US Corporate Bond Yield Spread: A default risk debate·

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Abstract

According to theoretical models of valuing risky corporate securities, risk of default is primary component in the overall yield spread. However, sizable empirical literature considers it otherwise by giving more importance to non-default risk factors. Current study empirically attempts to provide answer to this question by presuming that problem lies in the empirical measurement technique. By using *post-hoc* estimator approach of Lubotsky & Wittenberg 2006, we construct an efficient indicator for risk of default, by using sample of 252 non-financial US corporate data. On average, our results manifest significantly that potential problem lies in the ad-hoc measurement methods used in existing empirical literature.

JEL Codes: G12, G14, C1, C30

Keywords: Default risk, credit spread, risk-aversion, measurement error, index construction

1) Introduction

Importance of identifying and studying corporate bond yield spreads (hereafter yield spreads) into interpretable factors is justified by the size of the US corporate bond market reaching almost $ 13 trillion.[1] Besides, the significance of understanding plausible components of yield spread is vital for academics and policy makers in order to better regulate the financial (non financial) institutions. Further, the magnitude of different components of the yield spread render important information for assessing and predicting overall risk factors for corporate and market as whole.

Recent financial crisis, in addition, has led the regulators to increase their attention towards controlling the credit risk[2] component of the overall corporate structure of financial institutions.[3] On the other hand, yield spread also provides support in evaluating whether potential and existing investors are adequately compensated for the risk they are bearing or not, particularly in the period of poorer economic outlook which in turn correlated with likelihood of lower-wealth situations invigorating reduce willingness to bear and hold risk by risk-averse investors.

This aporia leads theoretical financial economists[4] to devise efficient methods to adequately value the risky nature of the corporate securities. The way theoretical models price these corporate debt securities depends fundamentally upon their related credit risk. In particular, gauging the default uncertainty linked to such securities and assuming risk of default as the profound component in the overall risk premium requirement by risk-averse investor.

On the other hand, extensive empirical literature on the issue[5] finds it practically arduous to accept this conjecture. Stated differently, sizable empirical work in the field do not come across to find the presence of default risk factor as a major proponent in the overall yield spread of the risky corporate securities.

The purpose of this paper is try to fill this gap by conjecturing that the problem lies in the adhoc measurement techniques employed by existing empirical literature. This

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[1]See « Sharing experiences in developing corporate bond markets », Dinner remarks by Malcolm Knight, General Manager of the BIS, at the "Seminar on developing corporate bond markets", organised by the People's Bank of China, Kunming, 17-18 November 2005.
[2]we will use terms of credit risk, default risk and risk of default interchangeably in this paper and will define it in the next section
[3]See, « Credit risk models and management » 2nd Edition, Section 3, David Shimko; « What do we know about loss given default » by Til Schuermann.
[4] See, Black and Scholes (1973), Merton (1974), Black and Cox (1976), among others
[5] Elton et al (2001), Collin-Dufresne et al (2001), Deliandis and Geske (2001), Huang & Huang (2003), Tsuji (2005), among others

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work, following Lubotsky & Wittenberg (2006), attempts to construct an optimal indicator for our variable of interest—default risk, by broadening its scope including explicit (direct) and implicit (implied) factor proxies in this regard.

The main attribute of current empirical study is that it strives to combine the information from micro level factors and macro level factors to gauge the change in the risk perception of risk-averse investor on default risk of risky corporate securities.

Thus a sample of 252 US corporates (non-financial) is being used to cater firm-specific risk of default factors and the factors effecting default risk due to macroeconomic uncertainty to construct an efficient indicator. Our results, significantly, validate the surmise of treating default risk as a cornerstone in the valuation of risky corporate debt securities. And conclude that indeed potential solution for this progressing debate lies under effective measurement of risk of default perception of risk-averse investor.

The rest of the paper is organized as follows. Next section delineates briefly theoretical and empirical literature on the issue. Section 3 defines risk of default; its explicit and implicit factors. Section 4 outlines the methodology and data used in the study. Empirical result analysis with limitations is presented in Section 5. Finally, Section 6 sums up the main findings and concludes the work.

2) Literature Review

Extensive literature exists on the issue explaining the probable components of the corporate bond yield spread. Historically these components divide the literature into two main categories; risk of default and the residual risk premium attributing to non-default factors (Fisher 1959). But with the advent of option pricing formula of Black & Scholes (1973), new horizon emerges to value the risky corporate liabilities. They work on the premise as to how to cater the existing uncertainty present in valuing the price of a risky corporate security. So in an attempt to eliminate this uncertain nature, (which we call "risk"), of these risky securities (i.e. options), they found that the price of the equity security is determined by investor's expectation and so does the price of its option. Hence they conclude that by separating the risky nature (i.e. the uncertainty) of the asset they will leave with that combination of asset which will have no risk (i.e. no expectation for uncertainty). In other words, due to this investor is able to rightly price the risky option contracts along with the equity stocks (or debt securities) to render riskless investment for hedging their risk.

On the basis of this insight, Robert C. Merton (1974) gives contingent claim theory by evaluating the credit risk of corporate debt as a function of call option on its equity securities. Thus the fundamental principle behind this work is that risk could be priced as long as investor holds position in the risky corporate event (for example; stock, bond) and in the security on that uncertainty (i.e. in such security's option contract). Hence, in his seminal work on the pricing of risky corporate debt, Merton (1974) mainly focuses to incorporate the corporate debt valuation process on the basis of risk of default and non-stochastic interest rate. Later, Black and Cox (1976), Longstaff and Schwartz (1995), among others,[6] also treat risk of default as their primary pillar in deriving their new valuation models incorporating and relaxing assumptions[7] made by Merton Model to value corporate securities. In addition, succeeding literature, in a similar vein incorporates additional factors in their valuation models such as business cycle, liquidity, transaction costs to increase the capability to produce more realistic predictions of the overall corporate yield spread (Longstaff, Mithal and Neis (2005), Couderc, Renault, Scaillet (2007)).[8]

Despite the immense effort made by the theoretical authors in treating risk of default as the primary focus for valuing risky corporate securities, most empirical work do not confirm on their premise to give key weight to the risk of default as the major component of the yield spread. Elton et al (2001), a pioneer empirical work in disentangling the determinants of corporate yield spread show that expected default loss (risk of default proxy) do not contribute to the overall yield spread more than 25 percent. Among many others, Jones, Mason and Rosenfeld (1984), Collin-Dufresne et al (2001), Delianedis and Geske (2001), Huang and Huang (2003), Tsuji (2005), Liu et al (2009), also show that, in general, risk of default does not contribute majorly in explaining the overall yield spread as compared to the other non-default factors.

On the other hand, Hattori, Koyama and Yonetani (2001), Nakashima and Saito (2009) in the case of Japan, whereas King and Khang (2005), Churm and Panigirtzoglou (2005), and Tang and Yan (2010) in the case of USA, empirically support the theoretical school of thought provided by Merton and show that the risk of default explain major portion in the yield spread.[9]

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[6] See Chance (1990), Duffie (1999), Leland and Toft (1996), Ericsson and Renault (2006), Liu et al (2009)

[7] Merton (1974) assumes firm will default only when they fully exhaust all their asset value and include constant interest rate in his valuation model.

[8] List is not exhaustive

[9] However, the empirical work is sparse in this respect.

Lack of consensus, theoretically and empirically, in treating risk of default as a major determinant in the yield spread spur the question; Why risk of default is not being proven empirically as a major component in explaining the yield spread?. The answer to this question is the primary objective of this study which in turn helps to better understand empirically the importance of default risk premium and support investors to proactively manage their overall portfolios.

We argue, in this paper, that from a simple investor-borrower relationship it is evident that a potential risk-averse investor when invest in any risky security (such as corporate debt), they expect (minimum) to replicate their required return, over a specific time horizon, as investing in a risk-free security. In particular, one of the main concerns for the investor is of the risky nature of the security for which they ought to be satisfied through the inclusion of default risk premium with other non-default related return. Therefore, the greater a security's risk of default, the greater its default premium should be (Sharpe, Alexander and Bailey 1999).[10] Stating differently, we suggest that, in reality, risk-averse investor assign more weights to economic outcomes where the level of wealth is low especially in the period of economic downturn and in a similar vein he/she will assign higher weights to financial market outcomes in the periods of turmoil. Along with assigning adequate weights to any particular industry or firm outcomes where there is fluctuation in their overall operational activity. Thus a risk-averse investor penalizes the expected rate of return of a risky portfolio by a certain percentage to account for the risk involved (Bodie, Kane and Marcus 2009).[11] In particular, stimulus for our surmise comes from the general risk-averse investor expected utility[12] hypothesis that they are primarily focused on to optimize the utility of their investment i.e. they want to be adjusted for any change in their perception of risky corporate debt security.

Hence, we conjecture that this controversial issue of empirically lacking to accept risk of default as a major proponent for the yield spread is mainly due to the measurement error induced by the usage of different nature of ad hoc proxies used in the literature. Which in turn undermine the true effect of the risk of default on investor's expected perception of overall yield spread premium. Therefore, we

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[10]See, « Investments », Fifth Edition, William F Sharpe, Gordon J. Alexander and Jeffrey V. Bailey (page 447)

[11] See "Investments", Eigth Edition, Zvi Bodie, Alex Kane and Alan Marcus, 2009 (pg 158)

[12] See "The Theory of Money", Jürg Niehans, The John Hopkins University Press, Baltimore and London, 1978 (pg 30)

hypothesize that the investor's perception of risk of default is a function of more than the ad-hoc proxies utilized in the previous empirical work.

Elton et al (2001) employ recovery rate and transition probability matrix (i.e. the expected default loss factor) in order to formulate the effect of risk of default in the yield spread. Further they built their rating transition probability matrix on the credit ratings for each class of corporate debt. We argue that in order to evaluate the optimal effect of risk of default in the overall formulation of yield spread one should follow the holistic view with emphasizing not only on the information from the financial market but also giving weights to the firm specific factors and more importantly macro economic factors that reflect the change in perception of the investors for the corporate risk of default. Since, the transition probability matrix focused by Elton et al. to find the marginal default probabilities only caters the change from one rating class to another over a period of one year; the main attention is given only to include the change in the ratings which do not delineate the true-effect of the risk of default. In addition, the historical and lagged nature of credit rating lacks to present the true merit of risk of default for the corporate risky debt. Thus focusing on credit ratings only is not optimal measure of default risk (Hilscher and Wilson (2010)). Therefore relying solely on the firm-specific information to explain the portion attributed to the risk of default leads to under estimation of the overall effect of default risk in the yield spread. On the other hand Nickell, Perraudin, and Varotto (2000) in quantifying the dependence of rating transition probabilities show that different stages in business cycle (peak and trough) significantly explains the differences in default probability levels implying that economic activity significantly affects the frequency of corporate defaults and hence should be given due consideration in the overall formulation of expected premium from the risk of default.

Similarly, analyzing the effects of determinants of credit spread changes, Collin-Dufresne et al (2001), find that change in the probability of future defaults and change in recovery rate only accounts for one-quarter of the total change in the yield spread. In fact they indifferently define the credit spread as the function of the risk of default and instead treat it as the overall corporate yield spread. This empirically obscure the explaining power of the default risk factor just to 25 percent; which inhibits the true effect of the risk of default in explaining the overall yield spread.

Likewise, in the context of Japan, Tsuji (2005) conclude the same result by limiting the credit risk determinants, implied by theoretical models, just to distance to

default, stating that this variable explain little in the overall formulation of yield spread. Whereas what we argue is that, it is inadequate to limit the explanatory power of the effect of credit risk just to the prominent factors, instead we should also, ideally, include the latent factors relating to the risk of default i.e. part of that economic and financial variables which generates or causes change in the overall risk of default perception of risk-averse investor for the optimal formulation of expected required return from the risky corporate securities.

Therefore, we, in this paper, suggest that in order to optimally evaluate the effect of credit risk in the overall formulation of the yield spread one should adequately define the default risk. To serve this purpose, we define risk of default as a function of explicit factors and implicit or latent factors associated to the default perception of the risk-averse investor to efficiently gauge its true effect on the yield spread. Here we include the implicit factors in defining the risk of default because it will not be unfair to say that most of the existing literature on this issue limits their scope of defining the risk of default to just some of the ad hoc explicit factors (i.e. the prominent factors suitable to the ad hoc situation to define risk of default such as distance to default, and expected default loss) which is inconclusive. Thus it basically ignores the effect of the other explicit factors and the factors that are dormant in the overall economic and financial determinants. In particular, this causes change in the risk-averse investor's perception of formulating the expected risk premium due to default risk in their overall required return from investing in the risky corporate securities.

3) Default Risk

By convention there is no standard definition of what constitutes a risk of default. [13] Most of the time in the existing literature, risk of default, is being defined for ad-hoc purpose. In order to streamline the optimal effect of risk of default we define it as a "function of possibility of default with occurrence of default event due to any financial, economic and or firm-specific factor." There are two aspects of this definition; first, the probability of default and the second, occurrence of default event. The probability of default is defined as "the perception of risk-averse investor of the likelihood of default of risky corporate borrower." In general, investor's perception of the likelihood of default is lower for investment grade securities as compared to non-

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[13]See, "Credit risk models and management" 2nd Edition (2004), Section 3, David Shimko: « What do we know about loss given default » by Til Schuermann.

investment grade, but it cannot be obliterated. In particular, we quantify the risk of default into two types of uncertainty; one, regarding the likelihood of failure of a certain corporate bond security investor holds, and other, the uncertainty of the remaining corporate bond issues, within the same industry and or financial market, if former defaults. Stating differently, investor's risk perception regarding a certain debt issue they hold and, if it defaults, the overall uncertainty caused due to this event of default.

Thus in order to facilitate the default event part of our definition, we follow the Bank for International Settlements (BIS) definition of default event;

"A default is considered to have occurred with regard to a particular obligor when one or more of the following events have taken place.

➢ It is determined that the obligor is unlikely to pay its debt obligations (principal, interest, or fees) in part or full;

➢ A credit loss event associated with any obligations of the obligor, such as charge-off, specific provision, or distressed restructuring involving the forgiveness or postponement of principal, interest, or fees;

➢ The obligor is past due more than 90 days on any credit obligation; or

➢ The obligor has filed for bankruptcy or similar protection from creditor."

In particular, what we are disposing is that the formulation of expected premium from the risk of default by the investor is not only limited to the financial conditions specific to the firm but it also include the overall market and economic situation prevalent in the country. It, in fact, is one of the objectives of this study; because it is hard to quantify this phenomenon in explicit terms by the potential investor while expecting return due to the default risk determinant in the overall risk premium requirement of the risky corporate security.

By parameterizing these perceptions of risk-averse investor, as stated previously, we divide the determinants of risk of default into two broad factors; 1) explicit factors, and 2) implicit factors, effecting the overall formulation of expected risk premium of risk-averse investor from the risk of default.

3.1) Explicit factors

Explicit factors are those parameters through which risk-averse investor's perception of default risk of certain debt security is directly influenced. In other words, these determinants are specifically related to the debt issuer performance of

servicing their outstanding debt obligation (i.e. principal amount and interest therein, in our case of corporate bond obligations). From the existing empirical literature, it is evident that related contemporary studies mainly focus on the ad hoc explicit factors (and not the optimal explicit factors) to depict the risk of default which in turn obfuscates the true explanatory power of the default risk in the overall yield spread.

3.2) Implicit factors

On the other hand, implicit factors are those parameters which make their impact on investor's risk appetite in substantiating the explicit factors. Stated differently these factors support the explicit parameters in the overall formulation of expected risk premium by investor's from the risk of default. They are actually part of those determinants which in existing empirical literature treated as non-default factors i.e. portion of those economic and financial factors due to which the investors' perception of default risk changes. Therefore, in order to evaluate the realistic effect of risk of default, we should incorporate these parts into the overall formulation of expected return investor anticipate due to the credit risk related to the risky corporate debt securities. So, to optimally evaluate the risk of default we should also gauge the probability due to unexpected default which, in general, is accentuated by the implicit factors of risk of default in the overall formulation of expected return by the investor from the risky debt securities.

In the light of risk of default definition above, we first delineate the optimal explicit and implicit variable proxies that efficiently cater the realistic effect of risk of default and then in next section focus on to explain the procedure we follow to construct an efficient estimator in this regard. In addition, we evaluate the significance of these proxies to comprehend how they will affect the actual default probabilities which in turn will enable us to include those significant proxies to construct an optimal statistic that truly reflects the risk of default. This, ideally, should be used when indicating the credit risk in the overall formulation of yield spread. For the robustness of our optimal estimator we will assess its significance by testing it against the overall yield spread (i.e. difference between corporate bond yield and government bond yield) of investment and non-investment grade US corporate bonds.

3.3) Proxies

3.3.1 Explicit factors

3.3.1.1 Change in Distance to Default (ΔDD)

In light of our risk of default definition, this proxy takes into consideration the net worth of US corporate and volatility in its stock price. Explaining the possibility of default portion and first point in BIS definition of default risk, we calculate distance to default as a difference between the natural logarithm of total assets and total liabilities divided by its monthly stock price volatility. It, ideally, represents the percentage change in the overall long term default probability that debt issuer will unable to fulfill its obligation. This factor inter-changes the usage of expected default loss (Moody's KMV)[14] which is generally utilized in the existing literature.[15] We expect an inverse relation between distance to default and the risk of default.

3.3.1.2 Change in Z-score (ΔZ)

The third point in the BIS definition of default is being represented by the Z-score (Altman 1968) approach. This model predicts the corporate probability of default up to two years by using firm-specific ratios and plausibly caters the financial health of the obligor past due 90 days or more on any of its credit obligation.[16] In general, through this proxy we try to gauge the short term change in the overall default probabilities of debt-issuer in distress. Further, positive percent increase in Z-score expects to lower the default risk of the corporate.

3.3.1.3 Change in Credit ratings (ΔR)

In a similar vein, credit rating variation helps to cater the investors' immediate decision in investing and financing activities. Further, we include credit rating proxy because it presents the rating agencies' appraisal of risk of default associated with the corporate fixed income securities, which in turn is firm specific in nature. To represent the credit rating changes we use change in downgrade credit rating

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[14] Not available publicly.

[15] Löffler (2005) while assessing the credit ratings against market based measure (such as expected default loss from Moody's KMV) to predict defaults for Corporate investment grade securities show that there is no difference in using either default proxies.

[16] Z-score is calculated as (1.2a + 1.4b + 3.3c + 0.6d + 0.999e), whereas; a = working capital / total assets, b = retained earnings / total assets, c = Earnings before interest & tax (EBIT) / total assets, d = Market Value of Equity / Total liabilities, e = sales / total assets

percentage because it is suitable to assess the impact of credit rating change on the overall risk of default. Ideally, we would like to use the Credit default swap (CDS) premium because it proactively gauge the effect of any loss occurring in the case of default due to its highly liquid nature i.e. it enables direct trading on the risk of corporate default.[17] In addition, increase in downgrade credit change will certainly impact positively on the overall default risk for the corporate.

3.3.1.4 Cash Flow volatility (CFv)

In order to evaluate firms' position from cash flow perspective, we include in our analysis fluctuations in the operational cash flow situation of the debt issuer to assess their ability to service their outstanding debt as and when it become due. We expect a positive and significant relationship between firm cash flow volatility and the risk-averse investor expected return from the risk of default. Following, Tang and Yan (2010), cash flow volatility is calculated as the coefficient of variation of operating cash flows by dividing quarterly standard deviation to its absolute mean. In particular, we expect that this proxy will cater the true effect of firm's ability to meet its financial obligations in real terms. As cash flow volatility is negatively valued by investors (Allayannais, Rountree, and Weston 2005).

3.3.2 Implicit factors

3.3.2.1 Change in the state of economy

Volatility in the economic activity leads to affect investor's overall perception of required risk premium from the risky security (Tsuji 2005). We include change in GDP (ΔGDP) growth rate (Fons 1991), and Industrial production growth (ΔIPI) as a proxy for change in business cycle to evaluate the latent effect of change in the state of the economy which causes fluctuation in the investor's perception of risk of default for risky corporate debt. Corporate bond yield rise when economic conditions are weak (Fama and French 1993), and hence overall default risk.

3.3.2.2 Change in Market Volatility Index (ΔVIX)

This defining factor presents systemic risk and caters the information regarding the filing of bankruptcy or similar events occurred by the obligor. We present its effect by gauging the forward looking change in the overall market

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[17] Since the data is not available publicly, this limits our scope of study in this respect.

volatility index (hereafter VIX) on S&P500 because it is based on the current prices of S&P 500 index options and render expected market volatility over coming 30 days (Robert Whaley 2008). In particular this presents the investors' expected perception of the overall financial risk prevalent in the economy.

3.3.2.3 Change in Fed fund rate (∆FFR)

This parameter actually takes into consideration the effect of change in the interest rate on the investor's perception of default risk by the risky debt issuer. Change in fed fund rate enable us to gauge the inter-bank market effect on the overall financial state of the economy. Increase in this rate inhibits other banks to take inter-bank loan which in turn makes the cash difficult to acquire, leading to the increased lending rates for the corporate as a whole. In similar vein, with higher cost of debt, leveraged corporate will find itself in financial distress to service its already outstanding debt obligations, which in turn change the investors' perception of risk of default for such corporate.

3.3.2.4 Stock market fluctuation (∆SP)

From the financial market view point, in general, volatility of firms' equity is one of a major implied concern for risk-averse investor. Fluctuation in the returns investor obtain from a certain security leads to an increase perception of risk of default on its debt securities and hence provide basis to imply change in the overall required risk premium investor expect due to credit risk. To gauge this volatility we use change in S&P 500 index and expect to cater the equity market interaction in the corporate bond market.

3.3.2.5 Inflation

Change in the level of inflation impliedly affects the performance of debt issuer in servicing its outstanding debt and in general is a monist indicator of the economic condition. We take change in Consumer price Index (∆CPI) to cater the effect of inflation on the overall debt servicing performance of the corporate. We expect to observe increased difficulty in fulfilling short term debt as compared to long term due to significant positive change in CPI and in turn higher expected return required by the risk-averse investor from the long term risky corporate debt.

4) Data & Estimation Methodology

4.1 Data

In order to measure the optimal effect of risk of default on the overall yield spread, monthly data on explicit and implicit factors, outlined in previous section, has been used for the period of 2000 to 2010. This period is suitable for the study as it cited the occurrence of two recent financial crises (dot com and subprime crises) in the US economy. For the implicit factor indicators and corporate bond yield spread entire data is collected from the online source of Federal Reserve Bank of St. Louis.[18] On the other hand, for the explicit factor indicators we use Thomson Reuters database to calculate the distance to default, cash flow volatility and z-score, individually, for 252 US non-financial corporate. In particular, using New York Stock Exchange (NYSE) Bond Master service we came to include the sample of 252 US corporate (non-financial) listed with plain vanilla bonds of medium and long term maturities. In addition, the actual risk of default percentage of the US Corporate (non-financial) issues and downgrade percentage change in their credit ratings data is being collected from the Standard & Poor's research report 2011.[19] In addition, to collect stock prices (daily and monthly) for US corporate's in order to calculate explicit factors, we use Yahoo! Finance website.

Further, in order to obtain average monthly time series of these explicit factors we include simple weighted average across individual firms'. It is a very crude disposition but the impetus behind this is due to the fact that, ideally, to assess the economic and statistical significance of our explanatory variables on the US investment and non-investment grade corporate's we should have actual risk of default percentage of their debt securities along with their downgrade rating change. Since we only have overall actual risk of default percentage and downgrade rating change of the US corporate's, on average, we are limited in this respect.

The variables of our sample are reported in table I. The downgrade credit ratings data and actual risk of default percentage were available in annual frequency with GDP and US corporate data in quarterly frequency. We use cubic spline method

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[18] Investment & non-investment grade corporate bond yield is sourced from Bank of America Merill Lynch.
[19] "2010 Annual US Corporate Default Study and Rating Transitions" , March 30, 2011 (Global Fixed Income Research—Standard and Poor's)

to convert the data into monthly frequency in order to make these time series in harmony with the rest of the data.

Table I		
Variables	Description	Predicted Sign
Explanatory		
Implicit		
ΔGDP	Percentage Change in the real Gross domestic product (GDP)of US economy	-
ΔCPI	Percentage Change in consumer price index (CPI) of US economy	+
ΔIPI	Percentage Change in the Industrial Production Index (IPI) of US economy	-
ΔVIX	Percentage Change in the volatility index on S&P500 (VIX)	+
ΔFFR	Percentage change in the US inter-bank rate	+
ΔSP	Percentage change in the S&P 500 index (SP)	-
Explicit		
CFv	Coefficient of variation (weighted average) of monthly operating cash flow for US corporate	+
ΔDD	Percentage change in the distance to default (weighted average) for US corporate	-
ΔZscore	Percentage change in the Z-score (weighted average) for US corporate	-
ΔR	Percentage change in the downgrade rating of the US corporate bond issues	+
Dependent		
ΔDR	Percentage change in the risk of default of US corporate bond securities	

Since the data follow time series we checked whether it has a unit root or not. Following the Phillips-Perron test (1988)[20], it is observed that almost all of the time series were stationary integrated with zero order[21].

In order to condense the effect of the cubic spline algorithm we, in our preliminary model, use natural logarithmic form of the change in downgrade credit ratings variable and natural logarithmic form of actual risk of default percentage variable. Further, for monthly yield spread data, we use US treasury monthly yield data (averaged on 1, 2, 5, 10 and 20 years) and US corporate bond monthly yield data (averaged on investment and non-investment grades) from the online source of Federal Reserve Bank of St. Louis. Finally, this gives us total of 132 monthly observations of the focused time series data.

4.2 Methodology

Following our premise of specifically defining the risk of default as a function of explicit and implicit proxy variables in order to provide solution to the existing debate of empirically not treating risk of default as a major component in overall yield spread,

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[20] We follow Phillips-Perron test which is a generalization of augmented Dicky-Fuller (ADF) test for unit roots because it's assumptions are moderate as compared to ADF test regarding the distribution of error terms.
[21] This is due to the fact that the objective of our study is to gauge the relative change of the explanatory variable on the dependent variable.

we adopt "post-hoc" estimator approach of Lubotsky and Wittenberg 2006. Using multiple regressions (least square) of independent proxy variables on latent dependent variable, they use the regression coefficients of each explanatory proxy to compute a weighted average index, showing true effects of the latent variable. By assuming risk of default as a latent dependent variable, we focus on to evaluate the effect of the specific implicit and explicit proxy factors, in order to optimally construct our default risk indicator.

Since, the weights used here are the ratio of covariance's of dependent variable and the statistically significant independent variables to the covariance between the most significant independent variable and dependent variable, this technique helps in optimally minimizing the variance of errors terms of these proxy variables. Thus, enabling us to reduce the noise or measurement error caused, in the existing empirical literature, due to using biased coefficients of independent proxies treating as the risk of default. This approach of efficiently building a composite proxy index is better as compared to other approaches like principle component analysis (PCA) or factor analysis. As in this approach we are not redefining the data in terms of pure hunch bases (i.e. only selecting eigenvector's with highest eigenvalues). Instead Lubotsky and Wittenberg's post-hoc estimator gives better economic sense to use the least square regression coefficients of statistically significant explanatory variables to construct an optimal parameter for any latent variable of interest. In particular, here, we are efficiently including those explanatory variables to construct our required index (for default risk) which is significant without losing any adequate information (which is not the case in PCA).

Therefore, we use this statistic in order to build an optimal proxy reflecting the true effect of risk of default by utilizing previously explained proxies simultaneously through multiple regressions. Following our argument on the debate between theoretical and empirical literature on the issue; to whether treat risk of default as a main factor in pricing the risky corporate securities or not, we suggest that the solution lies in the optimal empirical measurement of the variable of interest i.e. default risk.

While broadening the scope of treatment of risk of default term used by empirical studies in the existing literature, we argue that the risk of default perception of risk-averse investor is not only limited to the explicit factors but also it is equally

important to include the implicit factors which in turn indirectly affect the risk of default.

Consequently, in order to validate this argument, we first evaluate, individually, the effects of explicit factor proxies on risk of default, which is manifested as;

$$\Delta lnDR_t = \theta_t + \alpha_1 CFv_t + \alpha_2 \Delta DD_t + \alpha_3 \Delta Zscore_t + \alpha_4 \Delta lnR_t + \varepsilon_t \tag{1}$$

Then to substantiate our broader treatment of risk of default, we regress change in risk of default on the implicit factor proxies;

$$\Delta lnDR_t = \theta_t + \gamma_1 \Delta GDP_t + \gamma_2 \Delta CPI_t + \gamma_3 \Delta IPI_t + \gamma_4 \Delta VIX_t + \gamma_5 \Delta FFR_t + \gamma_6 \Delta SP_t + \varepsilon_t \tag{2}$$

And finally following our objective of ideally parametring the default risk into combined linear function of explicit and implicit variable factors, shown as;

$$\Delta lnDR_t = \theta_t + \beta_1 \Delta GDP_t + \beta_2 \Delta CPI_t + \beta_3 \Delta IPI_t + \beta_4 \Delta VIX_t + \beta_5 \Delta FFR_t + \beta_6 \Delta SP_t + \beta_7 \Delta CFv_t + \beta_8 \Delta DD_t + \beta_9 \Delta Zscore_t + \beta_{10} \Delta lnR_t + \varepsilon_t \tag{3}$$

In equation (1), (2) and (3), α, γ and β respectively, represents the coefficient of explanatory variables, whereas Δ represents monthly percentage change in variables, subscript "t" indicates monthly time series observations and ε_t shows error term following i.i.d[22]. Further, "ln" refers to natural logarithmic form.

Now, using Lubotsky and Wittenberg (2006), we treat risk of default (equation 3) as a latent dependent variable which is not been optimally measured in the existing empirical literature, thus it is being represented by an optimal mix of significant explicit and implicit factor indicators.

Stated differently, to show the optimal effect of risk of default factor on the yield spread of US corporate securities (investment and non-investment grade), we use the post-hoc estimator approach which provides an efficient indicator for the

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[22] i.e. series of identically distributed independent random variables of expected value equal to zero and constant variation—white noise error term)

focused dependent variable (risk of default), through the use of explanatory implicit and explicit proxy factors.

In addition, our presumption delineate that the explicit and implicit factors are valid proxies for the risk of default perception of risk-averse investor and that they are not related to other variable of interest—i.e. non-default risk factors. In other words our surmise is based on the belief that part of the implicit factor affects the perception of risk-averse investors' required premium due to default risk from risky corporate securities. Further in order to satisfactorily explain the effect of default risk on the yield spread formulation of risky corporate securities; the residual portion of these implicit indicators belongs to non-default risk factors.

On the basis of equation (3), we include those variables which are statistically significant in order to construct our representative indicator for the risk of default.

$$\rho_t = \sum_{j=1}^{k} \frac{Cov(Y_t, X_{jt})}{Cov(Y_t, X_{1t})} * \beta_{jt}$$

(4)[23]

In equation (4), ρ_t shows our post-hoc estimator for the risk of default indicator in month t. Further, Y_t represents our latent dependent variable (change in risk of default—ΔDR) in month t, and X_{jt} represents our statistically significant explanatory variable j in month t, whereas β_{jt} represents the least square regression coefficient of significant j explanatory variables at time t (months). Further X_{1t} presents the primary statistically significant explanatory variable on which the post-hoc estimator is constructed.

Equation (4) gives us the optimal proxy indicator for default risk to utilize in order to evaluate its effect on the overall yield spread formulation for the risky corporate securities. To assess this effect we regress US corporate bond yield spread on our post-hoc risk of default estimator.

$$\Delta YS_t = \kappa_t + \lambda \Delta\rho_t + v_t \qquad (5)$$

In equation (5), YS_t represents the difference between US corporate bond yield (investment and non-investment grade) and the US treasury yield, on average, in month t. ρ_t represents the default risk post-hoc estimator in month t, whereas λ

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[23] Detail derivation can be found in "INTERPRETATION OF REGRESSIONS WITH MULTIPLE PROXIES", Lubotsky .D, and Wittenberg. M, 2006, The Review of Economics and Statistics, vol 88(3), pg 549-562

shows the regression coefficient of our default risk estimator and υ_t represents i.i.d error term. Δ represents the monthly percentage change in the variables. Next section delineate and analyze the econometric result and limitations of the specification introduced in this section.

5) Results & Limitations

5.1 Results

In order to get the overview of our sample time series data, first, we present graphical description, figure 1, of how our implicit and explicit variable time series spreads around the focused interval. Since our preliminary objective is to study the monthly percentage change of these explanatory variable on our presumed latent variable of interest i.e. change in risk of default, the focused controlled time series become stationary integrated with order zero after taking percentage change effect. Further, from figure 1, the effect of dot com crisis (2000-2002) and subprime crisis (2007-2009) is quite evident with macroeconomic time series especially monthly change in GDP, consumer price index (CPI) and industrial production index (IPI) showing significant fluctuations in these periods respectively. In addition, S&P 500 index (SP) and its implied volatility (VIX) report abrupt fluctuation in this period, while short-term interbank fund rates (FFR) changed to more than negative 50 (almost 100) basis points showing the US Federal Reserve intervention in the financial market of September, 2007[24] in order to stimulate the economy out of the subprime crisis. In addition, our calculated micro time series explicit factors also manifest the existence of turbulent economic situation in USA in these periods. Distance-to-Default (DD) and Z-score of US corporates substantially show downward trend up to more than 50 basis points in 2007-2009 sub-prime crisis period.

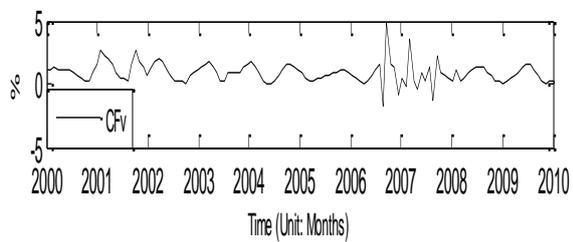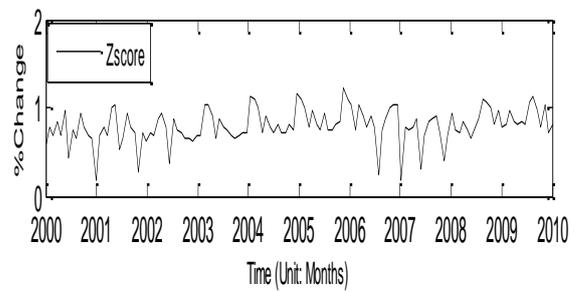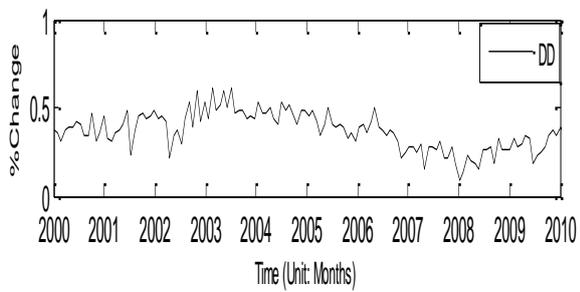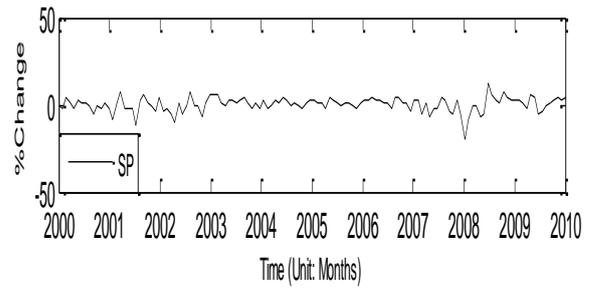[24]   "Fed   cuts   interest   rates   to   4.75%",   BBC   News,18   September   2007 (http://news.bbc.co.uk/2/hi/business/6999821.stm)
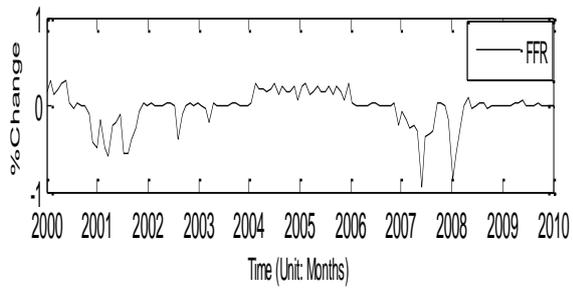
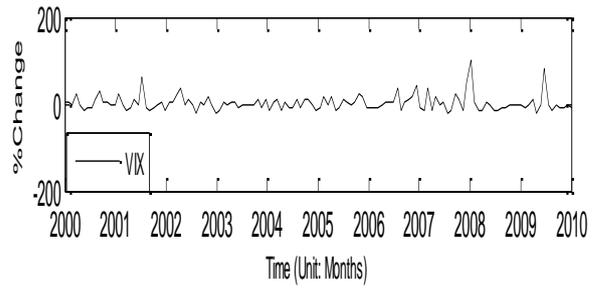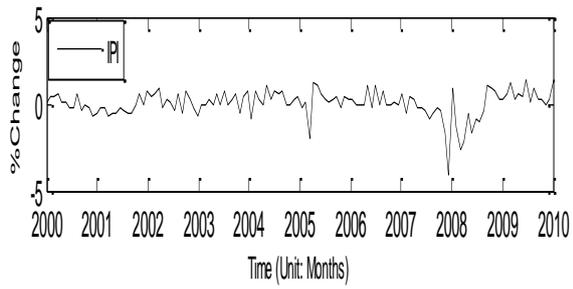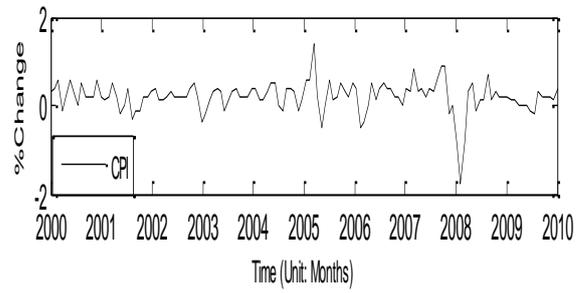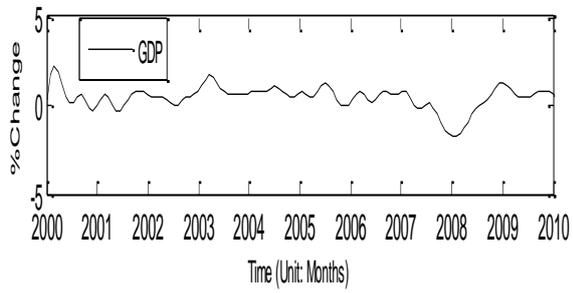Figure I: Graphical description of explanatory variables time series (2000-2010)

On the other hand, operational cash flow volatility of US corporates (non-financial), on average, demonstrates abrupt fluctuations in this period, validating the macro economic factors in this regard.

Since explanatory variable time series are stationary, we follow ordinary least square (OLS) regression for the econometric estimation of our conjecture that risk of default is being optimally measured with an efficient mix of explicit and implicit factors. The primary belief behind this surmise comes from the expected utility hypothesis[25] that investor's are mainly focus on to maximize their utility i.e. they want to maximize the expected utility of their investment.[26] So, any factor explicit or implicit affecting the default nature of the risky securities should be adjusted by the risk-averse investors. In other words, risk-averse investors expected premium from the change in the risk of default perception of risky corporate securities should be ideally compensated by any factor affecting it directly or indirectly.

But before going into that, we first try to validate this by evaluating, individually, the effect of explicit proxy factors and implicit proxy factors on the risk of default. In turn it basically lay down the foundation for our argument in defining the default risk. Table (II), column (1), shows the result of specification in equation (1), assessing the effect of explicit proxy factors to determine the change in the dependent default risk factor. In column (1), we can see that all the explicit explanatory control variables follow the presumed relation (table 1) with the dependent variable. Further, operational cash flow volatility (CFv) and change in z-score (ΔZ score), generate statistically significant results along with the constant parameter in the specification. Whereas, change in distance-to default (ΔDD) and change in downgrade credit ratings (ΔR) though showing expected relation with the dependent variable but are insignificant. In addition, on average, in US corporates a one percent increase in operational cash flow volatility increases the risk of default by almost 2.5 percent, whereas a percent decrease in overall z-score increases their chances of short-term technical insolvency by 1.24 percent. Perhaps the most interesting result for us, here, is the statistical significance of the constant term of this regression specification, showing evidence of presence of other implied factors in the

[25] "The theory of money", Jürg Niehans, (The John Hopkins University Press, Baltimore, London), 1978, (pg 30)
[26] "Investments", Zvi Bodie, Alex Kane, Alan J. Marcus (Eighth Edition), (pg 188-192)

overall change in our dependent variable. These findings validate the utilization of explicit factor proxies for risk of default from the previous literature.[27]

Table (II), column (2) show specification (2), which delineates the effect of implicit factor proxies on the risk of default of US corporate debt issues. Again, all the explanatory control variables follow the presumed relation with the dependent variable. Out of others, only the effect of change in consumer price index (ΔCPI) and change in industrial production index (ΔIPI) proves to be statistically significant in effecting change in the dependent variable. On average, one percent increases in the inflation level increases almost 2.4 units in the overall risk of default of US bond securities. Whereas, a percent increase in their industrial activity reduces it by approximately 1.2 percent. In similar vein to specification (1), the constant regression coefficient of specification (2) dispose statistically significant relation giving the presence of adequate other factors in the overall evaluation of the dependent variable.

After the adduction of the first two specifications, we may be factual to validate our conjecture of risk-averse investor perception of default risk of corporate debt securities. But, before drawing such conclusion, we should, ideally, first assess specification (3), which primarily demonstrates foundation for such presumption. And enable us to include optimal explanatory factors to construct an efficient indicator for our risk of default variable. Column (3), table (II) delineates the risk of default of US corporate bond issue as a linear combination of explicit and implicit factor proxies. Following the first two specification, we evaluate the effects of specification (3) by means of standard regression approach (i.e. the least square regression with white noise errors). In estimating equation (3), we find that out of ten explanatory control variables, six are statistically significant. Further, there is no significant change in the effects of explicit proxy factors with operational cash flow volatility (CFv) and change in z-score proving as statistically significant,[28] on the other hand, implicit proxy factors show interesting change with the combination of explicit proxy factors. Now, change in overall financial market volatility indicator (VIX) and the inter-bank market indicator, the fed fund rate (FFR), proves to be significant statistically at 1% and 5% respectively.

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[27] Collin-Dufresne et al (2001), Elton et al. (2001), Tsuji (2005), King and Khang (2005)
[28] This result is in line with the existing literature showing cash flow volatility affecting the risk of default (Molina 2005, Tang and Yan 2010).

Table II: Estimating effects of explicit and implicit factor proxies on risk of default			
Standard errors are reported in parentheses. Column (1) & (2) present least square regression (OLS) effects of explicit factor proxies and implicit factor proxies, individually, on the default risk in natural logarithmic form. Whereas, column (3) shows their combined effect.			
Variables	**(1)**	**(2)**	**(3)**
Explicit Factors			
θ	2.038**	2.073***	0.037*
	(0.039)	(0.007)	(0.010)
CFv	2.427***		3.833***
	(0.065)		(0.075)
ΔDD	-0.492		-0.251
	(0.082)		(0.028)
ΔZscore	-1.24***		-1.183***
	(0.093)		(0.037)
IΔR	0.318		0.558
	(0.039)		(0.037)
Implicit Factors			
ΔGDP		-0.001	-0.259
		(0.002)	(0.024)
ΔCPI		2.398***	1.724**
		(0.002)	(0.090)
ΔIPI		-1.219***	-0.029*
		(0.032)	(0.001)
ΔVIXX		0.017	0.039***
		(0.022)	(0.014)
ΔFFR		0.318	0.381**
		(0.084)	(0.019)
ΔSP		-0.131	-0.087
		(0.073)	(0.075)
No. of Observations	131	131	131
R-squared	0.262	0.29	0.474
D-W	1.99	2.148	2.104
Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level. D-W represents Durbin Watson test			

Specification (3) in turn cater the effect of risk-averse investor s' change in perception of default risk due to the combination of micro and macro level economic and financial factors. Among all the explanatory control variables, change in the operational cash flow volatility (CFv), change in z-score (ΔZ score) and change in financial market volatility index (ΔVIX) proves to be the most significant variables. In addition, the positive sign of the significant regression coefficient of change in fed fund rate (ΔFFR), indicate that rise in interbank rate adversely affects the financial position of the leveraged US corporates resulting increased distress in meeting their debt obligations and hence changing the default risk perception of risk-averse

investor. On average, one percent change in the fed fund rate effects approximately 0.4 percent change in the overall risk of default.

In a similar vein, bleak and dismal outlook for the financial market may increase risk-aversion among investor because such periods of lower-wealth situation change their willingness to hold and bear risk. The volatility index on S&P 500 (VIX) reflects the market sentiments about this condition. On average, one positive percent change in VIX, changes the investor's risk-aversion by almost 0.4 percent. On the other hand, micro level indicator of the state of economy, the industrial production index (IPI), though statistically significant, shows minimal effect on the dependent variable. In fact, it is quite interesting to see that in specification (2) & (3) only one of our states of the economy indicator (i.e. IPI) is significant, whereas change in GDP is not. This may be due to the fact that IPI tend to be more linked as a micro level indicator of the state of economy against the GDP level. The regression coefficient of change in IPI (-0.029) implies that, all things remain constant, as there is one percent increase in the overall IPI the default risk of US corporate debt securities goes down by almost 0.03 percent, which is quite minimal, indicating improved economic growth as a whole.

Further, the regression coefficient of change in CPI, on average, indicates that one percent change in inflation level increases the resulting dependent variable by almost 1.8 percent. On the other hand, in previous section, we assumed that our residual error term is identically distributed independent random variables with zero mean and constant variance (i.i.d), while evaluating the error term after running the three specifications (1), (2) & (3); we came to know that our assumption is valid through residual tests of Correlogram.[29] Further, result of constant parameter θ_t in specification (3) is significant but with minimal effect, perhaps it basically manifests the weak signal of our explicit proxy factor long term effect like the distance-to-default instead of using market based proxies such as expected default loss (EDF), provided by Moody's rating service. On the contrary, we forget to mention the fact that our specification (1), explains 26 percent change in the risk of default due to explicit explanatory control variables, while specification (2) explains 29 percent change due to implicit factor proxy variable. In addition the combination of specification (1) & (2), specification (3), satisfy the change in the effect of risk of default by almost 47

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[29] Interested readers can ask these results by reaching author at syed-muhammad-noaman.shah@etu.univ-orleans.fr

percent, validating the assumption of our surmise of not only focusing on explicit proxy factors but also including the implicit proxy factors in the overall formulation of risk premium required by investors from default risk of risky corporate debt securities.

Generally, not all of the explanatory variables proved to be statistically significant. But then our preliminary objective in equation (3) is to determine those factors which significantly affect the change in risk of default so that we can use them to construct an optimal indicator for the risk of default factor through the post-hoc estimator procedure. From table II column (3), we took only those explanatory variables showing statistically significant relation on the actual default risk and by following equation (4), in the previous section, we construct a monthly time series of an efficient indicator of change in default risk factor delineating the optimal mix effect of implicit and explicit proxies. In particular, as shown in table II, we use operational cash flow variability (CFV) as our main principle factor explaining the change in the overall default risk of risky corporate bond issue in developing this estimator. Figure II graphically depict our optimal default risk indicator time series (ES) along with the yield spread (YS) of US corporate bonds for the period 2000-2010
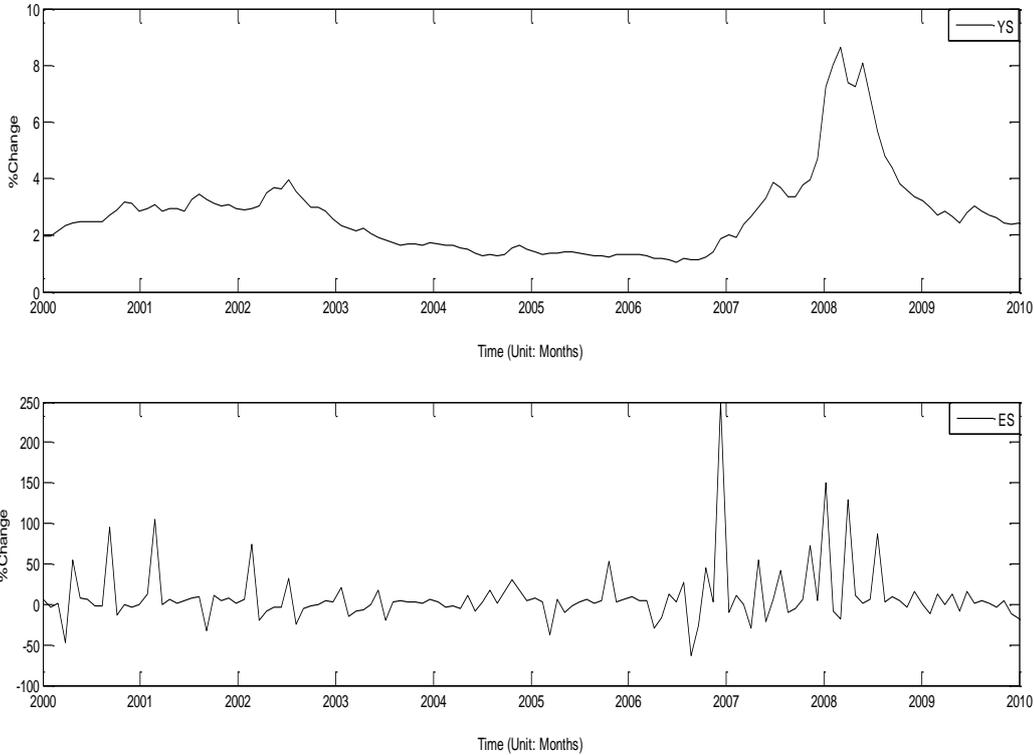

Figure II: Risk of default estimator post-hoc (ES); whereas YS represents yield spread of US corporate bond securities.

As figure II manifests, our risk of default estimator almost systematically depicts a leading relation with the overall yield spread of US corporate bond securities, showing the similar long term trend. Further, our variable of interest quite effectively gauge the dot-com (2000-2002) and sub-prime (2007-2009) financial crises, reporting as high as almost 250 basis point change in the overall risk of default during the sub-prime crisis and almost 100 basis point increase in the overall risk of default for US Corporate bond issues in dot-com crisis. From figure II, it is evident that default risk estimator may significantly explain the formulation in the overall yield spread.

Table III shows the results of our final specification (equation 5), which is the main objective of this study i.e. evaluating the effect of risk of default estimator on the overall yield spread of US corporate bonds (on average, investment and non-investment grade). In turn equation (5), in previous section, also assesses the robustness of the estimator built to represent the default risk indicator in the overall yield spread formulation.

Table III: Default risk post-hoc estimator	
Standard errors are reported in parentheses. Column 1 show least square (OLS) effect of risk of default post-hoc estimator on change in the yield spread of US corporate bonds (specification 5).	
Variables	**(1)**
$\Delta\rho_t$	1.120***
	(0.099)
κ_t	3.52*
	(0.280)
No. of Observations	131
R-squared	0.49
D-W	2.01
Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level. D-W represents Durbin Watson test	

Here, following our conjecture in previous section, we treat the risk of default estimator function as a continuous process by risk-averse investors', evaluating the overall expected premium from the default risk present in the risky investments. Table III show that our default risk estimator is statistically significant in explaining the variation in US corporate yield spread. In particular, the regression coefficient is 1.120, indicating that one percent change in the risk of default will increase almost

1.1 percent in the US corporate bond yield spread level. In addition, the explanatory power of our default risk indicator is 49 percent which validates and supports the theoretical model assumptions in treating risk of default as a primary component in valuing risk corporate securities.[30] Further, the significant constant term in specification (5) shows the presence of non-default factors in the overall formulation of corporate bond yield spread. In addition, the residual error term follows i.i.d[31] supporting that the default risk estimator time series is integrated with order zero.

5.2 Limitations

This study is limited in its implications due to the inherent restrictions. First, due to inaccessibility of adequate US Corporate bonds default risk and fixed income databases, we conduct this analysis only on aggregate US corporate level (non-financial). This fact is validated through our acknowledgment remarks at the start of this article. With aggregate US corporate bond's default data we are unable to assess the true potential of this work in its entirety (for example, analysis on the level of sector basis, investment & non-investment grade basis). Second, the robustness of our default risk proxy indicator is also limited in the sense specified above. In specification (5) we, ideally, would like to include non-default factors of US corporate bonds such as assessing the illiquidity effect (age factor, bid/ask factor, maturity, transaction cost), in order to gauge true potential of our risk of default estimator.

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[30] Contradicting Elton et al. 2001
[31] Interested readers can ask these results by reaching author at syed-muhammad-noaman.shah@etu.univ-orleans.fr

6) Conclusion

The aim of this study is to explore the default risk debate that exists between the theoretical and empirical risky corporate debt valuation literature. The dominant view exists in the theoretical literature is that risk of default is fundamental to value the risky corporate securities which is evident in the structural models of valuing the credit spread. Whereas major empirical literature on the issue shows that non-default risk factors are more important in valuing these risky corporate securities. The current study try to fill this void by presuming that the solution to this debate lies under the measurement techniques existing empirical literature use in identifying the default risk. Using risk of default as a function of explicit and implicit factors, we construct an optimal indicator (following Lubotsky and Wittenberg 2006) for the default risk which contributes to solve this debate. In particular, our risk of default estimator significantly explains the level change in the US corporate bond yield spread but with limitations. It explains about 49 percent change in the overall yield spread model, indicating the dominance of theoretical[32] school of thought in treating risk of default as a cornerstone in the risky corporate debt valuation process.[33] Further, we hope to improve the implications of these results by streamlining the limitations described in the previous section.

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[32] Provided by Merton Model (1973)
[33] Empirical literature is sparse in this regard. See Koyama and Yonetani (2001), King and Khang (2005).

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