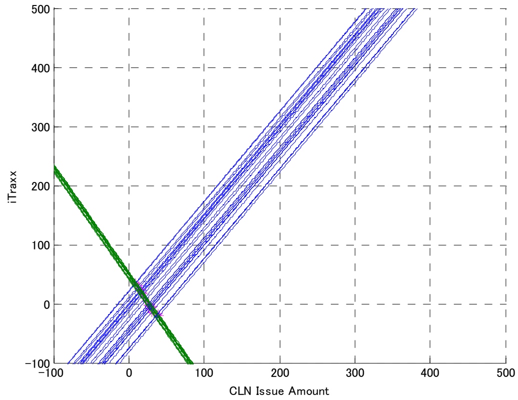
Figure 3: Protection Seller and Buyer Functions



Note: The figure shows the protection selling and buying curves at t=0 (e.g., prior to an event) and t=1 (after the event).

Figure 4: Demand for and Supply of Protection in Five Subperiods

(a) 2006/11-2007/4



(b) 2007/7-2007/12

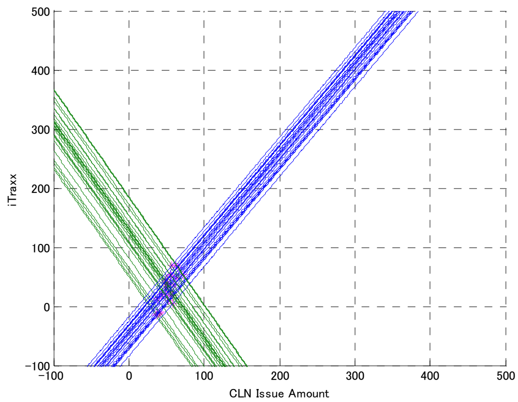
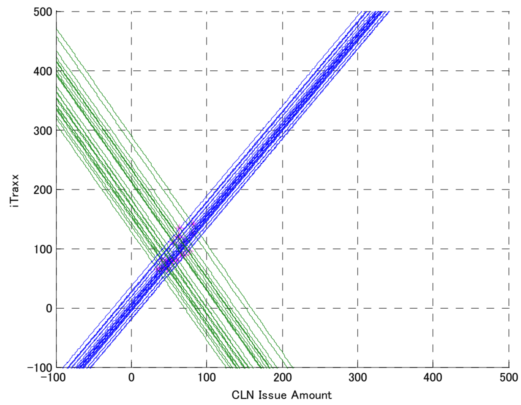
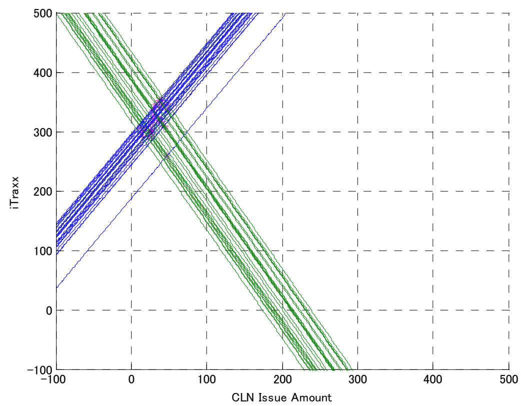


Figure 4 (continued): Demand for and Supply of Protection in Five Subperiods

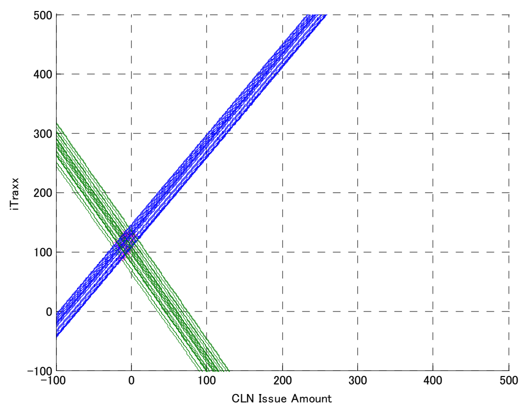
(c) 2008/2-2008/7



(d) 2008/10-2009/3

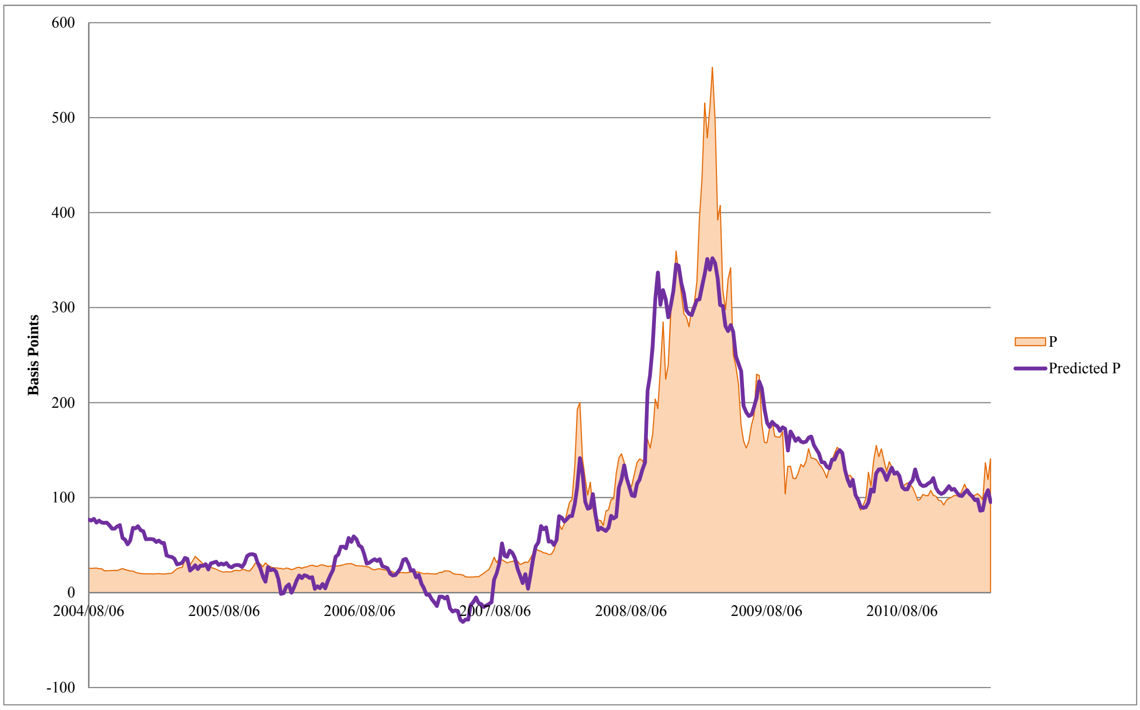


(e) 2010/3-2010/8



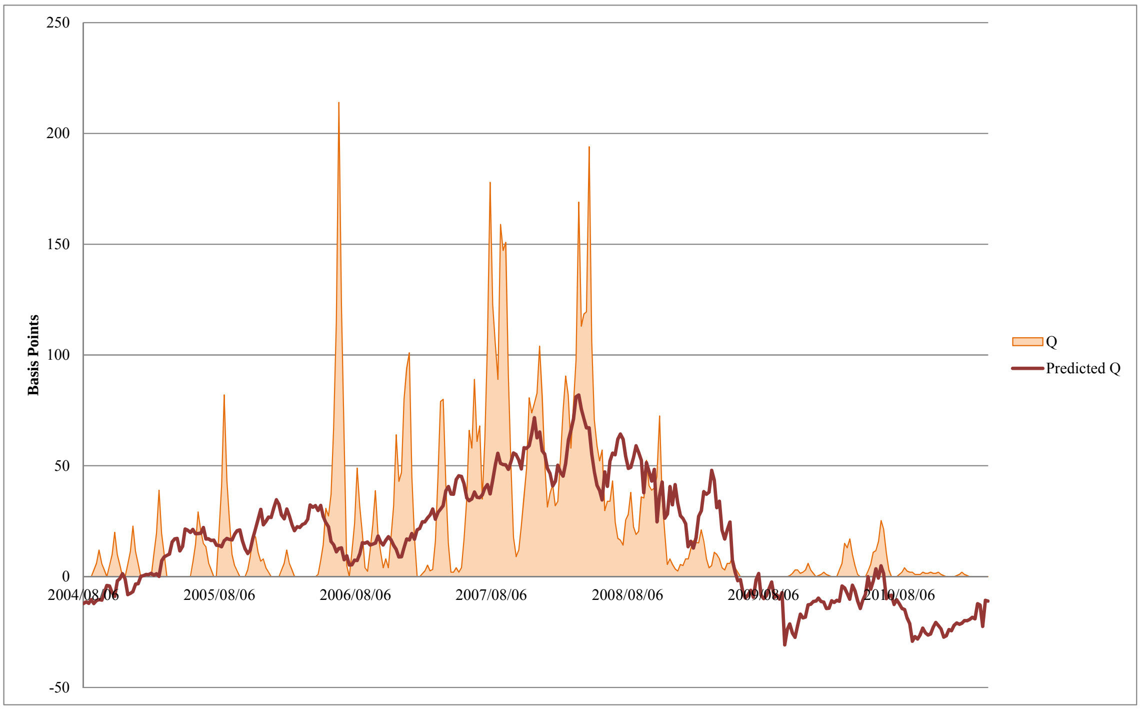
Note: Each figure plots the protection selling and buying curves based on the estimated results. The intersections of the two curves are obtained by solving the simultaneous equation system.

Figure 5: Predicted Price



Note: P stands for the actually observed iTraxx Japan, while Predicted P is the model prediction. Each point is obtained by solving the estimated simultaneous equation system.

Figure 6: Predicted Quantity



Note: Q stands for the actually observed CLN issuance volume, while Predicted Q is the model prediction. Each point is obtained by solving the estimated simultaneous equation system.

Table 1: Summary Statistics

Variable	Definition	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
iTraxx_P	Markit iTraxx Japan	bp	348	93.37	97.13	16.26	552.94
CLN_ISSUE_Q	Issued CLN amount	100 million yen	348	22.72	35.63	0.00	214.00
NKY_AVG	Monthly average of Nikkei 225 Stock Index	yen	348	12629	3012	7257	18191
JGB_5Y	Yield of 5-year Japanese government bonds	bp	348	84	33	23	154
RATING_CHANGE	Issued amount of each CLN times the concurrent change in its ratings (1 if downgraded and -1 if upgraded)	-	348	2113	2756	-23	6993
LOAN_DEPOSIT	Loan to deposit ratio	%	348	75.68	1.74	70.43	78.29
MARK_TO_MKT	Potential gains (positive number) and losses (negative number) from CLNs investment	-	348	-17.57	26.85	-117.55	6.14
LIBOR_TREASUR3M	3-month Libor minus yield on 3-month US treasuries	bp	348	58.95	60.03	9.99	410.93

Note: The table shows the summary statistics for the variables used in the estimation. Our observation period is from August 2004 to April 2011, providing 348 weekly observations for each of the variables.

Table 2: Correlation Coefficients

(Obs.=348)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	iTraxx_P	1.00							
(2)	CLN_ISSUE_Q	-0.14	1.00						
(3)	NKY_AVG	-0.68	0.38	1.00					
(4)	JGB_5Y	-0.25	0.46	0.80	1.00				
(5)	RATING_CHANGE	0.58	-0.38	-0.73	-0.63	1.00			
(6)	LOAN_DEPOSIT	-0.07	0.15	0.36	0.52	-0.68	1.00		
(7)	MARK_TO_MKT	-0.94	0.01	0.57	0.10	-0.38	-0.11	-0.54	
(8)	LIBOR_TREASUR3M	0.37	0.43	-0.04	0.30	-0.13	0.24	1.00	1.00

Note: The table shows the correlation coefficients for the variables used for the estimation. Our observation period is from August 2004 to April 2011, providing 348 weekly observations for each of the variables.

Table 3: Baseline Results

Simultaneous equation						
First Stage	Coef.	Std. Err.	Second Stage	Coef.	Corrected Std. Err.	Non-Corrected Std. Err.
Protection seller curve	Tobit		Protection seller curve	OLS		
	Dep. Var. = CLN_ISSUE_Q			Dep. Var. = iTraxx_P		
CLN_ISSUE_Q			CLN_ISSUE_Q	1.5175	0.3606 ***	0.1678 ***
NKY_AVG	0.0029	0.0019	NKY_AVG	-0.0251	0.0041 ***	0.0019 ***
JGB_5Y	0.1852	0.1376	JGB_5Y	0.8902	0.4029 **	0.1872 ***
RATING_CHANGE	-0.0054	0.0015 ***	RATING_CHANGE	0.0270	0.0046 ***	0.0021 ***
LOAN_DEPOSIT	-7.7658	1.8255 ***	LOAN_DEPOSIT	25.3441	5.7413 ***	2.6580 ***
MARK_TO_MKT	-0.1872	0.1411				
LIBOR_TREASUR3M	0.2626	0.0417 ***				
cons	544.9784	143.5038 ***	cons	-1664.6280	456.4465 ***	211.2360 ***
Obs.	348		Obs.	348		
LR chi2	165.51		F	255.34		
Prob. > chi2	0.0000		Prob. > F	0.0000		
Pseudo R-squared	0.0575		Adj. R-squared	0.7856		
Log Likelihood	-1357.34		Root MSE	44.97		
Protection buyer curve	OLS		Protection buyer curve	Tobit		
	Dep. Var. = iTraxx_P			Dep. Var. = CLN_ISSUE_Q		
iTraxx_P			iTraxx_P	-0.5482	0.0912 ***	0.1154 ***
NKY_AVG	-0.0003	0.0012				
JGB_5Y	0.0515	0.0860				
RATING_CHANGE	0.0079	0.0009 ***				
LOAN_DEPOSIT	0.1640	1.1384				
MARK_TO_MKT	-3.2859	0.0889 ***	MARK_TO_MKT	-1.5928	0.3578 ***	0.4457 ***
LIBOR_TREASUR3M	-0.1650	0.0266 ***	LIBOR_TREASUR3M	0.2538	0.0458 ***	0.0530 ***
cons	15.8964	89.3725	cons	24.2595	4.8671 ***	5.8669 ***
Obs.	348		Obs.	348		
F	1138.03		LR chi2	124.48		
Prob. > F	0.0000		Prob. > chi2	0.0000		
Adj. R-squared	0.9516		Pseudo R-squared	0.0432		
Root MSE	21.37		Log Likelihood	-1377.85		

Notes: ***, **, and * indicate statistical significance at the 1, 5, and 10% level, respectively. The dependent variable is either iTraxx or CLN_ISSUE. The left-hand side shows the results of the first-stage reduced form regression. The right-hand side shows the second stage regressions for the protection seller and buyer functions. The column "Corrected Std. Err." shows the standard error adjusted following the methodology employed by Nelson & Olson (1978) and refined by Amemiya (1979), while the column "Non-Corrected Std. Err." shows the unadjusted standard error.

Table 4: Ignoring Simultaneity

Simultaneous equation (from Table 3)				Single equation			
Second Stage	Coef.	Corrected Std. Err.			Coef.	Std. Err.	
Protection seller curve	OLS				OLS		
	Dep. Var. = iTraxx_P				Dep. Var. = iTraxx_P		
CLN_ISSUE_Q	1.5175	0.3606	***	CLN_ISSUE_Q	-0.0461	0.0361	
NKY_AVG	-0.0251	0.0041	***	NKY_AVG	-0.0002	0.0009	
JGB_5Y	0.8902	0.4029	**	JGB_5Y	0.0603	0.0701	
RATING_CHANGE	0.0270	0.0046	***	RATING_CHANGE	0.0077	0.0009	***
LOAN_DEPOSIT	25.3441	5.7413	***	LOAN_DEPOSIT	-0.1603	1.0760	
				MARK_TO_MKT	-3.2902	0.1763	***
				LIBOR_TREASUR3M	-0.1547	0.0389	***
cons	-1664.6280	456.4465	***	cons	39.5119	83.7058	
Obs.	348			Obs.	348		
F	255.34			F	582.13		
Prob. > F	0.0000			Prob. > F	0.0000		
Adj. R-squared	0.7856			R-squared	0.9526		
Root MSE	44.97			Root MSE	21.36		
Protection buyer curve	Tobit				Tobit		
	Dep. Var. = CLN_ISSUE_Q				Dep. Var. = CLN_ISSUE_Q		
iTraxx_P	-0.5482	0.0912	***	iTraxx_P	-0.0344	0.0754	
				NKY_AVG	0.0029	0.0024	
				JGB_5Y	0.1864	0.1816	
				RATING_CHANGE	-0.0051	0.0014	***
				LOAN_DEPOSIT	-7.7340	1.9530	***
MARK_TO_MKT	-1.5928	0.3578	***	MARK_TO_MKT	-0.3015	0.3610	
LIBOR_TREASUR3M	0.2538	0.0458	***	LIBOR_TREASUR3M	0.2565	0.0504	***
cons	24.2595	4.8671	***	cons	543.4174	154.0935	***
Obs.	348			Obs.	348		
LR chi2	124.48			LR chi2	22.42		
Prob. > chi2	0.0000			Prob. > chi2	0.0000		
Pseudo R-squared	0.0432			Pseudo R-squared	0.0575		
Log Likelihood	-1377.85			Log Likelihood	-1357.26		

Notes: ***, **, and * indicate statistical significance at the 1, 5, and 10% level, respectively. The dependent variable is either iTraxx or CLN_ISSUE. The left-hand side shows the second stage estimation results from Table 3. The right-hand side shows the results obtained from the OLS and Tobit estimations which regress either iTraxx or CLN_ISSUE on all the exogenous variables and either CLN_ISSUE or iTraxx.

Table 5: Ignoring the Limited Dependent Variable

Simultaneous equation considering LDV (from Table 3)				Simultaneous equation without considering LDV			
Second Stage	Coef.	Corrected Std. Err.		Second Stage	Coef.	Std. Err.	
Protection seller curve	OLS			Protection seller curve	OLS		
	Dep. Var. = iTraxx_P				Dep. Var. = iTraxx_P		
CLN_ISSUE_Q	1.5175	0.3606	***	CLN_ISSUE_Q	1.6407	0.3754	***
NKY_AVG	-0.0251	0.0041	***	NKY_AVG	-0.0256	0.0036	***
JGB_5Y	0.8902	0.4029	**	JGB_5Y	1.0014	0.3471	***
RATING_CHANGE	0.0270	0.0046	***	RATING_CHANGE	0.0266	0.0033	***
LOAN_DEPOSIT	25.3441	5.7413	***	LOAN_DEPOSIT	25.4084	4.4336	***
cons	-1664.6280	456.4465	***	cons	-1683.7840	350.7460	***
Obs.	348			Obs.	348		
F	255.34			F	91.42		
Prob. > F	0.0000			Prob. > F	0.0000		
Adj. R-squared	0.7856			R-squared	0.5420		
Root MSE	44.97			Root MSE	66.21		
Protection buyer curve	Tobit			Protection buyer curve	OLS		
	Dep. Var. = CLN_ISSUE_Q				Dep. Var. = CLN_ISSUE_Q		
iTraxx_P	-0.5482	0.0912	***	iTraxx_P	-0.3971	0.0790	***
MARK_TO_MKT	-1.5928	0.3578	***	MARK_TO_MKT	-1.0673	0.3337	***
LIBOR_TREASUR3M	0.2538	0.0458	***	LIBOR_TREASUR3M	0.2317	0.0632	***
cons	24.2595	4.8671	***	cons	27.3863	5.3824	***
Obs.	348			Obs.	348		
LR chi2	124.48			F	50.61		
Prob. > chi2	0.0000			Prob. > F	0.0000		
Pseudo R-squared	0.0432			R-squared	0.2691		
Log Likelihood	-1377.85			Root MSE	30.59		

Notes: ***, **, and * indicate statistical significance at the 1, 5, and 10% level, respectively. The dependent variable is either iTraxx or CLN_ISSUE. The left-hand side shows the second stage estimation results from Table 3. The right-hand side shows the results obtained from the two IV estimations without considering the limited dependent variable (i.e., CLN_ISSUE_Q) in the estimation.

Table 6: Comparison of Economic Impacts

Change in Exogenous Variable		Predicted change in iTraxx_P (bp)		
		Baseline	Single equation	Ignoring LDV
Δ1 std. dev. ↑ in	NKY_AVG	-24.6	0.0	-46.7
	JGB_5Y	9.7	0.0	20.3
	RATING_CHANGE	24.3	21.3	44.4
	LOAN_DEPOSIT	14.4	0.0	26.8
	MARK_TO_MKT	-21.2	-88.4	-15.5
	LIBOR_TREASUR3M	7.5	-9.3	7.5

Note: The column "Baseline" shows the predicted change in iTraxx_P in the case that each covariate increases by one standard deviation. The results are based on the estimated parameters in Table 3. The next two columns show the results of the same exercise based on the estimated parameters in Tables 4 and 5, respectively. All changes in iTraxx_P are measured in terms of bp.