Understanding Credit Risk: A Classroom Experiment

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Abstract: This classroom experiment introduces students to the notion of credit risk and expected return, by allowing them to trade on comparable corporate bond issues from two types of markets—investment-grade and high-yield. Investment-grade issues have a lower probability of default than high-yield issues, and thus provide a lower yield. There are three ways in which participants can earn money—from coupon payments, the face value of the bond, and by capital gains. While participating in an experiment, students learn about the notion of risk and return, how credit risk affects bond prices, the movement of bond prices through time, as well as other general characteristics of the bond markets.

One of the fundamental factors that determines bond yields is credit risk. This refers to the possibility of default by one of the counterparties in a financial transaction. Default can be triggered by a missed or delayed interest payment, bankruptcy, or a distressed exchange. The probability of default affects the future cash flows, and, in turn, the current market price of the security. Understanding the concept of credit risk, or more generally the connection between risk and return, is extremely important. It helps to evaluate the compensation that an investor would require for taking extra risk, as well as comprehend the effect of risk aversion on trading behavior. These are fundamental, yet challenging, topics to business, economics, and finance students and the purpose of our classroom experiment is to facilitate this learning process.

Within the bond market, there are a wide variety of instruments carrying various levels of credit risk. For example, investors can choose between Treasury or corporate bonds. Treasury bonds are considered risk-free because they are backed by the full faith and credit of the U.S. government. Consequently, they provide a lower yield than corporate bonds. On the other hand, corporate bonds carry credit risk, causing investors to demand a higher return on otherwise similar Treasury issues. Moreover, the corporate debt market can be further subdivided into the investment-grade market and high-yield (or junk) market.[1] The investment-grade market consists of issues by companies that usually carry a low level of credit risk, whereas the high-yield market consists of issues by firms that are more risky. Thus, within the corporate bond market, investment-grade issues trade at a higher price/lower yield than comparable high-yield issues.[2] Information on the credit status of borrowers usually is obtained from rating agencies such as Moody's, Standard & Poor's, and Fitch.[3]

This article describes a classroom experiment with the purpose of introducing students to the notion of credit risk and the connection between risk and return in financial markets. The

students trade on comparable issues from two types of markets—investment-grade and high-yield. Investment-grade issues have a low probability of default, whereas high-yield issues have a high probability of default. Consequently, there is a 1/20 and a 1/5 probability that an issue will default at the end of a period, for the investment-grade and high-yield sector, respectively. To compensate for the higher risk, junk issues provide a higher yield (coupon). Every trader is endowed with an equal number of securities from both sectors, as well as an amount of cash that is used for trading purposes.[4]

This experiment can be applied to a number of MBA or upper-level undergraduate courses in business, economics, and finance—financial management, investments, fixed income securities, portfolio management, or microeconomic theory. It helps students not only in understanding credit risk, but also how risk is priced, the notion of risk and return, and the effect of risk aversion on returns. Furthermore, it helps instructors to facilitate discussions on other important topics such as the time value of money, the mechanics and general characteristics of the corporate bond market, as well as various market trading strategies.

The remainder of this article proceeds as follows. The next section presents some selected papers related to this classroom exercise. They are intended to provide further references and follow up reading. The following section describes the experimental design and procedures. Results and experience from the experiment thus far are provided in the next section, which also gives guidelines for classroom discussion. The last section concludes.

RELATED LITERATURE

There is a vast experimental literature that tackles various issues in financial markets, at both the research and teaching level. In their seminal papers, Forsythe, Palfrey, and Plott (1982) examined the progression of asset prices through time using laboratory experiments, while Smith,

Suchanek, and Williams (1988) first documented the existence of price bubbles. Plott and Sunder (1988) used laboratory markets to examine how information is aggregated when traders have diverse information. Ball and Holt (1998) designed a classroom game that compares the traded prices of an asset to its fundamental value. When traded prices rise above this value, bubbles and subsequent crashes can develop. Dufwenberg, Lindqvist, and Moore (2005) revisited the concept of bubbles in laboratory financial markets that contain a mixture of experienced and inexperienced traders to examine whether the presence of the former eliminates bubbles. Oechssler, Schmidt, and Schnedler (2007) used an experiment to investigate whether bubbles can actually occur without the existence of dividends. While there are many other excellent papers studying laboratory asset markets, we only present a few which we believe provide natural follow-up readings for interested instructors and students or which are well-suited for more advanced classes.

EXPERIMENTAL DESIGN AND PROCEDURES

The setup for this experiment closely follows that of Ball and Holt (1998). The exercise takes about 75 minutes, depending on class size. You can always shorten the exercise by decreasing the number of trading periods. However, it is essential to announce the true number of periods before the start of the experiment as this might affect the strategies employed by students. You also can have a short discussion at the end of the experiment, or during the next class.

Some preparation must be done before the class begins. You should prepare copies of the instructions to be given to each student at the beginning of the experiment. You will need to prepare record sheets for each trader to complete during the experiment.[5] You also should record all decisions on the board. At the same time, you should have one of your student assistants keep track of all the information that you record on the board. This minimizes the possibility of

recording errors and allows the preservation of the data. This is particularly important when you record bids and asks on the board and erase them after every transaction and every period. Then at the end of the session, your assistant can transfer all relevant information into a spreadsheet prepared specifically for this experiment, which is available upon request or can be downloaded through the authors' websites. In the spreadsheet, you can record all the quotes and transaction prices, as well as the number of assets held and cash in hand available to each player at the end of each period. Once you enter the necessary information for every period, it is then pre-programmed in such a fashion that provides you with summary statistics and figures instantaneously. This file can be used for the purpose of class discussion either in the current or next lecture, and can be emailed to the class. This will allow the students to carry out additional tests and answer a variety of homework questions.

You will also need an empty jar to perform a raffle, otherwise you can use 5-sided and 20-sided dice. You can use blue and red colored sheets of paper to represent the two assets. You will need three blue and three red sheets of paper for each trader's endowment of assets. Each trader also starts with 400 points cash account to finance trading. Although you can opt not to give out any money payments (announce that all profits are hypothetical), we encourage you to provide some monetary rewards. You can use an exchange rate to convert the experimental points into real currency to keep the rewards at a reasonable level. This makes the experiment more interesting to students and makes their decisions salient. Table 1 provides a summary of the experiment.

[Insert Table 1 about here]

If it is impossible to have each student as a separate trader, you can divide the class into groups of two or three students each. It is usually better to have an odd number of students per

team, with majority vote deciding the outcome if decisions cannot be made unanimously. Using multiple people per team can also provide opportunities for students to get help from team members, share ideas, and discuss strategies.

Each student, or team if necessary, will represent a "trader" in this experiment. Codes on the instruction sheets are pre-marked to identify the traders and save time. Pass out the instructions to students, read them aloud, and at the conclusion of instructions go through the columns of the record sheet with the students to ensure understanding. Clearly explain the auction rules. Answer the students' questions and clarify the objective of the exercise, which is to earn as many points as possible. However, make sure not to suggest any trading strategies as this could compromise the results and learning objectives. In case of teams with multiple members, separate the markets physically to avoid confusion about who belongs to which team and to prevent teams from communicating and colluding with one another. You will need two student assistants for this experiment. One assistant can help with keeping time and performing the raffle at the end of each trading period. The second will be responsible for keeping track of the information that you record on the board.

There are three ways in which the trading teams can earn money: 1) A 5- or 20-point dividend (coupon) is received for each existing blue and red asset at the end of each trading period, respectively, 2) they can make profits by buying and selling assets, and 3) the traders receive 100 points cash for any assets (both blue and red) that survive until the last trading period (face value of the bond). The experiment consists of nine trading periods, with the first one used for practice. This helps the students to get acquainted with the terminology and the rules of the experiment. In shorter classes, we recommend setting up the experiment for five or six periods. Each period lasts three minutes. The timekeeper should inform the class of the time about 30

seconds before the end of the period. Approach all trading teams that own red or blue assets at the end of each trading period, after the dividends for that period have been paid, and do a raffle (using a jar which includes numbers from "1" to "20") where a pick of "1" results in the destruction of the blue asset while a pick of "1," "2," "3," or "4" will result in the destruction of the red asset. Picks of any other number will allow the owner to keep or trade that asset in the next period. As already mentioned, any asset that is not destroyed by the end of the last period will be redeemed for 100 points. Have each trader calculate and record their profits and cash balance on the record sheet each period, while your assistant determines the failures of each asset. The instructions provided on the website explain in detail how to fill out the trader's record sheet.

The experimental setup employs oral double auction as the trading institution. More detailed description of the auction rules, along with examples, can be found in the instructions. There are two simultaneous asset markets—one for *blue* and one for *red* assets. Record the two markets on the board, clearly indicating which market is blue and which one is red. You will then record the bids and asks that each team submits and announce the transactions. Once the trading period begins, each trader is free at any time to raise a hand, and when called on, to take one of the following actions: submit a *bid* expressing a commitment to buy a blue or red asset at a certain price; submit an *ask* expressing a commitment to sell a blue or red asset at a certain price; accept the *bid* submitted by another trader, and thus making a transaction to sell; or accept an *ask* submitted by another trader, and thus making a transaction to buy. In addition, each action by a trader has to identify the asset it is related to. The auction is moderated by the instructor who records the bids and asks on the board and announces the transactions. The auction follows the bid/ask improvement rule; i.e., each successive bid has to be higher than the previous one and

each successive ask has to be lower than the previous one. Short sales are not permitted; i.e., traders cannot sell an asset that is not in their possession. Traders are allowed to make a purchase only if they have enough cash in hand.

A possible modification or variation to the existing setup is to introduce a third asset that has zero probability of default and consequently has a lower coupon rate. This asset will symbolize a Treasury security and will give the students a better perspective of the type of assets that can be found in the bond market. Another variation is to allow students to short-sell. One of the growing markets in the United States and abroad is the *repo* market, where Treasury or agency securities are received as collateral for lending money. The borrowers of money at the end of the repo term have to pay back the loan plus a collateral rate (repo rate). The other party, on the other hand, has to return back the collateral. Short-sellers are using these collateral securities to close out their short positions. Again, this modification may make the experiment more in line with the current setup of the bond markets and introduce the students to the notion of short-selling. Other modifications could involve the use of bonds with the same credit risk but different maturities, or bonds with option-like features, such as callable, or putable bonds. On the authors' webiste there is a brief description of how to modify the existing setup to accommodate the above suggestions (Appendix A). However, we believe that these variations, although interesting and appealing, might compromise the simplicity of experiment and the ease of understanding the notion of credit risk, or risk and return. Therefore, we recommend running them only as a follow-up to the current classroom exercise.

RESULTS AND CLASSROOM DISCUSSION

We conducted two experimental sessions with two distinct groups of students from the MBA class of 2009 at SKK GSB. Each session consisted of eight students where each participant

represented a separate trader. The experiment lasted 75 minutes including the initial instructional period. After the initial practice period, eight more periods were carried out. At the end of the experiment, each student was paid an amount of money that was computed based on their performance; i.e., cash in hand at the end of the eight periods. The points were exchanged into USD using an exchange rate of 50 points = 1 USD. Students earned an average 19.80 USD. Three figures presenting pooled results from the two sessions can be found on the authors' websites (Appendix C). Figure 1 depicts the average transaction price per period, figure 2 shows the number of transactions, while figure 3 presents the range of the bid–ask spread per period for each of the two type of assets.

Figure 1 shows that, on average, the blue asset traded close to its fundamental value (100) throughout the experiment. The red asset on the other hand traded at each period above the price of the blue asset, a sign that traders feared the higher risk of the red asset and demanded a higher compensation. Furthermore, as we approach the end of the experiment (maturity of the issues), the transaction prices for both assets gradually move towards their fundamental value. This is the pattern often observed in the actual market, that is, the price of a security might be trading above (premium) or below par (discount) but as the security approaches maturity, its price converges to the par (face) value. From figure 2, one can see that the number of transactions decreases as we get closer to the maturity date. One reason is that there are less securities available for trading due to default. Another reason, however, could be that there is less trading (or liquidity) since the assets are close to their maturity date. This pattern of behavior can actually stimulate a discussion on topics such as the liquidity of corporate bonds and the "on-the-run/off-the-run" pattern.[6] Figure 3 shows a wide range of bid–ask spreads, with the average level being higher on average for the red asset compared to the blue asset. All of the figures and summary statistics are

provided through the online spreadsheet.

The classroom discussion can start by asking the students what they think about the expected value of the two assets. To help them, you can first focus the discussion on the value of the two assets at the end of the last period, and then work backwards. There should be a clear understanding and agreement that if the two assets survive by the end of the last period, then their value is 100. Working backwards, after the last payment has been made but before the final draw, you should explain that the value of either asset should be again 100; $5 + 0.95(100)$ for the blue asset, and $20 + 0.8(100)$ for the red asset. This approach should be continued until it becomes clear to the students that both assets have the same flat, fundamental value throughout the experiment. This implies that a risk-neutral investor should not pay more than 100 for each asset. However, investors have different levels of tolerance to risk. Thus, the risk-loving investors might want to exploit the risk and rewards provided by the red assets, whereas the risk-averse investors might prefer the relative safety provided by the blue assets. It should be made clear to the students that in the current setup, risk is fairly priced. In other words, the level of risk is known in this setup and investors are properly compensated. Then, based on their level of risk aversion they can decide on an appropriate strategy. This discussion can lead to an introduction of "bubbles" in the market, where securities are trading above their fundamental values until the market corrects this pattern.

A new discussion also can begin on how to invest in credit markets, as well as the main types of risk of which traders should be aware. Credit risk is one type of major risk in credit markets, but definitely is not the only one. That is the reason traditional credit risk models are not able to capture the type of yield spreads (difference between the yield of a corporate bond and the yield of a comparable Treasury security) observed in the economy. Liquidity risk as well

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as differential taxation between Treasury and corporate bonds are other candidates for sources of risk. Therefore, it is difficult to exactly pinpoint the discount rate that should be used to price a corporate bond. However, once investors decide on an appropriate level of risk inherent in different securities, they can devise their trading strategies based on their risk preferences. Some investors might want to exploit the risk and subsequent high returns of risky securities and therefore invest only in high-yield bonds, while others prefer the low risk-return combination of investment-grade issues.

Another discussion can relate to the level and components of the bid–ask spreads. Although in this setup there is no dealer (market maker) and investors are only trading among themselves, in the real world the bid–ask spreads (transaction costs) are the reward to the dealers for creating a market. One part of that reward is the inventory risk faced by the dealers. In other words, dealers need to keep an inventory to facilitate the buy/sell transactions with investors, and thus are exposed to price fluctuations. Another component of the bid–ask spread relates to information risk. Dealers might be transacting with informed investors and thus need to be compensated for this exposure. The last known component of the bid–ask spread is due to the market power of the dealers who are able to increase the level of the bid–ask spreads in specific occasions (such as during a liquidity crisis) accordingly.

A final discussion can relate to the movement of bond prices through time. As noted above, it is common to see in the real markets securities trading above or below the face value. But as they approach maturity, prices move towards the face value. Equation (1) depicts the price of a bond:

$$P = \sum_{t=1}^{n} \frac{C}{(1+y)^t} + \frac{M}{(1+y)^n} \tag{1}$$

where n represents the number of periods remaining to maturity, C stands for each

coupon payment, *M* is the maturity (face) value, and *y* is the discount rate per period. Observing the above equation, one can see that the reason for the movement of the price towards the face value is two-fold—first, less coupon payments remain as we approach maturity, and second, the discounting for the remaining payments occurs for a shorter period of time. Expressing this in a more intuitive way, because the only payment that you will be receiving immediately after the final coupon payment is the face value, then why should you pay anything more than this amount? The instructor can use the above intuition to explain to the students the pattern observed in our sessions.

CONCLUSION

Understanding the concepts of credit risk, risk and return, and the effect of risk aversion on trading behaviors are challenging topics for business, economics, and finance students. This simple exercise aims to facilitate the learning process as well as to help students understand the general mechanics and classifications of the bond market. It can also stimulate a discussion on bubbles and speculation. More sophisticated setups could involve the ability to short-sell, the introduction of a third asset with zero credit risk symbolizing the Treasury market, the introduction of bonds with different maturities, or bonds with option-like features; i.e., callable, putable bonds. However, we believe that the simplicity of this basic setup is important for helping students comprehend these basic, but difficult, concepts of financial markets.

NOTES

[1] Within each subgroup, there are further divisions. For example, within the investment-grade sector, there are AAA, AA, A, and BBB-rated issues. The high-yield sector consists of BB, B, CCC, CC, and C-rated issues.

[2] Although in practice corporate yields carry also a nondefault component (maybe due to differential taxation or liquidity issues), for the purpose of this experiment we assume that differences in prices/yields are only due to credit risk.

[3] See Fabozzi (2010) and Sundaresan (2002) for excellent expositions regarding fixed income markets.

[4] The design is similar to that of Ball and Holt (1998) where the assets have the same fundamental value throughout the experiment; i.e., flat value. However, unlike Ball and Holt (1998), in this experiment we have two assets with different levels of risk and reward.

[5] The instructions, sample record sheet and recording sheets that cover periods one through eight, as well as any other relevant materials are available upon request, or can be downloaded through the authors' websites: *http://www.econ.canterbury.ac.nz/people/servatka.shtml or http://web.skku.edu/~georghio/,* under the *research* section (there is a link related to relevant resources for this experiment).

[6] Usually older bonds that are closer to maturity are considered less liquid, while the most liquid are the "on-the-run" securities (most recently auctioned). Once a bond ages (becomes "off-the-run"), it usually gets into "buy-and-hold" investors' portfolios and becomes idle until it matures.

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TABLE 1: Summary of the Experiment

Course	Financial Management, Investments, Fixed Income Markets, Portfolio Management, Microeconomic Theory
Level	Undergraduate, MBA
Subject	Credit Risk, Risk and Return, Bond Market Mechanics, Trading Strategies, Risk Aversion
Class size	8 or more students
Time	75 minutes, depending on class size
Variation	Addition of a third type of security (Treasury), ability to short-sell, securities with same credit risk but different maturities, callable and putable issues
Requirements	Blue and red paper; for a class of 8 traders, you need 24 blue and 24 red assets Empty jar to perform a raffle; otherwise, a 5-sided and a 20-sided die Online spreadsheet, instructions, sample record sheet as well as recording sheets that cover periods one to eight (available upon request, or downloaded through the authors' website)