How Does Bond Market View IT Investments of Firms? An Empirical Analysis of Bond Ratings and Yield Spread

Completed Research Paper

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Abstract

This study investigates the business value of information technology (IT) in terms of performance in bond markets, which constitute the single largest source for firms' financing. We evaluate risk-adjusted benefits of IT investments in the bond market in the United States over the 1995-2002 period. We find a significant association between a firm's IT intensity and bond ratings at issuance. The results also indicate that the impact of IT on the cost of debt is different across industries. IT investments have a favorable influence on the cost of debt in automate and informate industries but not in transform industries. This finding from the bond markets differs from that in prior equity market findings which report higher returns to IT investments in transform industries. These findings suggest that bondholders and shareholders have different perspectives toward IT investments.

Keywords: IT investments, bond market, credit rating, yield spread, IT strategic role

Introduction

Bond markets are an important component for any economy to finance economic activities and public services. The issuance of bonds is a significant source of finance for business activities of firms. In 2009, total corporate bond issuance in the United States amounted to a total of $874.9 billion, surpassing funds financed through stock markets by a wide margin. Many technology firms make use of bond markets to access capital. For example, Microsoft, one of the largest technology companies in the world, issued $3.8 billion of bonds in May 2009.

Information technology (IT) investments and initiatives have significant implications for bond holders because IT investments can influence firm risk and the debtors' ability to repay the debt. Trade press suggests that in the healthcare industry, credit rating agencies and bond lenders such as pension funds assess hospitals' and health systems' use of IT as part of their rating or investing process (Sweeney 2007). According to some reports, investors channeled their money into the bond markets when they were concerned with the Y2K in 1999, resulting in wider credit spreads (Dalziel 1999).

Despite the significance of the bond market and the likely role of IT investments in influencing bond prices, few studies investigate whether and how IT investments affect the bond market. In contrast, several studies have examined the association between IT investments and the equity market (Anderson et al. 2006; Bharadwaj et al. 2009; Bharadwaj et al. 1999; Chari et al. 2008; Chatterjee et al. 2001; Dehning et al. 2003; Dewan et al. 2007; Dos Santos et al. 1993) and suggest that IT investments positively influence equity-based firm valuation.

Do these findings from equity market also hold for bond market? The corporate finance literature suggests that both the return and risk have the same directional impacts on firm valuation in the equity market (Jensen and Meckling 1976; Merton 1974). Hence, an increase in risk arising from a firm's IT investments will increase the market value of the equity for the same expected returns. In contrast, the risk and return influence bond prices in the opposite direction. In other words, though shareholders and bondholders both benefit from higher return, shareholders might benefit at the expense of bondholders from higher firm risk. Thus, one might conjecture that prior studies showing higher equity returns from IT investments might reflect a wealth transfer from bondholders to shareholders, not an increase in the firm value (i.e., the sum of stock and debt values).

This study tests this conjecture and examines the effect of IT investments on bond ratings and yield spreads for newly issued bonds. We also study how the effect differs across three industry groups. We contribute to the prior work in two important ways. First, we investigate the risk-return trade-off of IT investments in the context of the bond market. We show a significant association between IT investments and the bond market and find that IT investments influence bond ratings and yield spreads. This study shows how IT investments might contribute to firm value through a reduction in financing costs and thereby adds a new mechanism to explain the effect of IT investments on profitability and firm performance (Mithas et al. 2012).

Second, our study shows that bond investors and equity investors have different perspectives toward IT risks and investments. The previous literature based on the stock market suggests that equity investors are favorably disposed toward IT-driven transformation (Anderson et al. 2006; Chatterjee et al. 2001; Dehning et al. 2003). Our finding implies that bond investors prefer small but stable cash flows from IT automation to large but uncertain cash flows from IT-driven transformation. Our findings suggest that IT may have asymmetric effects on stock and bold-holder value because of difference in their pay-off structure. An overall impact of IT on firm performance should take into account these differential effects for a more nuanced view of how IT contributes to firm value.

Theory and Hypotheses

Background

Prior research, largely using data in the context of equity markets, has provided several useful insights. First, prior work suggests that IT investments are positively associated with shareholder value. While some studies show a positive association between IT investments and Tobin's q (Anderson et al. 2003a; Anderson et al. 2006; Bharadwaj et al. 1999; Brynjolfsson et al. 2002; Chari et al. 2008), others show abnormal stock returns from public announcements related to IT initiatives (Bharadwaj et al. 2009; Chatterjee et al. 2001; Dehning et al. 2003; Im et al. 2001).

Second, prior studies suggest that IT has different impacts on equity-based returns across industries and has played a stronger positive role in transform industries. These studies use a classification of the strategic roles of IT in three broad categories: automate, informate, and transform (Armstrong and Sambamurthy 1999; Chatterjee et al. 2001; Schein 1992; Tanriverdi and Ruefli 2004). In automate industries, firms typically use IT to replace human labor. In informate industries, the main role of IT is to provide information to empower senior managers and engage employees. In transform industries, IT fundamentally changes business models and market structures and thus renders traditional business practices obsolete.

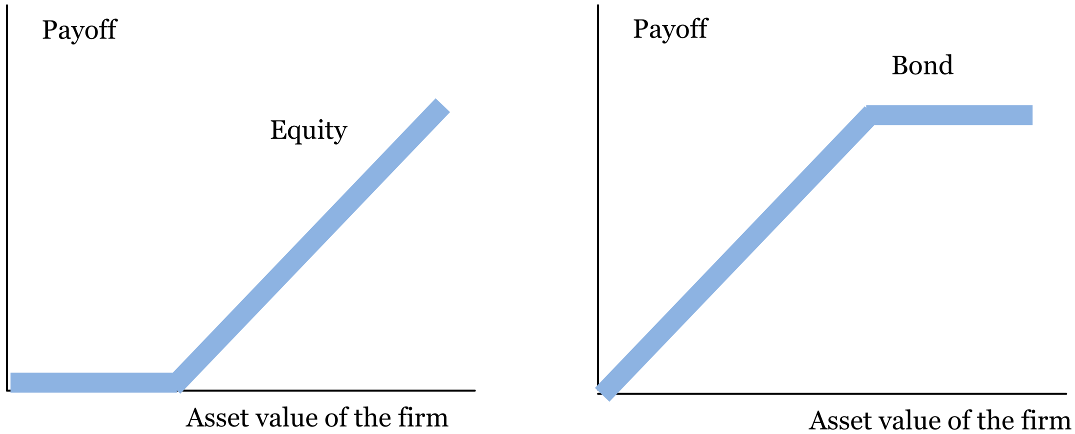
Chatterjee et al. (2001) use the event study methodology to show that the market positively reacts to announcements of newly created CIO positions in firms in industries undergoing IT-driven transformation. Dehning et al. (2003) investigated the strategic role of IT investments at both firm and industry level and found that firms making transformative IT investments and in the transform industries enjoy positive, abnormal returns to announcements of IT investments. Anderson et al. (2006) show that the Y2K spending is positively associated with higher firm value and subsequent earnings, mostly for firms in industries where IT drives transformation.

Third, increasingly researchers are beginning to take into account the risks associated with IT investments. Bharadwaj et al. (2009) evaluated the financial impact of IT failures based on the event study methodology, and showed a significant, abnormal decrease in stock prices. Dewan et al. (2007) developed a proxy measure for measuring IT risk and estimated risk-adjusted returns in the equity market. They suggest that IT capital investments are riskier than non-IT capital investments. To the best of our knowledge, this is the only paper that empirically tested the return and risk trade-off of IT investments in the equity market.

Although useful, equity based studies need to be complemented with studies from bond markets to make a more complete assessment of IT value across stakeholders. This is because of differences between shareholders and bondholders, especially in perspectives on firm-level risk (Rego et al. 2009). Corporate finance theory provides useful predictions about the different impacts of changes in cash flow on equity and bond valuation. Merton (1974) applied the option pricing framework to price corporate debt. In this view, the payoff of equity resembles the payoff of a call option on the underlying firm value (See Figure 1). To the extent shareholders are residual claimants of a firm's assets while bondholders get only a fixed return from their investments, shareholders are more likely to favor risky investments than bondholders because positive but risky returns from IT investments will have a limited impact on the payoff of the bondholders (Jensen and Meckling 1976; Myers 1977).

Due to the potential conflict of interest between bondholders and shareholders, bondholders generally require firms to make protective covenants and implement monitoring devices to prevent risk shifting (Berlin and Loeys 1988; Eberhart et al. 2008). Furthermore, because these contracts are incomplete, bondholders require higher risk premiums (Anderson et al. 2003b; Shi 2003). Thus, when a bond is issued, its risk premiums reflect firm-level risk, including the risk associated with IT investments (Jensen and Meckling 1976). Furthermore, since the benefit of holding bonds is limited, the return (i.e., an increase in cash flows) will have a limited impact on bondholders.

Figure 1: Payoff schedules of equity and bond



We draw on prior work which shows the relevance of other intangibles such as customer satisfaction (Anderson and Mansi 2009), innovative capability (Czarnitzki and Kraft 2004), research and development (R&D) investments (Eberhart et al. 2008), accounting quality (Bharath et al. 2008), and a positive ownership structure (Anderson et al. 2003b) on bond markets such as better bond ratings and lower yield spread. Building on this body of research, we argue that IT investments are likely to influence the costs of debt financing in the corporate bond market.

Hypotheses

The Association between IT Investments and Costs of Debt

We noted earlier that changes in the mean and variance of future cash flows from IT investments have the same directional effects on the market value of firms in the equity market, but opposite directional effects on bond prices. This implies that a positive (negative) sign in the impact of IT investments on yield spread (bond ratings) means a dominance of IT risk effect over IT return effect from the bondholders' perspective.

Because IT investments are believed to increase expected future benefits as well as the volatility of organizational performance, it is hard to ascertain the net effect of IT investments on the costs of debt. On the one hand, IT investments should have a favorable impact on cost of debt by enhancing the creation of future cash flows through IT-enabled intangible assets such as product quality, customer satisfaction, knowledge assets, information management, and agility. In turn, accumulation of intangible assets influences future cash flows (Brynjolfsson et al. 2002). For example, customer satisfaction enhances the stability of future revenue and lowers the costs associated with customer retention (Meuter et al. 2000; Mithas et al. 2005). Agility can accelerate future cash flows by facilitating speed to market (Sambamurthy et al. 2003). Embedded knowledge assets enabled by IT applications enhance knowledge sharing to facilitate product and service innovation for improved firm performance (Alavi and Leidner 2001; Cole 1998; Dodgson 1993).

On the other hand, IT investments increase the volatility of future cash flows and, as a result, increase the risk premium that the bond investors require (Minton and Schrand 1999). It is widely recognized that IT investments are inherently risky (Dewan et al. 2007). Anecdotal evidence and case studies inform us about the difficulties to deploy and effectively manage IT assets (Bharadwaj et al. 2009). The risky nature of IT investments results from many internal and external factors. IT failure literature suggests that at the IT project or investment level, IT failure is generally due to poor IT capabilities (Bharadwaj et al. 2009; Lyytinen and Mathiassen 1998). Other studies also consider external variables, such as competition and market risks, that lead to IT failures (Benaroch 2002; Tanriverdi and Ruefli 2004). Due to these causes, IT investments increase the uncertainty of organizational performance at the project level or firm level (Tanriverdi and Ruefli 2004). A few recent studies have empirically tested the IT riskiness and have shown that IT increases firm risk-the volatility of firm performance (Dewan et al. 2007; Kobelsky et al. 2008).

On the whole, the impact of firms' IT investments on their performance is ultimately an empirical question. Previous literature has showed high returns from IT investments in equity markets even after adjusting for risk (Dewan et al. 2007). This might suggest that IT benefit effect dominates IT risk effect even in bond markets and thereby IT investments are associated with lower yield spreads and higher bond ratings.

H1a: IT investment is positively associated with initial bond rating.

H1b: IT investment is negatively associated with initial yield spread.

Industry Heterogeneity to the Impact of IT Investments

We argue that the strategic role that IT plays in an industry affects the relationship between IT investments and bond market value. This relationship differs from what one might expect based on that in equity markets where firms with the transform IT strategic role and in industries with the transform IT strategic role enjoy higher increase in market value by investing in IT (Anderson et al. 2006; Dehning et al. 2003).

Consider IT investments in automate industries first. In automate industries, firms are likely to use IT investments to replace human labor and automate existing business processes. Firms are likely to apply these investments to well-known organizational functions and to have some knowledge of complementary resources associated with those activities. This implies that implementation risk is low in this type of investments and will not vary much across firms in the same industry. Thus, firms utilizing automate type IT investments will enjoy positive, if small payoffs with lower risk due to easily imitated nature of automation.

Next, consider informate industries which are more likely to utilize IT investments to aid richer information flows to support decision-making. These information flows help senior managers and employees to better recognize problems and initiate appropriate measures quickly (Chatterjee et al. 2001). Typically, IT investments in these industries do not involve significant changes in business process and market structure, hence they create lower risks in implementation. Further, IT investments in these industries involve capture and storage of data within organizations (Dehning et al. 2003).

In contrast to automate or informate industries, the transform industries use IT investments to fundamentally alter business and market relationships. These investments render traditional business practices obsolete and redefine complementarities in an unpredictable way. Although the transform investments may present valuable opportunities to increase significant returns (Dehning et al. 2003), the risks of implementation are higher and future cash flows are more uncertain. Benaroch (2002) indicates that the payoffs from these investments will depend more on industry and market factors thus making the payoffs more uncertain. Tanriverdi et al. (2004) also suggest a significant variation in IT returns across firms in the transform industries. Thus, because positive returns will have a limited impact on bondholders' payoff, large but uncertain returns are unlikely offset negative perceptions of the corporate bond investors toward high risks arising from transformative IT investments.

In summary, we expect that bond investors will view automate and informate IT initiatives as relatively less risky with small, but certain, future cash flows. However, we expect that the bond investors will be more concerned about IT initiatives within transform industries than those in automate or informate industries. Thus,

H2a: Firms in industries where the transform IT strategic role dominates enjoy a less positive association between IT investments and initial bond ratings than those in industries where the automate or informate IT strategic role dominates.

H2b: Firms in industries where the transform IT strategic role dominates enjoy less negative association between IT investments and initial yield spreads than those in industries where the automate or informate IT strategic role dominates.

Method

Data

Following prior studies, we examine two measures of the cost of debt: bond ratings and yield spreads on new bond issuances (Anderson and Mansi 2009; Eberhart et al. 2008; Gu 2005; Shi 2003).[1] Bond ratings and yield spreads are measured at the bond level. The yield spread is a direct measure of the firms' ex ante incremental cost in issuing public bonds and is used as the cost of debt measure in many prior studies (Sengupta 1998; Shi 2003). Bond ratings by credit rating agencies provide a level of the bond issuer's creditworthiness.[2] They are closely related to the issuers' default risk (Altman 1992) and have been widely used as a measure of cost of debt (Anderson and Mansi 2009; Czarnitzki and Kraft 2004).

We use Mergent Fixed Income Securities Database (FISD) to gather data on yield spreads and bond ratings for new bonds.[3] This database releases bond transactions since 1994, while issuer- and issue-specific information is covered beginning in 1950. The database contains details on more than 550 bond characteristics, such as issue date, bond features, bond ratings, coupon rate and frequency, and maturity dates. Although this database does not cover all of the traded bonds, it has been commonly used in bond market literature (Anderson and Mansi 2009; Easton et al. 2009). Prior studies have suggested that this database is not biased (Easton et al. 2009). To limit any confounding effects which might result from issue-specific features, we excluded any convertible bonds or bonds with other nonstandard features except for the callable option (puttable, asset-backed, private placements, etc.).[4] In addition, we removed bonds with security levels of "none" or "subordinate". Mergent FISD reports market-quoted yield spreads and bond ratings for these bonds. We included only the bonds with positive spreads in our sample.

We obtained data on IT budgets from the *InformationWeek* 500 database. Since 1991, *InformationWeek* has identified 500 leading firms each year after tracking IT practices of many firms across core areas of operations, including technology deployment, IT budgets, business-technology infrastructure, and IT strategies. Data from this source has often been used in prior studies (Bharadwaj 2000; Kobelsky et al. 2008; Ray et al. 2009). We also used the Compustat database for bond issuers' financial information.

To merge the Mergent FISD with the Compustat data we first matched the Issuer CUSIPs of borrowers with bonds in the Mergent FISD to the Issuer CUSIPs of firms in Compustat. Since each issuer has a unique Issuer ID but may have multiple Issuer CUSIPs, then we identify Issuer IDs corresponding to the Issuer CUSIPs and collect extra bonds with the same Issuer IDs. After matching our cost of debt measures with the IT budgets and control variables, our sample comprised 253 new bonds by 165 firms during 1995 to 1997 and 1999 to 2002.

Because a firm can have multiple bond issues in a given year, following prior studies we included only one issue in a given year to control for confounding effects other than credit risk (Gu 2005; Shi 2003).[5] Note that 1995 was the year in which investments in IT, including the Internet and commercial enterprise software, began to rise dramatically in the U.S. and U.S. public firms had to disclose their year Y2K budgets in their financial statements beginning in 1999 (Anderson et al. 2006; McAfee and Brynjolfsson 2008).

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[1] Bond rating and yield spread are highly correlated to each other. But, using both variables allows us to better understand the role of IT investment in determining the yield spread. For example, we can investigate whether IT investments influence the risk premium directly or indirectly through default risk.

[2] For more information on credit ratings, refer to Frost, C.A. 2007. "Credit Rating Agencies in Capital Markets: A Review of Research Evidence on Selected Criticisms of the Agencies," *Journal of Accounting, Auditing & Finance* (22:3), Summer2007, pp. 469-492.

[3] We do not study seasoned bonds to avoid problems such as lags in ratings revision and lack of bond yield data.

[4] Our sample includes 54% bonds with callable options in our final sample and consistent with previous literature, we use a dummy variable in our models to control for differences in types of bonds.

[5] One can pick the first issue or the largest one of a given year; both provide similar results in our analysis. We select the largest issue of a firm in a given year for our main results.

Variable Definition

Our first dependent variable is the bond-specific credit rating. Bond rating is defined as the average of both Moody's and Standard and Poor's (S&Ps) bond ratings just after the date of issuance. For purpose of our analysis, the multiple ratings were aggregated into seven categories in a way that AAA-rated bonds are assigned a value of 7 and D-rated bonds are assigned a value of 1 (Ashbaugh-Skaife et al. 2006).[6]

Our second dependent variable is yield spread defined as the difference between the yield to maturity on a corporate bond and the yield to maturity on a U.S. government bond with the similar maturity (Anderson and Mansi 2009). In the bond market, U.S. government bonds are expected to be the least risky debt investment and, in turn, provide the lowest returns to holders. Therefore, the spread reflects the risk premium that investors required for taking the risk that an issuer might not observe its debt obligations. Since the distribution of the yield spread was skewed positively, yield spreads were log-transformed in our study.

We used IT budgets for the current survey year as a proxy for an IT investment. This included expenditures for hardware, software, and IT personnel. In our analysis, a level of IT investment was scaled by sales to control for firm size and log-transformed for normality.[7]

InformationWeek 500 divided companies into 20 to 22 industries during 1995-2002. We made 18 broader industry groups by aggregating similar industries which have the same strategic role of IT assets shown on Chatterjee et al. (2001). To categorize the entire economy into three different groups based on the industry IT strategic role-automate, informate, and transform, we used the industry categories during 1995 to 1998 period suggested by Chatterjee et al. (2001). Since they did not cover the entire industry, we adopted the level of IT-driven transformation proposed by Anderson et al. (2006) for missing industries. We applied the industry categorization during the 1995-1998 period to the later 1999-2002 period. Any bias from changes in the level of IT-driven transformation through the latter period would make our findings more conservative (Dehning et al. 2003). Our industry classification is, to some extent, empirically supported by Dewan et al. (2007). For example, the transform industries (Airlines, banking and financial services, media, professional services, and telecom industries) in our sample are among industries that exhibit high IT risk in their paper. Also, they show that high IT risk sample accrue a higher marginal return than low IT risk sample. Thus, these imply that our transform industries are likely to get high returns from IT investments with high risk, which is consistent with our arguments.

Our analysis included two sets of variables that controlled for firm specific and bond issue specific characteristics, which prior studies have suggested as determinants of credit risk. Using data from Compustat, we controlled for firm size and financial risk such as leverage, profitability, interest coverage, and firm risk. Size is operationalized as the natural logarithm of total assets. Larger firms are expected to have lower credit risk and hence lower risk premiums. Leverage is the firm's financial leverage, defined as its long-term debt divided by total assets. Higher leverage results in a higher risk of going into default, thereby increasing yield spread. Interest coverage is calculated as the ratio of the sum of operating income and interest expense to interest expense. The higher interest coverage, the higher the default risk and risk premium. Profitability is defined as the ratio of earnings before interest, taxes, depreciation, and amortization divided by total assets. Profitability is expected to be negatively associated with the cost of debt. Firm risk is measured as the firm's standard deviation of the cash flow ratio for the past five years. The higher this risk is, the higher the cost of debt financing is (Minton and Schrand 1999). As in prior studies, we also controlled for R&D intensity and advertising ratio (Anderson and Mansi 2009; Shi 2003). For some firms in the sample, R&D and advertising variables are missing and we retain these observations setting R&D and advertising expenses equal to zero as in prior work(Fee et al. 2009).

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[6] One can categorize multiple ratings into twenty two categories and the results using twenty two categories are quite similar to those by seven categories in our sample.

[7] The results are qualitatively similar if the investment variables are scaled by total assets.

Table 1 Variable definition

Variables	Definition	Data Items	Source
IT Intensity	IT projected spending as a percentage of revenue	IT budget	IW 500
Spread	Difference between the yield of benchmark treasury issue and the issue's offering yield expressed in basis points	treasury_yield	Mergent FISD
Bond Rating	Average of both S&P and Moody's bond ratings based on a numerical conversion process in which AAA-rated bonds are assigned a value of 7 and D-rated bonds are assigned a value of 1	rating	Mergent FISD
Firm Size	Firm's total assets	Ln(data6)	Compustat
Leverage	Ratio of long-term debt to total assets	data9 / data6	Compustat
Profit	Ratio of earnings before interest, taxes, depreciation, and amortization divided by total assets	(data172 + data14 + data15 + data16) / data6	Compustat
Interest coverage	The ratio of the sum of operating income and interest expense to interest expense	(data178 + data15) / data15	Compustat
Firm Risk	Firm's standard deviation of the cash flow ratio for the past five years	Sqrt[$\Sigma\{(\frac{data308}{data9}) - (\frac{data}{dat}$	Compustat
R&D Intensity	R&D expenses as a percentage of total sales	Data46/data12	Compustat
Advertising Intensity	Advertising expenses as a percentage of total sales	Data45/data12	Compustat
Maturity	Number of years to maturity date	offering_date;maturity	Mergent FISD
Amount	Par value of issued bond	Ln(offering_amount)	Mergent FISD
Redeemable	Whether the bond is redeemable under certain circumstances, (1=yes, 0=no)	redeemable	Mergent FISD
Subordination	Whether the bond is senior subordinated, (1=yes, 0=no)	security_level	Mergent FISD
Investment Debt	Whether the bond is investment-grade, (1=yes, 0=no)	rating	Mergent FISD

Note: data6=total assets, data9=total long-term debt, data12=sales, data14=depreciation and amortization, data15=interest expenses, data16=income taxes, data45=advertising expenses, data46=R&D expenses, data172=net income, data178=operating income after depreciation, data308=net operating cash flows.

The main contract terms for bonds that we analyzed are the maturity, issue size, security level, and redeemability. The maturity is a bond's maturity period stated in years and is thought to be positively associated with credit risk. Issue size is the size of a bond issue which is measured as the natural logarithm of its issued par value. This variable is viewed as a measure of liquidity which is negatively associated with yield spread. We controlled for security level of an issuance. *Sub* is a dummy variable that equals one if the bond issue is compiled as senior subordinated. Subordination bonds are expected to have higher risk premium. *Redeemable* is a dummy variable that is equal to one if the bond has a call option. The call provision bears interest risk to the bondholder, so it is positively associated with the cost of debt variables. To allow for a nonlinear relationship between credit ratings and yield spread, we also included a dummy variable that has a value of 1 when the bond is investment-grade and 0 if otherwise. Finally, we included industry dummies and year dummies in our regression models to control for the heterogeneities in firm-specific and issue-specific characteristics across industries and over time. Table 2 describes variables definition and denotes data items for each variable.

Summary Statistics

Tables 2 and 3 provide the descriptive statistics for the variables used in the sample. To minimize potential effects of outliers, we winsorized all continuous independent variables at the top and bottom percentiles in our analysis. Looking at the descriptive statistics in Table 3, the mean level of the IT budget in the sample for issue-level is 2.55% of sales. But, IT investments made by firms in our sample exhibits a wide variation in the magnitude from 0.33% to 22% of total revenues for the issue-level sample. The average bond rating is 4.56 (equating to S&P ratings between BBB- and BBB+). Interestingly, the minimum rating of the bond rating is B+, which indicates that only firms with certain levels of quality attempt to issue a public bond. The yield spread in our sample has a mean of 139.85 basis points and minimum and maximum values of 3 and 728, respectively.

Table 2 Summary statistics

Variables	N	Mean	Median	St. Dev.	Min	Max
IT Intensity (in %)	253	2.55	1.90	2.76	0.33	22
Bond Rating	253	4.56	5.00	0.92	2	7
Spread (in basis points)	253	139.85	104	115.23	3	728
Firm Size (asset in million $)	253	13,558	7,314	22,353	642	258,329
Leverage	253	0.25	0.25	0.12	0.02	0.63
Profit	253	0.14	0.14	0.07	-0.07	0.31
Interest Coverage	253	8.16	5.92	7.58	0.8	59.56
Firm Risk	253	0.54	0.18	1.62	0.02	13.64
R&D Intensity (in %)	197	2.33	0.78	3.90	0	27.21
Advertising Intensity (in %)	62	3.44	2.20	3.02	0.44	13.42
Maturity (in years)	253	14.59	10.01	16.73	3.00	100
Amount (in million $)	253	765	300	6,273	50	10,000
Redeemable	253	0.54	1	0.50	0	1
Subordination	253	0.04	0	0.19	0	1
Investment Debt	253	0.88	1	0.32	0	1

The mean of total assets in the issue-level sample is $13.6 billion with a standard deviation of $22.4 billion. The mean leverage ratio is 0.25. The average firm has a profitability ratio of 0.14 in the sample and an interest coverage of 8.16. Firm risk which represents volatility of cash flows is, on average, 0.54. In terms of bond-specific characteristics, the mean debt has a maturity of 14.59 years and an issue size of $765 million. 54% have a callable option and subordinated debt comprises 4% of debt issuance during the sample period.

Table 3 provides the number of subsamples and IT intensity by industry. Based on the classification of industries suggested by Chatterjee et al. (2001), we also identified 18 industries as automate, informate, and transform industries. Five, eight, and five of 18 industry groups are classified as automate, informate, and transform, respectively. The data indicates that transform industries are generally IT-intensive.

Table 3 Industry segmentation data

Titles of industries	Industry Type	Primary two-digit SIC Code	IT budget intensity	Firm-Year Observations	%
Metals & natural resources	A	10, 26, 33	1.36	26	10.3
Manufacturing (auto, building materials, etc.) & construction	I	15, 25, 26, 32, 37	2.10	53	20.9
Consumer goods	I	20, 23, 28	2.32	27	10.7
Transportation (Ground & railroad)	A	40,41, 42	2.84	11	4.3
Airlines	T	45	6.63	2	0.8
Banking & financial services	T	61,62	7.16	7	2.8
Insurance	A	63	4.54	14	5.5
Chemicals & petroleum refining	I	28,29	2.00	18	7.1
Utilities	A	49	2.00	17	6.7
Electronics	I	36, 38	3.51	6	2.4
Retail	I	50-55, 59	1.09	26	10.3
Healthcare	I	38, 80	2.49	7	2.8
Media services	T	27	2.80	8	3.2
Pharmaceuticals	I	28	3.37	11	4.3
Computer manufacturing	A	35	3.47	2	0.8
Professional services	T	73	3.44	9	3.6
Telecom	T	48	6.06	7	2.8
Hotels, restaurants & services	I	70, 72	1.56	2	0.8

Note: A=automate, I=informate, and T=transform. Industry type is determined by the strategic role of IT during 1995 to 1998 period as in Chatterjee et al. (2001).

Table 4 provides Pearson coefficients. The table shows positive associations of IT investments with bond ratings and also positive associations with yield spreads. The correlation coefficient is significant only for the bond rating. The correlation coefficients of control variables with dependent cost of debt variables generally show consistent results with prior studies. Firm size, profitability, and interest coverage are positively associated with bond and firm rating, while leverage is negatively associated. Regarding yield spread, the variables show opposite signs. Finally, two dependent variables, bond rating and yield spread, are negatively associated.

Empirical Model

We conducted multivariate analyses to test the association between IT investments and the costs of debt, bond ratings, and yield spread. The base models for testing the linkage of IT investment to bond risk variables are as follows (Anderson and Mansi 2009):

$$\text{Bond Rating}_{it} = \beta_0 + \beta_1 * I_{it} + \beta_2 * X_{it} + \beta_3 * Y_{it} + \beta_4 * \text{Time\_Dum} + \beta_5 * \text{Ind\_Dum} + \varepsilon_{it} \quad (1)$$

$$\text{Log(Spread)}_{it} = \beta_0 + \beta_1 * I_{it} + \beta_2 * X_{it} + \beta_3 * Y_{it} + \beta_4 * \text{Time\_Dum} + \beta_5 * \text{Ind\_Dum} + \varepsilon_{it} \quad (2)$$

where the subscript represents firm (bond) i in year t. I represents IT intensity of each firm, and X and Y include vectors of firm-specific and bond-specific characteristics that potentially affect the costs of debt financing. We conducted ordinary least squares regression based on the pooled sample. Since some of the firms in our sample had multiple observations over the study period and thus residuals are autocorrelated, we used cluster-robust standard errors estimation to allow for correlation within observations from the same firms but in different years (Gow et al. 2009; Petersen 2009). The standard errors clustered by firm are unbiased whether the firm effect is fixed or not (Petersen 2009). Since the bond rating is ordinal, we also conducted ordered probit regressions to estimate coefficients and standard errors resulting in nearly identical results (not reported due to space constraints).[8]

The residuals in Equations (1) and (2) are likely to be correlated (Shi 2003). For example, macroeconomic shocks such as a change in a federal interest rate might influence both bond ratings and yield spread. Therefore, we also conducted the analyses using the seemingly unrelated regressions (SUR) model to improve estimation efficiency (not reported due to space constraints).

Table 4 Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Ln (IT Intensity)	1												
(2) Bond Rating	0.18^{a}	1											
(3) Ln (Spread)	0.03	-0.67^{a}	1										
(4) Ln (Firm Size)	0.21^{a}	0.36^{a}	-0.18^{b}	1									
(5) Leverage	-0.16^{c}	-0.50^{a}	0.36^{a}	-0.24^{a}	1								
(6) Profit	-0.06	0.30^{a}	-0.39^{a}	-0.29^{a}	-0.03	1							
(7) Interest Coverage	0.07	0.40^{a}	-0.28^{a}	0.03	-0.51^{a}	0.41^{a}	1						
(8) Firm Risk	-0.04	0.10	-0.09	-0.05	-0.29^{a}	0.07	0.45^{a}	1					
(9) Maturity	0.05	0.11^{c}	-0.11	0.05	-0.10	0.20^{b}	0.12	0.05	1				
(10) Ln (Amount)	0.20^{b}	0.09	0.03	0.57^{a}	0.04	-0.21^{a}	0.05	0.01	-0.07	1			
(11) Redeemable	0.11	-0.26^{a}	0.45^{a}	0.04	0.31^{a}	-0.10	-0.01	-0.08	-0.01	0.45^{a}	1		
(12) Subordination	-0.07	-0.42^{a}	0.29^{a}	-0.21^{a}	0.18^{b}	-0.05	-0.09	-0.05	-0.06	0.29^{a}	0.09	1	
(13) Investment Debt	0.13^{c}	0.71^{a}	-0.57^{a}	0.36^{a}	-0.31^{a}	0.13^{c}	0.10	-0.02	0.13^{c}	0.11^{c}	-0.17^{a}	-0.52^{a}	1

$^{a}p<.001$, $^{b}p<.01$, $^{c}p<.05$.

Results

The Impact of IT and Industry Heterogeneity

Hypothesis 1a predicted a positive association between IT investments and <u>initial bond ratings</u>, on average. We find support for Hypothesis 1a. Table 5 presents the results of estimating OLS and 3SLS models where the dependent variables are bond ratings and yield spreads. Results indicate that IT investments are likely to lead to better bond ratings (see column 2 of Table 5). The estimate coefficient on IT spending for the model is 0.099. Thus, one standard deviation (SD) increase (about 100% increase) in

[8] Small sample size also prevents obtaining reliable standard errors from the ordered probit regression and previous research shows that the probit model does not produce any better results than the simple linear model in predicting credit rating (Shi 2003).

IT intensity holding other variables at the mean values increases the bond ratings by 0.007, which corresponds to about a fourth of one notch (e.g., from BBB to BBB+). These results complement other studies showing the positive impact of intangible assets on the bond ratings (Anderson and Mansi 2009; Ashbaugh-Skaife et al. 2006). Interestingly, IT effect is comparable to R&D effect on the bond ratings in our sample. However, we do not find any effect of advertising intensity on the bond ratings.

We did not find support for hypothesis 1b because we fail to find a statistically significant association between IT investments and yield spreads (See column 5 of Table 5). This implies that the unconditional effect of IT investments on yield spreads is statistically insignificant. But, this does not necessarily mean that IT investments have no impact on the yield spreads. When we include bond ratings as an explanatory variable in yield spread models, we find that bond ratings reduce yield spreads (see Columns 7). Because earlier we showed that IT investments are positively related to the bond ratings, the results indicate that IT may have an indirect effect on the yield spreads through the bond ratings (Sobel test, t=-1.732, p<0.1).

One reason why we obtain different results for bond ratings and yield spreads for IT investments than those in prior studies based on R&D investments (Eberhart et al. 2008; Shi 2003) may be because of the power of rating agencies to have access to corporate inside information, such as IT investments (Kliger and Sarig 2000). Unlike R&D and advertising expenses, IT budgets are not required to be publicly disclosed. Thus, rating agencies can incorporate privately disclosed information into their ratings, whereas bond investors solely depending on the public financial statements and bond covenants may not have sufficient information on firms' IT activities when investing them. Alternatively, bond investors might have different perspectives toward IT investments and R&D investments.

Hypothesis 2a predicted that firms in industries where the transform IT strategic role dominates enjoy a less positive association between IT investments and initial bond ratings than those in industries where the automate or informate IT strategic role dominates. This hypothesis is supported by the results of Table 5. We find that IT investments have a more positive effect on bond ratings in the automate and informate industries than in the transform industries (see columns 3 of Table 5). Furthermore, IT investments are negatively associated with bond ratings in the transform industries. These results imply that IT may decrease default risk in the automate and informate industries through relatively certain expected benefits, while in the transform industries IT may raise the default risk. After dividing the economy into three broad groups, we find higher economic significance of IT investments in the automate and informate industries. The automate industries have the coefficient on IT of 0.272 in column (3), which suggests that for one SD increase in IT intensity, the bond rating increases on average by 0.2, almost equivalent to increasing an investing firm's bond rating by two-thirds of one notch (e.g, from BBB to BBB+).

We found some support for hypothesis 2b (See columns 6). Firms in the informate industries enjoy higher benefits from IT investments than those in the transform industries. Interestingly, bond investors appear to have less negative perspective toward transform typed IT investments than credit rating agencies do. For economic significance of these results, we calculated how much more a mean firm in the transform industry pays for its bond issuance. The coefficient of 0.145 suggests that one SD% increase in IT intensity increases the yield spread by 13.5bp, which amounts to higher interest spending of about $ 1.03 million because the mean amount of bond issuance is $ 765 million.

The finding that IT investments have the negative impact on the bond ratings and yield spreads in the transform industries is different from equity-based prior studies that IT plays a significantly positive role in the transform industries (Anderson et al. 2006; Dehning et al. 2003). This finding appears to reflect different perspectives of shareholders and bondholders toward risky IT investments in the transform industries. Since an increase in the variance as well as mean of future cash flows increases the equity value, stock investors tend to prefer transformative IT investments which are likely to increase the uncertainty of future cash flows. On the other hand, an increase in the variance increases the default risk, this can lead to reduced bond ratings and, thus, making bondholders demand higher risk premium.

The preceding analysis assumed that IT investments were exogenously determined. However, the decision to invest in IT assets and issue bonds may be endogenous and be influenced by some omitted variables that are not fully controlled in our model. One possible solution to address endogeneity as well as correlation of error terms is to use a three-stage estimation that relies on instrumental variables.

Table 5: Results of OLS and 3SLS estimation relating IT investments to bond rating and yield spread

	OLS								3SLS	
	Bond rating	Bond rating	Bond rating	Ln(Yield Spread)	Ln(Yield Spread)	Ln(Yield Spread)	Ln(Yield Spread)	Ln(Yield Spread)	Bond rating	Ln(Yield Spread)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ln(IT Intensity)		0.099*	-0.165		0.003	0.145*	0.031	0.099	-0.844***	0.380**
		(0.053)	(0.112)		(0.034)	(0.082)	(0.031)	(0.070)	(0.273)	(0.193)
Ln(IT Intensity)			0.437***			-0.150		-0027	1.140***	-0.527**
*Automate			(0.157)			(0.104)		(0.088)	(0.312)	(0.220)
Ln(IT Intensity)			0.246**			-0.182*		-0.112	1.099***	-0.404
*Informate			(0.123)			(0.094)		(0.085)	(0.405)	(0.286)
Bond Rating							-0.283***	-0.283***		
							(0.046)	(0.047)		
Ln(Firm Size)	0.182***	0.177***	0.178***	-0.016	-0.016	-0.023	0.034	0.028	0.209***	-0.024
	(0.046)	(0.046)	(0.045)	(0.051)	(0.051)	(0.051)	(0.047)	(0.048)	(0.047)	(0.033)
Profit	1.777**	1.712**	1.796**	-2.377***	-2.379***	-2.549***	-1.895***	-2.041***	2.603***	-2.638***
	(0.817)	(0.801)	(0.800)	(0.558)	(0.562)	(0.588)	(0.560)	(0.592)	(0.797)	(0.564)
Leverage	-0.804*	-0.773*	-0.569	0.599**	0.600**	0.593**	0.382	0.433	-0.543	0.425
	(0.436)	(0.428)	(0.441)	(0.282)	(0.285)	(0.300)	(0.270)	(0.277)	(0.436)	(0.308)
Firm Risk	-0.026	-0.027	-0.021	0.029*	0.029*	0.028*	0.022	0.021	-0.013	0.023
	(0.024)	(0.023)	(0.022)	(0.016)	(0.016)	(0.016)	(0.013)	(0.014)	(0.024)	(0.017)
Interest Coverage	0.025***	0.026***	0.026***	-0.007	-0.007	-0.006	0.001	0.001	0.023***	-0.006
	(0.007)	(0.007)	(0.007)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)
Ln(R&D Intensity)	0.140***	0.102*	0.115*	-0.093**	-0.094**	-0.077*	-0.065*	-0.044*	0.037	-0.086
	(0.051)	(0.057)	(0.059)	(0.037)	(0.037)	(0.041)	(0.034)	(0.037)	(0.117)	(0.083)
Ln(Advertising	0.543	0.470	0.555	-0.112	-0.115	-0.025	0.018	0.132	0.141	-0.087
Intensity)	(1.688)	(1.664)	(1.676)	(1.622)	(1.626)	(1.592)	(1.606)	(1.583)	(1.898)	(1.341)
Investment Debt	1.535***	1.508***	1.516***	-0.843***	-0.844***	-0.820***	-0.417***	-0.391***	1.407***	-0.824***
	(0.143)	(0.145)	(0.144)	(0.123)	(0.123)	(0.122)	(0.115)	(0.115)	(0.174)	(0.123)
Maturity	-0.003	-0.003	-0.003	0.007***	0.007***	0.007***	0.007***	0.007***	-0.003	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Ln(Amount)	-0.064	-0.051	-0.065	-0.203	-0.203	-0.198	-0.217	-0.217	-0.087	-0.186***
	(0.058)	(0.058)	(0.057)	(0.148)	(0.147)	(0.147)	(0.148)	(0.149)	(0.066)	(0.047)
Redeemable	-0.177**	-0.186**	-0.191**	0.109	0.109	0.114	0.056	0.060	-0.215**	0.119*
	(0.089)	(0.090)	(0.087)	(0.075)	(0.075)	(0.074)	(0.068)	(0.068)	(0.086)	(0.061)
Subordination	-0.209	-0.244	-0.218	-0.014	-0.015	0.008	-0.085	-0.053	-0.326	-0.011
	(0.185)	(0.185)	(0.188)	(0.151)	(0.149)	(0.149)	(0.139)	(0.137)	(0.250)	(0.177)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	253	253	253	253	253	253	253	253	253	253
R-squared	0.72	0.72	0.73	0.77	0.77	0.77	0.80	0.81		

Note: *Automate* and *Informate* dummies are used to control for industry heterogeneities. Clustered robust standard errors based on the Huber-White sandwich estimator in parentheses for OLS estimation. *** significant at 1%; ** significant at 5%; * significant at 10%

Following prior studies, we instrumented for firm-level IT investments using industry average IT investments for the 18 industries we examined (Lev and Sougiannis 1996; Shi 2003). Results of the instrumental variable approach for various specifications are shown in the columns 9 and 10 of Table 5. We find significant, different impacts of IT investments across industries. Besides, the coefficients are larger and more significant. Overall, the results indicate that endogeneity is not a serious problem in our analysis and we have stronger results for our hypotheses even after accounting for endogeneity.

Additional Tests

We conducted several additional tests (not unreported due to space constraints). First, we examine whether the impact of IT investments on the costs of debt differs by the rating grade of bonds. A firm, on average, defaults more on speculative-grade debt than on investment-grade debt. Hence, irrespective of the news (both good and bad) IT investments convey, holders of speculative-grade debt are more likely to be sensitive to the news than those of investment-grade debt. This is because corporate bond investors in speculative-grade debt face high default risk and, thus, IT investments are more relevant to them (Easton et al. 2009). The results suggest that IT has a positive impact on the bond ratings for firms with investment-grade bonds, while it has a negative effect for those with speculative-grade bonds. This implies that for speculative-grade bonds, the risk effect induced by IT investments dominates the benefit effect. This finding is consistent with higher sensitivity of speculative grade bonds to risk that prior studies also show (Easton et al. 2009; Eberhart et al. 2008).

Second, we examined potential nonlinearities in the relation between investments and the cost of debt measures by including the square term of IT investments. We did not find any nonlinearity in the effect of IT investments on the bond ratings and yield spreads.

Third, because IT investments are often viewed as proxies for growth options, one interpretation of our results may be that firms with more growth options are perceived as more risky by bond investors regardless of any risk effect of IT investments. To rule out this explanation, we included annual market-to-book ratios to proxy for growth opportunities (Minton and Schrand 1999; Shi 2003) and obtained broadly similar results.

Finally, we examined whether financial distress is potentially associated with investment decisions as well as the costs of debt. We considered firms financially distressed if they have a speculative grade debt (Minton and Schrand 1999) and removed the firms from the sample. We obtained qualitatively similar results to those reported in Table 5. Thus, financially distressed firms do not appear to drive the results.

Discussion

Findings

This study provides several new insights. First, we find a significant association of higher IT investments with better bond ratings, which means that firms investing in IT assets enjoy a higher credit rating. This also implies that, from the perspectives of credit rating agencies, the expected benefits arising from IT investments dominate the IT risks effect. IT investments also have an indirect impact on yield spreads through the positive association between IT investments and bond ratings.

Second, our results suggest that IT's impact on the costs of debt is different across industries. IT has a positive influence on the bond ratings of issuing firms in automate and informate industries, while it has negative impacts in transform industries. The differential impact of IT across industries holds even after we controlled for endogeneity. Negative impacts of IT in transform industries is somewhat different from the prevalent view that transform industries enjoy higher returns to IT investments than other types of industries.

Implications for Research

First, this study complements prior studies that show a positive association between IT investments and the market value of firms in equity markets to assess the effect of IT investments on total firm value. The equity-based positive returns from IT investments do not necessarily mean an increase in total firm value and may just reflect the transfer of wealth from bondholders to stockholders. Thus, our study complements equity-based prior studies to lend support for the positive effect of IT on total firm value.

Bond markets also provide a complementary way of assessing risk-adjusted returns of IT investments, thus complementing the work of Dewan et al. (2007) who estimate IT risk as one determinant of the overall firm riskiness represented by the variability of stock returns and earnings.

Second, our study shows that bond investors and equity investors have different perspectives toward IT risks and investments. The previous literature based on the stock market suggested that equity investors are favorably disposed toward IT-driven transformation. Our finding implies that bond investors prefer small but stable cash flows from IT automation to large but uncertain cash flows from IT-driven transformation. This finding suggests that it is important to look at the effect of IT investments across various stakeholders to get a more complete assessment of IT value.

Finally, our results show that IT investments have a direct impact on bond ratings, whereas they have little unconditional impact on yield spreads. This finding is different from prior studies showing the direct impact of intangible assets on both bond ratings and yield spreads (Anderson and Mansi 2009; Shi 2003). This finding suggests that rating agencies may have access to more information (i.e., corporate inside information, such as that on IT investments) (Kliger and Sarig 2000). Unlike R&D and advertising expenses, IT budgets are not required to be publicly disclosed. Thus, rating agencies can incorporate privately disclosed information into their ratings, whereas bond investors solely depending on the public financial statements and bond covenants may not have sufficient information on firms' IT activities.

Implications for Practice

Our study provides important implications for firms. Our findings suggest that IT investments are not only associated with a firm's performance, but also related to financing costs of the firm. Thus, senior managers may need to look beyond measuring the improvement in organizational performance driven by IT assets and should consider potential financial benefits of increased IT capabilities such as the willingness of corporate bond investors to accept lower financing costs.

In addition, our study shows that bond investors view IT investments in transform industries as risky and do not want to place lower premium on new bond issuance of investing firms, while firms in automate or informate industries enjoy the reduction in the costs of debt by investing in IT assets. Therefore, firms undergoing IT-driven transformation need to share more information on IT investments with bond investors and assure them that the investments will not hurt the stability of cash flow generation. Likewise firms replacing human labor with IT or using IT to empower managers and employees should also be more willing to disclose their IT initiatives to bond investors to benefit from the investors' preference toward stable cash flows to reduce the cost of debt financing.

For investors, our study suggests that IT investments can play an important role to influence bond markets and investors would do well to pay attention to the potential economic benefits of intangible assets such as IT capabilities.

Limitations and Suggestions for Further Research

There are several possible extensions to this study. First, our study does not directly address the question of whether IT investments increase the total firm value, although along with equity-based prior studies, our study appears to suggest this may be the case. Future research can address the impact of IT investments on both the equity and bond market at the same time.

Second, a significant portion of firms investing in IT do not issue bonds, thus they are not in our sample. The results hold only for the sample of the bond issuers with IT investments. It would be interesting to study how creditors assess the risk-return tradeoff of IT investments for firms that do not use public bond financing.

Third, our industry classification has limitations because firms within the same industry may employ IT for different strategic purposes, and the role that IT plays within a firm may change over time. Future research may distinguish different types of IT investments made by a firm and look at their impact on risk measures in the bond market.

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