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Market efficiency : testing price discovery in the bond and credit derivative markets

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Market Efficiency: Testing Price Discovery in the Bond and Credit Derivative Markets

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1) Introduction

Recent developments in credit markets over the past few months have seen credit spreads widen dramatically for a range of debt products. Almost overnight, credit spreads for both investment grade and high yield bonds jumped as news continued to worsen about credit quality. The speed with which credit spreads increased this past summer led many investors to ask if markets were efficient in conveying material information, and to see if there were any indications prior to the credit crunch that the market for credit was going to tighten. New products such as credit derivatives have increased the number of indicators investors can use to evaluate markets and subsequently increase the efficiency of these markets. However, credit derivative products are relatively new and have only recently begun to be traded extensively, thus it is yet to be seen how efficient the market for credit derivatives is and whether they can be used to anticipate credit events.

The relatively young age of credit derivatives means that there are still many things to be determined about their nature in the financial markets. Their effects may not be fully comprehended, but the market has embraced their use, as there are over $62 trillion dollars worth of notational credit derivatives outstanding today. This is more than half of the real assets in the world. Credit default swaps may seem to be a great way to diversify risk away and distribute it across the financial system, but they actually amplify risk. For example, if Ford issues one billion dollars worth of bonds and defaults with a recovery rate of 40%, $600 million dollars will be lost in the cash market. However, ten billion dollars worth of credit default swaps could be written on Ford and could amount to losses of over three billion dollars.

In a recent Wall Street Journal article (April 2008), it was estimated that should a major credit default player fail to meet their obligations, it could result in $36 to $47 billion dollars worth of losses across the financial system. Many of these contracts are intertwined among numerous market participants and thus have overarching effects should an event like this occur. The possibility of a large market player failing was almost realized when Bear Sterns was sold in March of 2008. JP Morgan assumed all of Bear's debts and obligations and therefore avoided a wide scale crisis that could have occurred if Bear Sterns had folded. One of the reasons that the Federal Reserve assisted in the sale of Bear was because it feared a reported $1.4 trillion dollars worth of derivatives on its books that, should Bear Sterns had failed, would have sent a shockwave to an already strained financial system. Therefore the study of credit derivatives is crucial to understanding how financial innovation can effect financial markets.

Much research has been conducted to decide if markets- whether equity or fixed income, are efficient in conveying information among investors. In the fixed income realm, most research has centered on whether bond prices and yields accurately reflect risks associated with the credit rating of corporations or specific bonds. In, " The Price and Adjustment Process of Bonds to Rating Reclassifications: A Test of Bond Market Efficiency" by Katz (1974), the author found that in the price adjustment process of bonds, there exists no price adjustment or signaling prior to the public announcement of rating reclassifications. Further, Katz found that there was a slight lag of approximately six to ten weeks in the adjustment process following the announcement, suggesting gross inefficiencies in the bond market. When compared with the more efficient equity market, Katz's research demonstrated that there was little institutional research being done to determine the proper credit level of bonds. He determined that the market relied primarily on rating agencies for that information, thereby creating this inefficiency in the bond market. Efficiency suffered at the time because there were very few market participants pursuing profit opportunities.

Since Katz's original study in 1974, bond markets have evolved so that they demonstrate characteristics of market efficiency much like their equity brethren. This is observed for a number of reasons including better access to information and the sharing of that information due to technology. More importantly, the profit opportunity in the fixed income market has grown exponentially from Katz's original study. It is evident in the explosion in size of the high yield market in the 1980's and the growing use of leverage and quant strategies by hedge funds in fixed income products. All of this has contributed to the growing number of participants in the fixed income market and solves the main issue that Katz identified, that the lack of players created an inefficiency.

Most important to the evolution of efficiency in the bond market, has been the creation of credit derivative products. Relatively new, these products tie their value to an underlying bond. One of these new products is Credit Default Swaps (CDS). Credit Default Swaps act like insurance policies for bond holders. An investor, who holds a bond, can also buy the CDS for that bond. If a bond issuer triggers any number of events, such as defaulting on interest payments or breaks a covenant, the seller of the CDS is obliged to pay par value for the bond to the CDS buyer in return for the underlying. The premium paid for this protection should reflect all risks associated with the bond and corporation. Similarly to how a bond's price should incorporate the risk of default, the premium charged by a credit protection seller should include those risks. Therefore, market efficiency should price CDS premiums and bond prices equally as they both incorporate underlying credit risks into their prices.

If inefficiency were to arise in the ability of one market to lead the other in price discovery, an arbitrage opportunity would exist. Price discovery is defined by Lehman (2002) as the efficient and rapid processing of information which passes through trade into market prices. When trading related instruments in two separate markets, price discovery is divided into these two markets and the market with the larger contribution to price discovery is said to lead the other.

2) Literature Review

Di Cesare (2006) studied the ability of credit default swap spreads, bond spreads, and stock prices to anticipate the decisions of rating agencies. Di Cesare used a data set of 42 international banks over the course of four years. He found that CDS spreads were relatively more efficient than option adjusted spreads (OAS) and stock prices in anticipating negative rating events. Heinke (2006) conducted research where he tested for significance in credit spread volatility of plain vanilla Eurobonds over a period of twelve years. Heinke calculated the spread volatility based on the holding-period approach over traditional yield to maturity methodology because that approach tends to overestimate values for downgrades and underestimate test values for upgrades. He found that credit spread volatility rises around the announcement of rating downgrades and falls around upgrades, suggesting market anticipation of rating announcements.

Hull, Predescu, and White (2004) conducted research that included 31 named reference entities for a period of four years. Their research centered on the ability of the credit default market to anticipate ratings announcements by looking at predetermined time intervals surrounding a ratings announcement. They found that there was a relationship between all three types of negative credit rating announcements and credit spread levels. They concluded that 42.6% of downgrades, 39% of reviews for downgrades, and 50.9% of negative outlooks came from the top quartile of credit default swap changes. However, Hull et al. and Micu, Remolona, and Wooldridge (2004) found that there is little statistical significance in market indicators prior to positive rating announcements.

Heinke (2006) also found that volatility was not only related to credit rating announcements, but also rose with market uncertainty and fell with liquidity. A recent report by the Wall Street Journal found for the high yield sector that several Dow Jones indexes based on derivatives started to sell off before an index tracking the cash market did this summer, indicating that the credit derivative markets foreshadow the cash market. Further work conducted by FitchRatings Research (2003) over the course of two years found that in the summer of 2002, CDS spreads widened ahead of negative rating announcements. However, they also widened without any announcements. This suggests that market indicators may either present false signals or other external factors may influence volatility besides market anticipation.

In a Bank of International Settlements paper, Zhu (2004) developed a theoretical model that predicts the parity of bond prices in the cash market versus those in the credit derivative market. He performed analysis on 24 reference entities over the course of three years. His analysis shows that pricing of risk in these two markets is equal, on average, in the long term. However, in the short term, he concludes that prices can vary significantly due to how each market reacts to changes in credit conditions. The credit derivatives market prices credit risk quicker than the cash market. In addition, his research shows significant market segmentation between cash and credit markets between the United States and Europe because of a more developed derivatives market. This suggests that derivates are a better tool at pricing credit rating changes and events than traditional cash markets for bonds. Further research by Blanco, Brennan, and Marsh (2005) and Di Cesare (2006) demonstrate that CDS lead the pricing of credit risk for investment grade bonds; that is, they anticipate credit events better than bond prices.

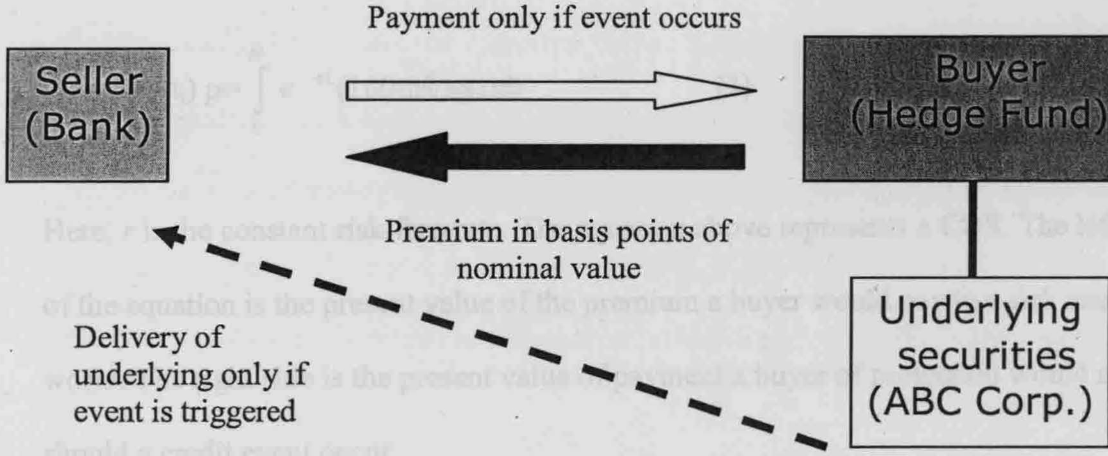
In a recent study, Dotz (2007) looked at 36 European firms of investment grade quality, using recent data from 2004-2005. He used similar measures of one market's ability to lead the other in price discovery, but his data was significantly better than past studies because the availability of accurate and liquid transaction prices was more prevalent during his study. He found, that out of his sample companies, markets were split in their ability discovery power. However, Dotz incorporated a time varying factor into his study that allowed him to track discovery power daily, rather than over a set period of time. He found that during a period of credit crisis, credit default swaps lose their pricing power.

Although prior studies have traditionally looked at investment grade bonds and whether market indicators have anticipated specific changes in ratings by rating agencies, this paper will test the price discovery power of credit derivatives for both investment grade and high yield bonds. This study will analyze the pricing of risk between cash and credit markets for bonds across both the investment grade and the high yield spectrum and test whether credit default swaps are a better anticipator at predicting credit events than cash prices. Zhu's theoretical model predicts equality in pricing of risk in the long term, but notes the deviation in short term pricing. Thus, by looking for a divergence in pricing across the credit and cash markets, this paper will be able to test whether one market enjoys an advantage in its ability to transfer pricing information more efficiently. The use of accurate data and a recent dataset should create more conclusive results than previous studies. The conclusion from this analysis will help determine if one product is a better measure of credit risk than the other, and give investors another tool to predict risk and potentially profit from.

3) Theoretical Model

Traditional cash markets for bonds have existed for quite some time. In the plainest sense, an investor can purchase any type of bond (sovereign, corporate, municipal) either at a discount or premium to the par price. The price in the cash market reflects several things including the default and credit risk associated with that particular bond, percentage yield on coupon payments and term premium among others. This paper focuses on the risk of the bond and the effect of risk on the price of a bond. If the risk of a particular bond were to increase, such as in the perceived default of a corporation's debt, the price for that bond would decrease as pressure from sellers would drive the price down.

Recently, credit default swaps have grown in popularity with the innovation of the credit derivative market. CDS are likened to insurance policies for bonds. An investor can purchase a CDS from a seller, protecting their investment in a particular bond by guaranteeing them in a number of default situations. Default events include but are not limited to: bankruptcy, failure to pay, obligation default or acceleration, repudiation or moratorium, and restructuring. Thus, CDS incorporate risk into their pricing similar to bond prices in the cash market. Therefore, premiums for CDS should be equal to the par fixed coupon bond in the cash market. An example of a credit default swap is included below:



In order to determine if CDS predict credit downturns before spreads in the cash market, existing models from Zhu (2004) and Hull et al. (2004) of CDS and credit spreads will be utilized. Zhu's model lays the theoretical framework that since there are no arbitrage conditions between CDS and bond price spreads, CDS premiums should be equal to the credit spread of a par fixed coupon bond for the same reference entity. That is to say, there is no profit in buying a risk-less bond, shorting a corporate bond and selling the CDS. Likewise, there would not be profit in buying a corporate bond, buying the CDS, and shorting the risk-less bond.

A CDS requires the buyer of protection to pay a premium (ρ) until the contract matures, (typically five years), or a credit event occurs. The payment upon a credit event is defined as the face value minus the market value (*Mt,)* for cash settlement. According to Zhu, a CDS buyer will pay premium (ρ) at time t1, t2,…tn, unless a credit event occurs. Similarly, a bond holder will receive a coupon payment, (*c*), at the same frequency. Also, define q(t) as the risk neutral default probability for the underlying asset at time, *t,* and Q(t) as the risk neutral survival probability until time *t*.. The premium for CDS should satisfy the following equation according to Zhu.

$$\sum_{i=1}^{N} e^{-rt_i} Q(t_i)\, p = \int_{0}^{N} e^{-rt} (100-M_t) q(t) dt \qquad (1)$$

Here, *r* is the constant risk-free rate. The equation above represents a CDS. The left side of the equation is the present value of the premium a buyer would pay in a risk neutral world. The right side is the present value of payment a buyer of protection would receive should a credit event occur.

Zhu uses the same risk neutral assumption in evaluating the current price of the defaultable bond in the cash market. It can be derived as follows:

$$P=100=\sum_{i=1}^{N} e^{-rt_i} Q(t_i) c + e^{rt_n} * 100 Q(t_n) + = \int_{0}^{N} e^{-rt} M_t q(t) dt \qquad (2)$$

In order to evaluate the no arbitrage theory, assume an investor shorts the defaultable bond and purchases a par fixed rate risk-less bond, with a coupon rate of *r*. According to Zhu's model, since the risk free rate is constant, the risk free bond can always be sold at par whenever the risky bond defaults. Thus the no arbitrage theory requires:

$$0=-\sum_{i=1}^{N} e^{-rt_i} Q(t_i) c - e^{rt_n} 100 * Q(t_N) - \int_{0}^{N} e^{-rt} M_t q(t) dt + \sum_{i=1}^{N} e^{-rt_i} r * Q(t_i) + \int_{0}^{N} e^{-rt} * 100 * q(t) dt + e^{rt_n} * 100 * Q(t_n)$$

$$\underline{=>} = -\sum_{i=1}^{N} e^{-rt_i} Q(t_i)(c-r) = \int_0^N e^{-rt}(100-M_t)q(t)dt \qquad (3)$$

The above equation on the right side highlights the value of the cash flows from shorting the risky bond and the last three items represent the value of cash flows from purchasing the par risk-free bond (Zhu 2004).When comparing this equation with the pricing formula of credit default swaps in (1), the following condition holds: $\rho=c-r$. Thus, CDS spreads should be equal to the credit spreads of the underlying security it is providing protection to. If this equation does not hold true, arbitrage opportunity would arise.

The above theoretical model is important because it provides the rationale that CDS and credit spreads in two different markets (cash and derivative) should be equal. If this model does not hold true, an arbitrage opportunity would arise and an investor could seize the opportunity to profit off of the price disparity. Further, a divergence from the equality of the two spreads reveals whether one, both, or neither of the pricing spreads offers insight into predicting credit events. The model holds in the equality of these two prices. A divergence of one from the other, preceding a credit event, may signify whether one market and/or price spread is more efficient at reacting to or predicting market information, or evaluating risk. To illustrate how a market participant could take advantage of a pricing discrepancy, the following table is included where y= the yield on the bond, r= the risk free rate and s = the CDS spread.

At Time T If s>y-r	CDS Premium greater
Short Underling	+ $100
Buy Treasury	- $100
Sell CDS on same underlying	-- (no cash outflow at sale)
At time T + 1 Collect Treasury proceeds	+ $110
Pay off CDS (assuming credit event)	- $100 (Receive underlying bond)
Replace underlying in short transaction	--(use bonds received from CDS transaction)
	Net = $10

If a market participant observed that the price of a CDS was indicating a higher probability of default than the cash market for the same underlying bond, a market participant could take advantage of this arbitrage opportunity. At time T, they could short the underlying security resulting in a cash inflow. Using the same proceeds, they could invest them in a risk free treasury security, and write protection on the same underlying name. At time T + 1, the treasury security would mature and it is assumed that at this point, a credit event occurred that triggered the credit default swap. The investor would redeem the treasury security, receiving the principal plus interest. In order to settle the CDS obligation, the investor would pay the counterparty par value using the treasury proceeds and receive the underlying bonds in return. They would then use the bonds received to replace the short transaction that was initiated at time T. The investor would then be left with the interest proceeds from the treasury security.

The presence of an arbitrage opportunity should force market powers to keep the two markets in equilibrium. If arbitrage were available, market participants would quickly seek them out and force prices to level off until the opportunity disappeared. Therefore, the equation that the CDS spread is equal to the yield on an underlying bond minus the risk free rate should hold true; but if it doesn't, the disequilibrium may signify how one market leads in price discovery power.

This model does present some limitations to the reality in which both of these markets exist. Although Zhu's theoretical model is correct in theory, external factors could affect the implementation of this transaction or adversely affect the accurate pricing of CDS. For example, there are two types of settlement options available to the writer of CDS, physical and cash settlement. Cash settlement would simply net the difference between par and market value of the underlying bonds. Physical settlement could be met by delivery of the actual bonds or any security with the necessary seniority in a major currency. This subsequently results in a "cheapest to deliver" option and contributes to CDS spreads being wider than bond spreads to offset the risk of receiving a less valuable bond.

When trading CDS, there is considerable counterparty risk, in addition to the underlying credit risk, that must be accounted for. Currently, there is no organized exchange or clearinghouse that guarantees trades. Therefore, each side to a credit default swap incurs counterparty risk into their transaction; the buyer bears a greater risk than the seller because if the seller does not follow through with their obligation, the buyer is out the par value of his bonds, whereas the seller can only lose the quarterly premium. This results in asymmetry of information and contributes to narrow CDS spreads.

4) Data

In order to find data that would be germane to the question, a relevant set of underlying companies was needed that had both actively traded bonds and credit derivatives. In order to satisfy this requirement, the Markit CDX index for high yield and investment grade names was chosen as a reference for possible companies. Markit is an independent company for credit derivative pricing that creates indices of credit derivatives such as credit default swaps. Both the high yield and investment grade index for credit derivatives were used as references for underlying companies to test because these names represent the most liquid and actively traded bonds and credit default swaps.

Liquidity is a key component of the study of credit default swaps because past research has faced constraints in the form of the availability of transaction data for CDS prices. Choosing liquid names helped ensure that transaction data would be available and that an accurate study could be completed. There are several different maturity lengths for credit default swaps ranging from one to ten years, but five year CDS are the most liquid instruments and thus all CDS data in this study are based off of that maturity.

Once reference names were selected, bonds needed to meet certain criteria. First, they needed to be option free. The presence of options could affect the price of a bond in a negative manner and not capture the same risk associated with the credit default swap. Thus, any bond with embedded options was removed. Second, the bonds selected must be the most senior issued. Again, if a junior or subordinated bond was chosen, the price could be negatively affected because of the incorporation of additional risk into its price.

Finally, because five years was chosen for the maturity length for CDS, it was necessary that bonds with a five year maturity were chosen to capture the same term structure of the CDS. Bonds with maturities of 4.5 to 5.5 years left till maturity were therefore selected. This does present the possibility that some of the bonds may not be as liquid because they could be towards the end of their maturity and are not traded as much. Some researchers have used linear interpolation to create a synthetic five year bond by using both a short and long dated bond of that reference name; however, this method was not incorporated in this study.

After defining the above selection criteria, 80 companies, (49 investment grade and 31 high yield names) were selected. The transaction data was downloaded from Thompson Datastream that has an extensive financial database based on trades from market makers. Both sets of data are daily quotes settled at the end of the trading day. There are 348 observations spanning a time span from November 1, 2006 to February 29, 2008. This time period does include the volatile period that began in the summer of 2007.

The quotes for credit default swaps are represented by the mid point of the bid-ask spread. The increase of liquidity shrank the spread between the bid-ask prices for CDS making the mid point measure a good indicator of price. For bonds, a credit spread was calculated based on the difference between the yield on the bond chosen and the swap rate. The swap rate is chosen as the risk free rate over other benchmark yields because swaps are very liquid while other benchmark curves can be distorted by market operations, such as repo transactions.

5) Econometric methods

In order to determine whether one of two markets for the same underlying reference leads the other in price discovery, the long-term consistency and short-term dynamic connections of both markets need to be analyzed. The credit and cash markets constitute time series and thus demand special consideration when running econometric tests. One of the main problems when dealing with econometric time series is that they are often non-stationary.

If a time series is non-stationary, its behavior can only be studied during that one particular instance for which data is available. It would not be possible to use the conclusions made from that data set to draw generalities about that markets. Therefore, in order for time series to be relevant in this research, it must be covariance stationary. Its mean and variance must be constant over time and the value of the covariance between the two time periods must depend only on the distance or lag between the two time periods and not the actual time at which the covariance is computed. To solve this problem, non-stationary time series can become stationary by taking the first order difference of the time series. This process enables the results to be interpreted and applied to these markets in general, outside of this time period alone.

In addition to the stationary problem, it needs to be determined if both time-series are cointegrated, meaning they have a long-term or equilibrium relationship. It would not be surprising to find that both of these markets price credit risk the same in the long-run considering that market forces would eventually push prices to market equilibrium in the long-term

It is important to note that for purposes of this study, it was assumed that the data included for each reference name were non-stationary and cointegrated. Past research tested the data to see if it was stationary and cointegrated and in all the cases, it was. Based on these results and consistency, these tests were not performed in this study, but measures were taken to correct for them, assuming they were present.

The next step in the process is to determine the short-term dynamic connections between the two time series. Using the assumption that these time series are cointegrated in the long run, the disequilibrium between the two time series must lie in the short term and provide insight on what market is more efficient in reflecting changes in the credit risk of the underlying securities. An error correction model (ECM) can correct for disequilibrium based on the Granger Representation Theorem, that states if two variables, *Y* and *X*, are cointegrated, the relationship between the two can be expressed as an ECM.

6) The Vector Error Correction Model (VECM)

Using the Granger Representation Theorem, a VECM model can be incorporated in order to tie the short term behavior with the long-run through the error term, by correcting for the disequilibrium. This process will provide for a direct answer to the causality relationship. Therefore, the following model adapted from Hull et al. (2004), was used in testing the relationship between the two markets:

$$\Delta\rho_{cds,t} = \lambda_1(\rho_{cds,t-1} - \alpha_0 - \alpha_1\rho_{cs,t-1}) + \sum_{j=1+}^{\rho} \beta_{1j}\Delta\rho_{cs,t-j} + \sum_{j=1}^{\rho} \sigma_{1j}\Delta\rho_{cs,t-j} + \varepsilon_{1t}$$

$$\Delta\rho_{cs,t} = \lambda_2(\rho_{cds,t-1} - \alpha_0 - \alpha_1\rho_{cs,t-1}) + \sum_{j=1+}^{\rho} \beta_{2j}\Delta\rho_{cds,t-j} + \sum_{j=1}^{\rho} \sigma_{2j}\Delta\rho_{cs,t-j} + \varepsilon_{2t}$$

In this equation, cds_t *and* cs_t represent CDS spreads and bond spreads respectively at period t. $\Delta\rho_{cds}$ and $\Delta\rho_{cs}$ represent the difference of the CDS and bond spread respectively and the two terms, while ε_1 and ε_2 are independent, identically distributed shocks. The two lambdas in the equation, λ_1 and λ_2 are the estimated coefficients that are to be determined. These will indicate how quickly CDS and/or credit spreads for bonds re-converge to the long-run relationship after a shock or deviation in the market.

This model solves several of the problems identified earlier when dealing with time series data. The two equations in the model are in first-order difference and therefore solve the problem that non-stationary data create. In addition, the model also includes a lagged basis spread term, where $\alpha_0 = 0$ and $\alpha_1 = 1$, that provides for an added explanatory variable to explain changes in credit spreads. Without this term in the equation, the cointegrated system estimated would be over differenced.

Finally the ρ term in the model represents the number of lags that were included in the short term equation of the full model. The selection of lags was determined using the Akaike (AIC) criteria by including many lags at first, and running regressions on six different entities as a sample. The initial test included all of the lags at once to determine which lag length had the lowest AIC criteria. It was determined that eight lags was the appropriate length, and thus data from eight trading days before time *T* were used in the model for all names.

Once the appropriate lag length was found, regressions were run for all 80 of the underlying companies. As described earlier, λ_1 and λ_2 were the estimated coefficients used to determine how fast CDS or bond spreads would reconverge. In this study, a significant and positive λ_1 (negative λ_2) would indicate that the CDS market moves to correct price discrepancies ahead of the bond market.

In addition to the information the lambdas provide, an additional measurement variable was included called the Gonzalo-Granger (GG) measure. This reflects the contribution of each market to price discovery. It can be defined as the ratio of the speed adjustment in the two markets, given by the equation:

$$GG = \frac{\lambda_1}{(\lambda_1 - \lambda_2)}$$

The upper and lower bounds of this equation are 0 and 1. A measurement greater than 0.5 indicates that the CDS market leads in price discovery of the underlying reference, with increasing pricing power as the measurement moves towards 1. A measure less than 0.5 indicate that the pricing power lies within the cash or bond market for the reference entity. When the measure is 0.5, this indicates that both markets contribute to the price of the bond equally and one market has no clear advantage than the other.

7) Results

The results are included in the appendix of this paper and include the significance levels for each lambda and the Gonzalo-Granger measurement for each company. To summarize, there were 49 investment grade companies used in this study. For all but five of them, the credit default market led in terms of price discovery. The average GG measures 0.677, indicating the credit derivative market's advantage in pricing power. In the high-yield market, all but five of the 31 companies studied indicate that the bond market had pricing power over the credit derivative market. The average GG measure for all of the high yield companies was 0.25, a strong indicator that the cash market leads price discovery for high yield names.

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These results indicate that credit default swaps are more efficient at price discovery in the investment grade market and that the bond market retains this power with high yield companies. Prior studies have not tested high yield names for price discovery and thus there is no past research to compare to, but the results are not surprising. The ability for credit default swaps to lead in price discovery relies on the fact that there is an active and liquid market for credit derivatives to have price efficiency. This may not be true for high yield companies as their probability of default increases. Market participants may not want to write credit default protection for companies with a high certainty of default, or may simply price it so high that it would not realistically be purchased.

Further, market participants in CDS not only trade the underlying credit risk of the named company, but also trade counterparty risk as described earlier. Currently, there are no organized exchanges for CDS. They are traded over the counter and largely rely on the reputation of parties involved. A recent Wall Street Journal article published in April 2008 highlights the potential creation of a clearinghouse for CDS in the second half of 2008. The creation of a clearinghouse that would guarantee trades would remove some of the uncertainty that is associated with counterparty risk and could potentially increase the liquidity for the high-yield market as some of the risk factors were removed. The increase of liquidity could lead to the increased ability of CDS to lead in price discovery for the high yield segment.

Another factor that can influence the discovery power of a market is the size of bond issuance and/or the distribution of that issuance throughout the market. Credit default swaps can be used by hedgers and speculators, and thus can write as many contracts as they can find counterparties to. On the other hand, bonds are restricted by the issuance size and can be influenced depending on if one buyer holds a large proportion of that debt. For example, there may be 100 million dollars worth of CDS written on a company, but there might only be a 10 million dollar bond issuance. This may limit the cash market's ability to serve as an indicator of price efficiency because there is a small notational amount outstanding, and/or one investor could have a significant holding. Investors may also hold bonds until maturity, which can affect the information processing component of the market. On the other hand, the nature of CDS allows large amounts of protection to be written and traded, allowing for CDS to reflect default risk more quickly. This could explain in some instances why the CDS market is a better indicator than the cash market.

Credit default swaps are not perfect though. Currently, there are five or six main players in the credit derivatives market. Thus, these products are highly concentrated and may contribute to inaccurate pricing of CDS because of this concentration. This can put a large strain on liquidity, especially during times of crisis as discovered by Dotz (2007).

Until this summer, investment banks were the only ones who could truly diversify the risk created by selling CDS and provide a liquid market for CDS that others could not. For example, when collateralized debt obligations (CDO) were popular, investment banks could create a synthetic CDO out of credit default swaps they had written. They were able to write protection on companies but securitize these obligations and sell them, removing the liability off of their books. This process had a negative impact on CDS premiums. But as the subprime crisis runs course, the absence of the ability to issue CDO may put more positive pressure on CDS prices than before. These net affects have not fully been incorporated into this study because of the timing of the data set used, but it must be considered that the potential for pricing power could alter significantly in subsequent years.

8) Conclusion

This paper built upon past studies examining the price discovery power of the bond and credit derivative markets for bonds. Incorporating techniques developed earlier, this study attempted to discover which market was more efficient at transferring information to market participants for both investment and high yield companies. In addition, it used a recent data set (November 1, 2006, to February 29, 2008) of domestic bonds. The results of the analysis show that for investment grade companies, the credit derivative market is more efficient in incorporating risk into the market in all but five companies. For high yield companies, the reverse is true and the cash market is more efficient in all but five cases as well. The results are not that unexpected considering that the investment grade market for credit default swaps may be more liquid as far as trading and number of contracts outstanding relative to the high yield market.

In a final note, this study incorporated data from the turbulent summer of 2007 that sent both credit and CDS spreads into uncharted territory as the market suddenly re-priced all aspects of credit from ultra safe to junk bonds. Although the data set was chosen to include a substantial time span of a relatively normal market environment beforehand, the full effect of the credit crisis of 2007 on this study is not fully known. Research based on the credit crisis of 2005 by Dotz suggests that CDS would lose its price discovery power in times of crisis, but things may have changed significantly since then. For one, the liquidity of the CDS market has greatly increased since then and the credit derivative market domestically was already more developed then that of its European counterpart. Nonetheless, potential for further study would include converting the existing VECM into a state space form and estimate it with time varying factors using a Kalman filter. This would enable us to track the price discovery power of each market over a daily measurement, to see what exactly happened to the discovery power this past summer in the credit derivative markets, and see how CDS hold up in the face of a market wide credit crisis.

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Appendix

Market Efficiency: Testing Price Discovery in the Bond and Credit Derivative Markets.

#	type	Company	λ 1	λ2	GG	Market
1	0	ALCOA INCO.	0.023 (1.42)	0.208*** (-6.92)	0.898	CDS
2	0	ALLSTATE CORP.	0.024** (2.26)	-0.052** (-2.50)	0.68	CDS
3	0	ALTRIA GROUP INCO.	0.055*** (5.67)	0.243*** (5.77)	1.297	CDS
4	0	AMER.EXPR.CR.CORP	0.022** (2.36)	-.059*** (-5.26)	0.724	CDS
5	0	ARROW ELECTRONICS	0.023* (1.89)	0.113*** (-4.24)	0.825	CDS
6	0	AUTOZONE INCO	0.058*** (4.00)	-0.152*** (-4.80)	0.722	CDS
7	0	BAXTER INTL.INCO.	0.077*** (4.84)	-0.100* (-1.94)	0.562	CDS
8	0	BELO CORPORATION	0.067*** (4.74)	0.103*** (-4.17)	0.605	CDS
9	0	BOEING CAP.CORP.	0.036*** (2.68)	0.336*** (-4.52)	0.901	CDS
10	0	CAMPBELL SOUP CO.	0.079*** (6.00)	0.145*** (-3.43)	0.647	CDS
11	0	CAPITAL ONE BANK	0.129*** (6.10)	0.134*** (-4.73)	0.509	CDS
12	0	CIT GROUP INCO.	0.118*** (6.21)	-0.047*** (-3.24)	0.285	CS
13	0	CHUBB CORP.	0.059*** (3.87)	-0.083*** (-3.23)	0.585	CDS
14	0	COMCAST CAB.COMMS.	0.064*** (3.76)	-0.075** (-2.57)	0.541	CDS
15	0	CMP.SCIS.CORP.	0.012 (1.47)	-0.003 (-0.16)	0.209	CS
16	0	CONOCOPHILLIPS	0.064*** (6.22)	-0.219*** (-6.14)	0.771	CDS
17	0	CONSTELLATION EN.GP	0.031* (1.88)	-0.165*** (-5.71)	0.839	CDS
18	0	COX COMMS.INCO.	0.063*** (4.09)	-0.129*** (-4.68)	0.672	CDS
19	0	CVS CORP.	0.072*** (4.43)	-0.136*** (-3.55)	0.652	CDS
20	0	DEERE J CAP.CORP.	0.032*** (2.94)	-0.260*** (-7.65)	0.887	CDS
21	0	DOMINION RES.INCO.	0.08*** (4.55)	-0.148*** (-3.46)	0.648	CDS
22	0	DUKE ENERGY CORP.	0.042*** (2.91)	-0.165*** (-4.50)	0.795	CDS
23	0	DU PONT DE NEMOU	0.076*** (5.85)	-0.273*** (-6.59)	0.781	CDS
24	0	EASTMAN CHEM.CO.	0.109*** (7.10)	-0.201*** (-6.17)	0.648	CDS

25	0	GANNETT CO.INCO.	0.093*** (6.21)	-0.110*** (-5.45)	0.54	CDS
26	0	GEN.ELEC.CAP.CORP.	0.03*** (5.25)	-0.025** (-2.12)	0.454	CS
27	0	HARTFORD FINL.SVS.	0.042*** (3.30)	-0.045*** (-2.88)	0.519	CDS
28	0	IBM CORP.	0.04*** (3.84)	-0.192*** (-5.14)	0.825	CDS
29	0	INTL.PAPER CO.	0.05*** (4.53)	-0.156*** (-5.60)	0.756	CDS
30	0	KRAFT FOODS INCO.	0.053*** (3.90)	-0.190*** (-5.18)	0.781	CDS
31	0	KROGER	0.029** (1.99)	-0.144*** (-4.10)	0.831	CDS
32	0	LOCKHEED MARTIN	0.025** (2.42)	-0.104** (-2.34)	0.805	CDS
33	0	MARSH & MCLENNAN	0.039*** (2.69)	-0.065*** (-3.13)	0.623	CDS
34	0	MCDONALDS CORP.	0.044*** (5.24)	-0.170*** (-5.47)	0.794	CDS
35	0	MCKESSON	0.074*** (4.94)	-0.032 (-0.91)	0.3	CS
36	0	MEADWESTVACO CORP	0.106*** (5.59)	-0.196*** (-5.72)	0.649	CDS
37	0	NEWS AMERICA INCO.	0.046*** (3.81)	-0.142*** (-3.08)	0.752	CDS
38	0	NORFOLK STHN.CORP.	0.057*** (3.79)	-0.158*** (-3.74)	0.733	CDS
39	0	QUEST DIAGNOSTICS	0.144*** (7.64)	-0.061*** (-3.69)	0.297	CS
40	0	RAYTHEON CO.	0.045*** (3.59)	-0.193*** (-4.31)	0.81	CDS
41	0	SAFEWAY INCO.	0.052*** (3.39)	-0.175*** (-4.79)	0.769	CDS
42	0	SEMPRA ENERGY	0.033*** (3.16)	-0.050*** (-1.84)	0.596	CDS
43	0	SOUTHWEST AIRLINES	0.044*** (3.21)	-0.119*** (-3.89)	0.727	CDS
44	0	STARWOOD HTLS.RSTS.	0.062*** (3.73)	-0.069*** (-3.21)	0.526	CDS
45	0	TIME WARN.ENTM.CO.	0.044*** (3.29)	-0.103*** (-3.84)	0.698	CDS
46	0	WASH.MUTUAL INCO.	0.319*** (13.88)	-0.338*** (-9.84)	0.514	CDS
47	0	WEYERHAEUSER	0.14*** (6.40)	-0.146*** (-4.85)	0.51	CDS
48	0	WYETH	0.036*** (2.58)	-0.176*** (-3.82)	0.828	CDS
49	0	WHIRLPOOL CORP.	0.015* (1.66)	-0.100*** (-4.74)	0.864	CDS

		Average			**0.677**	
		High Yield Bonds				
50	1	AMD.INCO.	0.123*** (4.85)	-0.063** (-2.52)	0.34	CS
51	1	AES CORP.	0.051*** (3.10)	0.004 -0.29	0.107	CS
52	1	ALLEGHENY EN.SUP.	0.058*** (2.99)	-0.142*** (-3.79)	0.708	CDS
53	1	ALLTEL CORPORATION	0.069*** (3.41)	-0.038* (-1.72)	0.357	CS
54	1	AMR CORPORATION	0.034*** (3.14)	0.003 -0.69	-0.1	CS
55	1	CHESAPEAKE ENERGY	0.031* (1.66)	-0.033 (-1.36)	0.517	CDS
56	1	CITIZENS COMMS.CO.	0.097*** (3.71)	-0.077*** (-2.62)	0.441	CS
57	1	CLEAR CHANNEL	0.075*** (4.71)	-0.016 (-1.17)	0.177	CS
58	1	CSC HDG.INCO.	0.048 (2.49)	-0.046** (-2.90)	0.489	CS
59	1	DILLARDS INCO.	0.032*** (3.09)	0.009 -1.32	0.449	CS
60	1	DOLE FOOD INCO.	0.103*** (5.29)	-0.005 (-0.55)	0.054	CS
61	1	EASTMAN KODAK CO.	0.03** (2.33)	0.003 -0.25	0.121	CS
62	1	EL PASO CORPORATION	0.08*** (4.18)	-0.113*** (-3.82)	0.583	CDS
63	1	FIRST DATA CORP.	0.005 (1.10)	0 -0.17	- 0.197	CS
64	1	FORD MOTOR COMPANY	0.134*** (6.51)	0.011 -0.9	0.094	CS
65	1	GENERAL MTRS.CORP.	0.123*** (6.23)	-0.003 (-0.22)	0.025	CS
66	1	HCA HEALTHCARE CO.	0.103*** (4.92)	-0.001 (-0.07)	0.016	CS
67	1	K HOVNANIAN ENTS.	0.192*** (7.14)	-0.085*** (-3.52)	0.307	CS
68	1	KB HOME	0.04** (2.22)	-0.007 (-0.28)	0.149	CS
69	1	MEDIACOM	0.037*** (2.68)	-0.027* (-1.87)	0.424	CS
70	1	MGM MIRAGE INCO.	0.034** (2.05)	-0.023 (-1.27)	0.404	CS
71	1	QUEBECOR WORLD CAP.	0.503*** (16.09)	0.124*** -8.04	0.328	CS
High Yie72	1	QWEST CAP.FDG.CORP.	0.052** (2.52)	-0.070** (-2.37)	0.574	CDS
73	1	RADIOSHACK CORP.	0.064*** (4.42)	-0.041** (-2.01)	0.39	CS

			0.059***	-0.041***		
74	1	RITE AID CORP.	(2.67)	(-3.21)	0.406	CS
			0.119***	-0.055***		
75	1	ROYAL CRBN.CRUISES	(5.79)	(-2.80)	0.315	CS
			0.054***	-0.01		
76	1	SMITHFIELDS FDS.	(3.11)	(-0.61)	0.159	CS
			0.113***	-0.068**		
77	1	STANDARD PACIFIC	(4.97)	(-2.11)	0.377	CS
			0.235***	-0.047**		
78	1	TOYS R US INCO.	(6.73)	(-2.18)	0.168	CS
			0.016*	0.005		
79	1	UNITED RENTALS	(1.90)	-0.75	-0.49	CS
			0.045***	-0.03		
80	1	WILLIAMS CO.INCO.	(2.62)	(-1.16)	0.402	CS
		High Yield Average			**0.251**	

***, **, * denote 1%, 5%, &10% respectively.

GC values > 1 (or negative CG values) were set to 1 to calculate the average (or equal to 0).