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4-X: The Game of Global Exchange

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We develop and discuss a simple board game, "4-X" that provides students a tactile, experiential learning opportunity in foreign currency exposures. Students form a portfolio of foreign currency receivables and payables, make hedging decisions, periodically settle positions, and mark A/R and A/P positions to market. As a simple experiential learning approach, the game offers several potential benefits and may be made into a more complex simulation through instructor modifications.

Keywords: Hedging, game, foreign currency, pedagogy, derivatives

Introduction

As businesses continue to globalize and economic distance continues to shrink, the breadth and depth of educational needs of business and finance students expand. According to the College Board (2019), 509 colleges in the United States offer bachelor's degree programs in international business, excluding many others offering significant but lesser programs, like major options or concentrations. The latest AACSB International (2018) business accreditation standards recognize the importance of globalization education in Standard 1.C: "The school must demonstrate a commitment to address, engage, and respond to … globalization of economic activity across cultures" (p. 7).

One important topic area in international business and trade is the financing of international transactions, including the management of working capital that is denominated in a foreign currency. Typically, the decision whether to hedge, and the hedge selection and implementation decisions are applied to foreign currency payables and receivables, and standard international finance textbooks include at least one chapter on hedging receivables/payables exposures to reduce transactional risk, if not making hedging the focus of the whole text.

The hedging decision is very important for any international enterprise, but it is also a challenging topic for students. For mastery of the subject, a student needs to learn the types and characteristics of various hedging products and techniques (derivatives, for example) and the techniques of identifying and measuring foreign currency exposures. These knowledge and skill sets then must merge into the whether to hedge and hedge selection and implementation decisions.

It is very common for students to have difficulty with the concepts and characteristics of derivative products upon their first classroom exposure to same. To make matters more challenging, financial and currency futures trade on intangible underlying assets; the student of agricultural and industrial hedging has the advantage of a familiar, tangible underlying asset (e.g., a load of soybeans or steel with fluctuating value) to associate with the derivative product. Standard textbooks present techniques of identifying and measuring currency exposures, but often do so in

a disjoint manner with stand-alone illustrations and practice problems. These problems do not allow for a dynamic development of one or multiple exposures over time.

In this paper, we present and discuss a simple board-type game, "4-X," in which students build and manage a portfolio of foreign currency-denominated working capital items. The game provides students with a simple, succinct, and interactive tactile simulation during which they make decisions and see the effects of currency fluctuations and hedging decisions on firm value. The paper proceeds as follows: First we provide a brief background on the use of games in teaching and learning. Second, we describe the 4-X game and mechanics of play, followed by a discussion of specific pedagogical aspects and specifications of the game. Lastly, we present results of beta tests of the game as a classroom assignment and then provide suggestions for instructor modification of the game and play to adapt to more basic or more advanced course situations.

Games in Teaching and Learning

Game-playing and simulation are very well established as effective mainstream pedagogical tools for business and financial management. Faria (1987) reports that approximately 5,000 US corporations use some form of game-based training for their employees. Tessema (1989) argues that student participation in stock market simulations is necessary in order to gain practical understanding and respect for the nuances of portfolio formation, monitoring, and revision. Mukherji, Ette-Nkwelle, and Streeter (2018) summarize results from several studies finding finance pedagogical benefits from game-playing and simulation, including increased motivation (Weiser and Schug, 1992), improved student learning and satisfaction (King and Jennings, 2004), and higher-order learning - i.e., Bloom's application and above - (Jankowski and Shank, 2010). Faria and Weffington (2005) validate the teaching effectiveness of simulations and games, using a very large sample size (n = 2,000) for this type of research.

Off-the-shelf, online simulations like Fingame (for business financial management) and StockTrak (for investment trading and management) have long been available to instructors, but Waggle and Moon (2009) report that less than one-third of the syllabuses of applicable finance courses in AACSB-accredited colleges indicate usage of simulations. Common barriers to gaming use include their long-time duration (Philpot and Peterson, 1998), limited faculty time resources and student cost (Jankowski and Shank, 2010). In response, Mukherji, et al. (2018) propose and discuss approaches to one major simulation—StockTrak—that reduce faculty time requirement and student cost.

Board games offer as an alternative to lengthy simulations. Faria (1987) notes that most corporate training games at the time were not computer simulations (although such were available then), but board games and role-playing exercises. Wines (1996) posits that board games allow player-students to focus on particular learning tasks and topics, quickly providing multiple opportunities for decisions, actions, and feedback. Philpot and Peterson (1998) review the board game "Stock Market Specialist," which was published by the American Stock Exchange and describe their use of the game in financial markets courses, finding that students benefit from tactile participation in market-making and from interaction with peers. van der Laan Smith (2013) describes use of the UK version of a Monopoly® game board to teach accounting for foreign currency transaction and translation accounting between the US and UK, reporting positive student response and self-evaluation of learning.

Our proposed game, "4-X" is a purpose-developed board game designed to illustrate foreign exchange transaction risks and to allow students the opportunity to make and assess hedging

decisions. Unlike van der Laan Smith (2013), we allow students to accumulate exposures in up to three currencies and to hedge using three types of derivatives. Unlike previously described classroom futures simulation games (see Alonzi, Lange, and Simpkins, 2000; Damianova and Damianov, 2018), we focus play on working capital hedging decisions, rather than market mechanics and trading.

Game Play

4-X play revolves around a game board that simulates the first six months of a calendar year. (A PDF file with the game board printable on 11"x17" paper is available from the authors upon request.) Each player is given charge of a fictitious firm that has a balance sheet consisting of USD10,000 in cash and USD10,000 in equity capital. The firms are engaged in international sales and purchasing and will have receivables and payables denominated in up to three foreign currencies—the British pound (GBP), the Euro (EUR), and the Mexico peso (MXN). Players take turns rolling a die, progressing one time through the game board. Figure 1 shows the 4-X game board. The object of the game is to maximize the final USD value of net working capital and thus the value of the firm.

Play begins in January, with players taking turns rolling a single die. With each die roll, the player lands on a January space and collects a foreign currency exposure. For example, an initial die roll of 5 will give the player a MXP25,000 account payable due in February; an initial die roll of 1 will give the player a GBP500 account receivable due in March. Each exposure is added to the player's accounts receivable/payable ledger, shown in Figure 2. (Recordkeeping and marking to market can be facilitated by setting the ledgers up as a spreadsheet.) With 24 January spaces and a six-sided die, each player is assured of accumulating at least four exposures. Players reaching the WAIT space will not roll again until all players have reached the WAIT space.

At the WAIT space, players make their hedging decisions and take appropriate positions in derivative products. Three derivative products are available. Forward contracts are available on each currency with maturities of 30, 60, and 90 days; these will correspond to payables/receivables due in February, March, and April. The forward rates have a spread that is centered on the initial spot rate for the underlying currency. Futures contracts are also available on each currency. These contracts expire in March and June (corresponding to March and June receivables and payables) and specify delivery of 500 units (GBP and EUR) or 12,500 units (MXN) of the foreign currency. A ½ of 1% commission is charged for a futures trade. Monthly-expiring options are available on the three currencies. The option premiums increase with the time horizon and reflect the different volatility levels of the three currencies. Puts and calls are available with strike equal to the initial spot rate. Figure 3 shows the derivatives market available to players when they are at the WAIT space. At the WAIT space, the players decide whether to hedge exposures and take appropriate positions. For options and futures positions taken, premiums and commissions respectively are subtracted from the players' firms' cash accounts.

Figure 1
The 4-X Game Board

WAIT		MARCH	SETTLE	MAY	SETTLE
+M$15,000 FEB +€1,700 JUN	GBP $1.45 EUR $1.23 MXN $0.057	GBP $1.44 EUR $1.12 MXN $0.073	GBP $1.38 EUR $1.26 MXN $0.061	GBP $1.54 EUR $1.26 MXN $0.057	GBP $1.46 EUR $1.18 MXN $0.059
-€1,600 FEB -M$15,000 MAR	GBP $1.34 EUR $1.30 MXN $0.070	GBP $1.35 EUR $1.29 MXN $0.062	GBP $1.37 EUR $1.22 MXN $0.066	GBP $1.53 EUR $1.31 MXN $0.061	GBP $1.40 EUR $1.24 MXN $0.054
+M$25,000 MAY -£1,400 MAY	GBP $1.42 EUR $1.19 MXN $0.068	GBP $1.58 EUR $1.28 MXN $0.056	GBP $1.56 EUR $1.12 MXN $0.059	GBP $1.44 EUR $1.28 MXN $0.054	GBP $1.42 EUR $1.10 MXN $0.068
+M$20,000 APR +€1,600 APR +£1,200 FEB	GBP $1.46 EUR $1.25 MXN $0.056	GBP $1.45 EUR $1.29 MXN $0.054	GBP $1.48 EUR $1.19 MXN $0.065	GBP $1.45 EUR $1.31 MXN $0.067	GBP $1.39 EUR $1.11 MXN $0.066
+€1,100 JUN +£1,000 APR	GBP $1.43 EUR $1.23 MXN $0.056	GBP $1.33 EUR $1.16 MXN $0.060	GBP $1.42 EUR $1.11 MXN $0.053	GBP $1.40 EUR $1.11 MXN $0.053	GBP $1.60 EUR $1.19 MXN $0.058
+£800 FEB +M$15,000 APR	GBP $1.55 EUR $1.20 MXN $0.070	GBP $1.38 EUR $1.20 MXN $0.064	GBP $1.51 EUR $1.18 MXN $0.060	GBP $1.56 EUR $1.28 MXN $0.062	GBP $1.59 EUR $1.19 MXN $0.066
-£800 JUN -€700 FEB	GBP $1.34 EUR $1.30 MXN $0.069	GBP $1.56 EUR $1.16 MXN $0.054	GBP $1.57 EUR $1.25 MXN $0.066	GBP $1.47 EUR $1.30 MXN $0.065	GBP $1.44 EUR $1.15 MXN $0.075
-M$15,000 JUN +€700 MAR	GBP $1.49 EUR $1.28 MXN $0.056	GBP $1.50 EUR $1.10 MXN $0.065	GBP $1.34 EUR $1.18 MXN $0.061	GBP $1.47 EUR $1.23 MXN $0.055	GBP $1.52 EUR $1.11 MXN $0.056
+€1,100 MAR -£1,200 MAY -M$25,000 FEB	GBP $1.55 EUR $1.27 MXN $0.055	GBP $1.55 EUR $1.21 MXN $0.071	GBP $1.59 EUR $1.29 MXN $0.064	GBP $1.52 EUR $1.30 MXN $0.065	GBP $1.37 EUR $1.15 MXN $0.053
+M$30,000 APR -€1,300 MAY	GBP $1.50 EUR $1.12 MXN $0.060	GBP $1.40 EUR $1.22 MXN $0.054	GBP $1.42 EUR $1.12 MXN $0.062	GBP $1.38 EUR $1.16 MXN $0.064	GBP $1.57 EUR $1.17 MXN $0.057
-£1,400 JUN +£500 MAR	GBP $1.52 EUR $1.14 MXN $0.068	GBP $1.49 EUR $1.12 MXN $0.072	GBP $1.43 EUR $1.28 MXN $0.060	GBP $1.51 EUR $1.13 MXN $0.059	GBP $1.40 EUR $1.17 MXN $0.070
START	FEBRUARY SETTLEMENT		APRIL SETTLEMENT		JUNE Settle/Liq

When all players have reached the WAIT space and made their hedging decisions/taken positions, players begin taking turns rolling the die and advancing to spaces on the board.

Figure 2

Accounts Payable and Receivable Ledger for Player's Firm

Cash Balance	$10,000			
Receivables				
FC Amount	**Due Month**	**January USD Value**	**Hedge**	**Hedged Value**
Payables				
FC Amount	**Due Month**	**January USD Value**	**Hedge**	**Hedged Value**

Figure 3

Derivatives Market Products and Prices/Rates Available at the January WAIT Space

January Rates/Prices (Forwards are bid-ask)							
	Spot	**30 Fwd**	**60 Fwd**	**90 Fwd**		**Mar Futures**	**Jun Futures**
GBP	$1.46	$1.455-1.465	$1.45-1.47	$1.445-1.475		$ 1.47	$1.48
EUR	$1.20	$1.195-1.205	$1.19-1.21	$1.185-1.215		$ 1.21	$1.22
MXN	$0.062	$0.0617-0.0623	$0.0613-0.0627	$0.061-0.063		$ 0.063	$0.064

Option Premiums (per unit of currency)						
	Strike	**Feb Call/Put**	**Mar Call/Put**	**Apr Call/Put**	**May Call/Put**	**Jun Call/Put**
GBP	$1.46	$0.018	$0.02	$.022	$0.024	$0.026
EUR	$1.20	$0.015	$0.017	$0.02	$0.022	$0.025
MXN	$0.062	$ 0.0009	$0.0015	$0.0021	$0.0029	$0.0035

Futures Specifications: GBP, EUR = 500 FC units per contract.
MXN = 12,500 units per contract.
A ½ of 1% commission is charged on futures trades.

Options Specifications: GBP, EUR option is for 500 FC units.
MXN option is for 10,000 FC units.

Each space on the playing board lists new spot rates for the three currencies. When a player lands on a space, the current quotes for all three currencies' spot rates are updated to the values on that space, and that player marks his/her payable/receivable exposures to market.

When a player rolls the die to reach or pass a monthly SETTLE space, that player stops on that month's SETTLE space and is required to settle any accounts and/or derivatives positions due that month using the latest spot rates. Net proceeds and/or costs of the settled accounts and hedge positions are added or subtracted to the firm's cash account. Play then continues with the spot exchange rates continuously changing, and players settling as they reach the monthly settlement spaces.

Play ends when all players reach the JUNE LIQUIDATION space. Upon reaching this space, all accounts and positions are settled to the players' firms' cash accounts. Players then compare their cash balances with their beginning cash balances and the potential receipts/payments that might have happened had their hedging decision been different. If players wish to view the game competitively, then the "winner" could be determined as the player with the highest ending cash balance, or the winner could be the player who managed to net the best USD cash flows given his/her initial portfolio of accounts.

Game Specifications and Pedagogy

The spot exchange rates in the playing board spaces were randomly generated based on 60 monthly observations of actual GBP, EUR and MXN spot rates over the period 2013-2017. For each currency and each space, the spot rate value is randomly generated from a uniform distribution centered on that currency's mean spot value, bounded at plus/minus two standard

deviations. The initial spot rate values are the means for each currency over the data collection period. Given this development, the expected appreciation in each foreign currency ($E[\Delta S_{FC}]$) is zero. Examination of the game board in Figure 1 shows that each month has significant rate variability in each currency. This fact, coupled with the random nature of the players' die rolls, means there is little if any value to attempting to forecast later spot rates.

Similarly, the derivatives prices/rates in Figure 3 are set assuming $E[\Delta S_{FC}] = 0$. One of our major objectives in the offering and pricing of the derivatives is to show (even if simplified or exaggerated) the relative costs, benefits, and shortcomings of the various hedging products. The forward rates have bid-ask spreads that are symmetric about the January spot rate. Thus, a student hedging a payable with a forward will pay a small premium, while a receivable will hedge forward at a small discount. To reflect greater uncertainty at longer terms, the forward spread increases slightly from February to April. The futures prices are set at the spot rate plus a small carry-cost adjustment, with the carry-cost adjustment being greater for the June contracts versus the March contracts, and the contract amounts are small (500 units for GBP and EUR; 12,500 units for MXN) so as to match better the size of the exposures generated in the preliminary die rolls. Players who choose to hedge with a futures will also pay a small (1/2 of 1%) commission on the hedge. We have designed the futures hedges to be less expensive than the forward hedges to reflect the decreased ability to match an exposure precisely with the futures, given these contracts' standardized expiration months and amounts.

Put and call options are available for each of the three currencies, for each of the settlement months. One strike price is offered for each currency, set equal to the January spot rate for the currency. The quantity specifications for the options are the same as for the futures contracts. Premiums for the options increase with the volatility of the underlying currency (MXN > EUR > GBP) and with the time to expiry. We have set the premiums so that hedging with an option is significantly expensive relative to hedging with a forward or futures; this is to charge for the option flexibility and for the ability to match precisely any of the settlement months.

The initial orders that players collect during the preliminary die rolls comprise the players' portfolio of accounts payable and receivable. The currency occurrence (which space hosts GBP, EUR, or MXN) was determined by blind drawing without replacement from a collection of 8 slips of paper from each currency. The identification as payable or receivable (- or +) was determined for each space by a coin toss. The amounts of the exposures were determined by random draw with replacement from five different possible values for each currency. If a game "winner" is determined by final net worth alone, it is very possible that the winner could be determined solely by the nature of the student's initial portfolio. Thus, another metric, such as change in value of net working capital between January and June, may be in order for determining a winner.

At the January WAIT space, students face a variety of decisions. These decisions will necessarily consider the amounts, directions, and currencies of the exposures and the available hedging products. The students must initially make a hedge/no hedge decision. A no hedge decision could be justified if a particular exposure is small (e.g., a player may decide that a GBP500 exposure is not worth hedging) or if there are largely offsetting exposures at or near the same date in the same currency (e.g., a player may have nearly equal euro receivables and payables in March). Similarly, an exposure may require only a partial hedge (e.g., player has the +MXP15,000 FEB and -MXP25,000 FEB exposures).

When a student decides to hedge, the student must select the appropriate method. Students will generally want to find a hedge that matches an exposure in time and amount at smallest cost. There are plenty of opportunities for students to discover that hedging is imperfect. For example, while

options can be used to hedge at any month, they have standardized amounts and are expensive due to their premiums. Similarly, futures are inexpensive but have standard amounts and will time-match only the March and June exposures. There are no forwards offered for May or June exposures. If a student wants to hedge a May exposure, that hedge will be imperfect.

There are multiple potential uses of the game as a teaching tool. An instructor may ask student volunteers to play the game as an in-class illustrative exercise. Alternatively, or in addition, an instructor may assign students to play the game outside of class and report on the gameplay and outcome. The reporting may be required either individually or from a group of players.

Given the multiple levels of randomness involved in designing the game board, we do not immediately envision an opportunity for a student player to "game" the game. Gaming the game would involve a student noticing an obvious mispricing or producing a very good forecast by closely studying the game board and prices. If a student were to game the game, that would in itself signal a very good interest in and understanding of the underlying subject matter.

Student Response to the Game

In order to estimate pedagogical efficacy and student response to the game, we used the game as a teaching/learning assignment in a senior level international finance course. Before playing the game, each student took a 10-item quiz in which the student had to identify the optimal hedge for a given currency exposure situation. After playing the game, the students were post-tested with the same instrument.

Table 1 shows the results of our pre-post testing. The first statistic to note is very high mean score ($\bar{x}$ = 7.15/10) on the pre-game quiz scores. In this sampled section, the students had already heard a lecture and completed a written homework assignment over the material. Thus, we are effectively measuring the incremental instructional effect of game play given an already-strong knowledge of the material. Post-game quiz performance improved on average by 0.14 question items. This score improvement is significant at a 0.10 level.

Table 1
Mean Student Scores on 10-item Assessment Quiz – 78 Student Subjects

	Pre-game play	**Post-game play**	**Difference (post –pre)**
Mean	7.15	7.29	0.14
Standard Deviation	1.73	1.54	0.93
t-statistic for H_0: Mean of score difference ≤ 0 = 1.31		Probability = 0.094	

We also surveyed students' attitude response to playing the game. After playing the game, each student completed a four-item questionnaire seeking their opinions. Table 2 shows the results of this survey. Student responses and opinions of the game as a learning tool were modestly positive. We suspect that these results, like those measuring learning response, are biased downward somewhat by the sequencing of the game after a graded homework assignment.

Table 2
Summary of Student Responses to Survey about Playing 4-X

Statement	SD(1)	D(2)	N(3)	A(4)	SA(5)	Mean
1. Playing the game was interesting.	6	9	26	18	24	3.54
2. The game gave me a good picture of what can happen in international markets.	3	9	25	24	18	3.57
3. The game has value as a learning project.	0	7	25	30	14	3.67
4. I learned more by playing the game than I would have in a regular homework assignment.	5	9	31	20	12	3.32

Instructor Modifications

The game can be modified to increase its complexity and challenge if this is desirable for an advanced or graduate-level course. An instructor can alter the distribution that produced the spot rates such that there is a non-zero $E[\Delta S_{FC}]$, or the mean of the random distribution can be changed to the prior randomly generated spot rate to allow a time series process. Instructors can also alter the game rules and the firm ledgers to allow speculation on foreign currencies during play.

A creative instructor may alter the game board to include Monopoly®-like "Finance" and "Hazard" cards. Like the "Community Chest" and "Chance" cards in Monopoly®, these cards can introduce unforeseen events for students to manage. Examples of "Finance" cards include "Borrow £10,000 for one month," or "Invest €12,000 for one month." "Hazard" cards might include events like contingent cash flows to be determined at a later die roll.

An instructor might also add the possibility of purchasing forecasts of later currency spot rates. Under such a scenario, a student's firm will pay a fee for the forecast. Purchasing a forecast allows the student, upon reaching a settlement date, to roll the die and possibly achieve a more favorable spot rate. The fact that a better spot rate is not guaranteed reflects the imperfection of purchased forecasts. Finally, an instructor might introduce interest rates in the four active currencies. This would allow students to borrow/lend in foreign currencies; students then might have the opportunity for covered interest arbitrage and/or money market hedging. Introducing interest rates will give students the opportunity (and perhaps incentive) to verify the existence of interest rate parity in the game.

Conclusion

Significant prior research has shown the value of games in pedagogy. We develop a board game that provides an illustration and simulation of foreign currency hedging. While this purpose might be accomplished by an online simulation, a board game has unique advantages. A board game will shrink the time required to a matter of an hour or so rather than a semester. Also, a board game avoids potential further expense, accessibility, or connectivity problems for students. Finally, a board game forces student face-to-face, rather than digital or no, interaction. We find that our "4-X" game offers potential value as a pedagogical device and elicits modestly positive student response.

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Mnemonics, M&Ms and Capital Structure: A Teaching Note

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A mnemonic is a tool to help remember facts or a large amount of information. It can be a song, rhyme, acronym, image, or a phrase to help remember a list of facts in a certain order. This short teaching note presents a classroom mnemonic that helps students better understand the Modigliani and Miller 1958 capital structure irrelevancy result. This mnemonic identifies homemade leverage in the context of creating a taste sensation equivalent to the M&M peanut. It also provides a fun time for the instructor as it allows a legitimate reason to eat candy in the classroom.

Key Words: Capital Structure, Mnemonics, Modigliani and Miller.

Introduction

Effective teaching requires showmanship. This paper provides the stage and the props for one short vignette. Capital structure theory usually requires discussion of Modigliani and Miller's (M&M) seminal work from 1958. What we have done in many classes is to use a bag of plain M&Ms, peanuts and peanut M&Ms to demonstrate the irrelevancy theorem.

In essence, we consume plain M&Ms and peanuts simultaneously to create the taste sensation of the peanut M&M. The act of chewing is the equivalent of "homemade leverage." Richard West (1967, p.419) states that, "… M-M's argument requires nothing more than that individuals manipulate financial claims similar to those which are manipulated by corporations. That is individuals 'sell bonds' to lever themselves just as would a corporation." We argue that if M&Ms with peanuts was priced at $10 a bag and the combination of M&Ms and the bag of peanuts were priced at $6 combined, the price would converge somewhere in the middle. The paper will discuss the overall message of M&M '58, including the lesser-known Proposition 2, which discusses the effect debt has on the cost of equity, along with some simple numerical examples as part of the appendix.

Some would argue capital structure—the means by which capital is acquired—is the heart of finance. How do we finance the left side of the balance sheet, or in other words how do we finance the assets that the firm has, and does the choice in financing make a difference? The orthodoxy at the time was that financial managers and the decisions that they make are of consequence. Accordingly, the decisions that they make would have a profound impact on the value of the firm.

Prior to 1958, the study of finance was anecdotal in nature. Practitioners would observe a few firms and draw conclusions based on a limited number of data points. There is nothing wrong with

this method. In fact, that is what most science is based on: observation leading to conjecture. Into this landscape, enter M&M. Given their assumptions in the 1958 paper, some will think the results bear no impact on the real world. We would argue otherwise. M&M provide a dose of healthy skepticism to the finance discipline that still carries on today. No longer do financial managers and academicians accept conventional wisdom as being correct, but rather try to explore and understand the underpinnings of current thought.

M&M demonstrate using a simple theoretical construct, that value and financing are independent. What matters is the *revenue stream* and not the source of financing. What matters is the left side of the balance sheet. In physics we have the conservation of energy which generally says that matter and energy can neither be created nor destroyed. In finance the conservation law would be as follows: value cannot be created or destroyed via financing—meaning that value lies with underlying cash-flows and not the financing surrounding the assets. In terms of a balance sheet, it is the asset side that creates value, not the liabilities. M&M were the first to demonstrate that allowing the financing choice to create value, is similar to finding a perpetual motion machine. Neither can exist without violating the laws of conservation/irrelevancy.

The Pedagogy of Mnemonics

Analogy, parables, and fables have been vital forms of pedagogical methods for millennia. One vital aspect of pedagogical analogies is that an object or idea that is familiar to the learner is linked to an object or idea that is less familiar with the learner. For example, in Plato's analogy of the cave, his audience would be familiar with caves and shadows and be expected to then draw a connection between those familiar concepts and the idea that there is often more to life than what we can see or directly sense. Analogies, parables, and fables are effective tools for expanding a learner's base of understanding.

Mnemonics—like analogies—typically use a familiar tag item to remind us of a more complex concept or idea. In the pedagogical psychology literature, though there is no broad consensus, there are several advocates for the use of mnemonics in the classroom, including Levin (1990), Lorayne (1990), Manalo (2002), Worthen & Hunt (2011), and Putnam (2015). The familiar mnemonic tag we propose to aid students' retention of the ideas associated with Miller and Modigliani's (1958) research regarding capital structure irrelevancy is the popular chocolate candy M&Ms. The candy is ubiquitous and comes in multiple varieties that enable us to mimic its synthesis by combining constituent components.

M& M Firm Value

Using M&M's simplifying assumptions:

1. No taxes
2. No transaction costs
3. Debt is riskless
4. Capital markets are competitive
5. Homogeneous expectations for investors
6. All cash flows are perpetuities
7. The cost of debt and the cost of equity are the same, and finally
8. Firms to be compared belong to the same risk class, *i.e.* they have the same degree and type of business risk as measured by σ_{EBIT}.

The corporate valuation model predicts that:

$$V = D + E \quad (1)$$

Where: V is the value of the firm
D is the value of the debt
E is the value of the equity

leading to:

Proposition 1: *The value of any firm is established by capitalizing its expected net operating income at a constant rate which is appropriate for the firm's risk class.*

Specifically, M&M (1958, p.268) state, "the market value of any firm is independent of its capital structure and is given by capitalizing its expected return at the rate ρ_k appropriate to its class." The M&M '58 model also includes a second proposition that deals with the cost of equity as a function of the debt ratio. While extremely important, the M&M mnemonic is not effective in teaching this area. We have included this part of the M&M theory as Appendix A. Appendix B provides numerical examples of M&M '58, 63 and Miller's 1977 models under conditions where the amount of debt increases. As debt is added (*i.e*. examples 1, 2, 3) the k_sL (cost of equity of a levered firm) goes up but the WACC (weighted average cost of capital) remains the same.

The arguments and proofs are based on the concept of *arbitrage*, which is a riskless return made with no investment. Arbitrage is the concept of buying low and selling high at the same time and capturing the difference. More often than not, such opportunities do exist but not for very long, and not for much money, given that too many people compete for these mis-pricings.

Following a similar example contained in Lee, Finnerty, & Song (2006) assume two firms of the same risk class. Firm L has $4,000,000 of 10% debt ($k_d$ = 10%) while Firm U is all equity financed. Assume that the capitalization rate (required rate of return for equity, k_s) is 10%. Finally, we assume that the firm has no growth, i.e., all cash flows are perpetuities L.

Table 1
Market Values for Levered and Unlevered Firms

	Firm L (Levered)	**Firm U (Un-levered)**
EBIT	$900,000	$900,000
Interest	$400,000	$0
Dividends	$500,000	$900,000
Market Value Bonds	$400,000	$0
Market Value Stocks	?	$900,000
Total Market Value	?	$900,000

What would happen if the market value of the levered stock were valued at something other than $5,000,000? Suppose that the value was $6,000,000. This presents an arbitrage opportunity that cannot exist for any extended time period.

Next assume initially one owns 20% of Firm L's stock so the investment is $1,200,000. Your wealth could increase by:

1. Selling the stock in L for $1,200,000
2. Borrowing $600,000 @10% to purchase 20% of Firm's U's stock
3. Buying 20% of Firm U's stock for $1,800,000.

Notice that you receive $1,800,000 as an inflow from (i) the sale of your 20% of Firm L's stock, plus (ii) your $600,000 borrowing. In summary,

Old income:		
20% of L's $1,200,000 equity income (20% of $500,000)		$100,000
New income:		
20% of U's $900,000 equity income	$180,000	
less 10% interest on $600,000 loan	($60,000)	$120,000
		$20,000

Eventually enough people would arbitrage the above disequilibrium, forcing the price of the levered firm to an equilibrium value of $5,000,000.

Alternatively, we can also see that the above situation does not provide the necessary rate of return for Firm L's equity holders.

Original return:

$$\frac{\text{income}}{\text{investment}} = \frac{\$500000*.20}{\$1200000} = .0833$$

New return:

$$\frac{\text{income}}{\text{investment}} = \frac{\$900000*.20 - \$60000\dagger}{\$1200000} = .1000$$

† $60,000 net interest paid for borrowing the equity difference

What would happen if the levered firm's equity had an initial value of $4,000,000? Think of the old adage "buy low, sell high."

Conclusion: *M&M state that in a world without taxes, the value of a firm is completely unaffected by its capital structure.*

Therefore:

$$V = D + E = \frac{EBIT}{k_{sU}} \tag{2}$$

Where, D = debt as a perpetuity

or

$$V = D + E \Rightarrow D + \frac{(EBIT - I)}{k_{sL}} \tag{3}$$

Note that: k_{sU} = the cost of equity for an unlevered firm
k_{sL} = the cost of equity for a levered firm
k_d = the cost of debt
$k_d \times D = I$ ("interest")
$E = S$ = equity

At this point, we reveal the following:

Figure 1
An Illustration of candy irrelevancy

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(Plain M&Ms plus peanuts must equal peanut M&Ms).

Rhetorically one can ask why we choose M&M candy. Most students wait for someone else to risk an answer, but occasionally someone will respond, "Modigliani and Miller."

We assume the bag of M&Ms and the bag of peanuts weigh the same as a single bag of M&M with peanuts. The cost of the M&M plain and the cost of peanuts are both $3 respectively. If the cost of M&M with peanuts is $10, what would happen to the prices?

Opening a bag of plain M&Ms, we grab a mouthful of candy and a handful of peanuts and begin to chew. After a few chuckles, we reinforce the concept that the act of creating the taste sensation of a M&M with peanuts through the use of a M&M (think "firm") and a peanut (think "leverage"). The person consuming the combination of the two—M&Ms and peanuts, gets the taste and satisfaction at a lower cost. The act of chewing and creating the M&M-with-peanut taste is the "homemade leverage." For the students to fully grasp the meaning of homemade leverage, further explanation is necessary.

Homemade leverage implies that there are no impediments to combining the peanuts and chocolate in the exact method to create the same taste as a M&M with peanuts candy. When you ask the class if they think that is possible, most will answer, "probably not." And this provides the means to discuss why individuals cannot borrow money under the same conditions as corporations. Corporations tend to have more resources and limited liability as compared to individuals, creating conditions that favor corporations. Likewise candy makers can create a chocolate encased peanut that will provide a different taste sensation as compared to a homemade peanut/chocolate concoction.

However, if homemade leverage exists then market forces through arbitrage will drive the price differential to zero. Yet we know M&Ms with peanuts exit. Why? Transaction costs—while being a nuisance for theorists, cannot be assumed away. Using another analogy most students realize that a whole chicken can be purchased at a lower per pound price than an equivalent weight of chicken breast. Why? Because of the convenience. In a world of no transaction costs, convenience has no value.

Skeptical students will ask why is the M&M theorem important if we never see this in the real world? Because the irrelevancy proposition helps individuals to see value created by discounted cash flow and not the transaction. Other well-known irrelevancy examples include M&M's dividend irrelevancy (1961), leasing irrelevancy, Lewellen et.al (1976), Myers et. al (1976), the binomial option pricing model, Cox et al (1979), and the put-call parity theorem, Stoll (1969). While transaction costs are real and cannot just be assumed away, by focusing on the capitalization of cash flows students can develop a deep, fundamental understanding of value. In terms of candy, it is the chocolate and peanuts that create value/taste, not the packaging.

Conclusions

Using an M&M candy mnemonic this paper provides a pedagogical approach to teaching the capital structure irrelevancy proposed by Modigliani and Miller (1958). Most students have bought M&M candy and can better understand the disequilibrium problem when presented in a familiar setting. Students think they understand why prices are different. Homemade leverage, i.e., combining peanuts and plain M&Ms, can simulate firm leverage by an individual borrowing money to buy equity. This levered position is equivalent to a firm using debt in its capital structure.

By using peanuts, plain M&Ms and peanut M&Ms as a mnemonic, students can gain a better understanding of homemade leverage through an enjoyable exercise in a more relatable environment. We emphasize the irrelevancy proposition exits if: first, we follow the strong assumptions proposed in Modigliani and Miller (1958)'s paper, second, we allow for homemade leverage to completely satisfy the consumer, and third, if the consumer knows this, then he/she will pursue an arbitrage strategy to drive any price differential to zero. These three conditions can emphasize to the student the real-world effects of assumptions (such as tax and bankruptcy risk), as well as drive home the price stabilizing power of arbitrage opportunities in markets.

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Appendix A
Cost of Equity in a Levered Firm

Often, textbooks ignore the second proposition that M&M provided in their '58 paper:

Proposition 2: *The cost of equity to a levered firm is equal to (i) the cost of equity to an un-levered firm in the same risk class plus (ii) a risk premium whose size depends on both the differential between the cost of equity and debt to an un-levered firm and the amount of leverage used*.

$$k_{sL} = k_{sU} + \text{Risk premium} = k_{sU} + (k_{sU} - k_d) * \left(\frac{D}{S}\right) \quad (4)$$

Assume that you had a firm with 200 units of risk associated with its cash flows. Also assume that this risk is distributed as follows:

Total Risk = Risk of Bondholders + Risk of Stockholders
200 = 50 + 150

In addition, you also know that there are 5 bondholders and 5 stockholders, so the average risk is:

$$\frac{50}{5} = 10 \qquad \frac{150}{5} = 30$$

However, two of the stockholders no longer want the risk associated with being a stockholder and decide that they would prefer to cash in their stock and buy bonds in the firm. Because these two bondholders will be subordinate to the original bondholders, the risk that they bare will be higher than the first five. Assume that it is for argument sake, 12. If the risk is higher, the return associated with their claims should also be higher. As far as the residual risk of the stockholders is concerned, part of their risk will be transferred to the bondholders as follows:

Total Risk = Risk of Bondholders + Risk of Stockholders
200 = 50 + 2*(12) = 150 - 24 = 74 + 126

The average risk of each group:

$$\frac{74}{7} = 10.57 \qquad \frac{126}{3} = 42$$

The average risk of both groups went up, but the total risk of the firm remained the same. At first thought, many would conclude that if the average risk of both groups went up, that this would also imply that the total risk of the firm went up as well. Obviously, this is not the case. Merton Miller (1991) referred to this example as analogous to the conservation laws in physics where energy is neither created nor destroyed. In this case, risk is not "created" but rather just distributed differently to give the appearance of more risk.

This example illustrates how the risk of the individual groups financing the firm may change while the total risk of the firm does not. Consequently, as the leverage goes up, the risk to the stockholders becomes more and more concentrated on the remaining three owners. The risk becomes greater and therefore the return should also go up.

Appendix B
A numerical example of M&M '58, '63 and Miller '77 models

Example 1: One of the first things you would like to accomplish as the new Vice President in charge of finance (CFO), is to oversee a comprehensive review of the firm's capital structure. Travel World is a service-oriented company that provides its customers with the usual travel agency features along with cruise packages that it creates with several Caribbean cruise lines. Currently Travel World has the following capital structure along with the respective costs:

Debt	7 million	k_d = 12%
Equity	? million	k_{sU} = 15%

Assume the corporate tax rate (T_c) is equal to 34%. Travel World's EBIT is equal to $3.5M.

Part 1:

1. What should the value of the firm equal if *M&M '58 (without taxes)* theory is correct?

$$V = D + E$$

$$V_U = V_L = \frac{\text{EBIT}}{k_{sU}\text{ (cost of equity for an unlevered firm)}}$$

$$= \frac{3.5M}{.15}$$

$$= \boxed{23.333M}$$

$$E = V_L - D = 23.333M - 7 = \boxed{16.333M}$$

2. What should the k_{sL} (cost of equity for a levered firm) equal?

$$k_{sL} = k_{sU} + (k_{sU} - k_d) * \left(\frac{D}{S}\right)$$

$$= .15 + (.15 - .12) * \left(\frac{7M}{16.333M}\right)$$

$$= \boxed{.1629}$$

As a check:

$$V_L = \frac{(EBIT - I)}{k_{sL}} + D$$

$$= \frac{(3.5M - .84M)}{.1629} + 7$$

$$= \boxed{23.333M}$$

3. Find the WACC. Recall that the:

$$WACC = k_d * \left(\frac{D}{D+S}\right) + k_{sL} * \left(\frac{S}{D+S}\right)$$

$$WACC = (.12) * \left(\frac{7M}{23.333M}\right) + .1629 * \left(\frac{16.333M}{23.333M}\right)$$

$$= \boxed{.15} = k_{sU}$$

Note the value of the WACC is equal to k_{sU} when the firm pays no taxes.

Part 2:

1. What should the value of a firm equal if *M&M '63 (with taxes)* theory is correct?

$$V_L = V_U + T_c * D$$

$$V_L = \frac{EBIT\ (1-T_c)}{k_{sU}} + T*D$$

$$= \frac{3.5M\ (1-.34)}{.15} + .34*7M$$

$$V_L = 15.4M + 2.38M = \boxed{17.78M}$$

$$E = V_L - D = 17.78M - 7 = \boxed{10.78}$$

2. What should the k_{sL} equal?

$$k_{sL} = k_{sU} + (k_{sU} - k_d)(1-T_c) * \left(\frac{D}{S}\right)$$

$$= .15 + (.15 - .12) *(1-.34) \left(\frac{7M}{10.78M}\right)$$

$$= \boxed{.1628}$$

As a check:

$$V_L = \frac{(EBIT - I\ )(1-T_c)}{k_{sL}} + D$$

$$= \frac{(3.5M - .84M\ )(1-.34)}{.1628} + 7$$

$$V_L = \boxed{17.78M}$$

3. What is the firm's WACC? Recall that the WACC for a tax paying firm can be represented as:

$$WACC = (1-T_c)k_d *\left(\frac{D}{D+S}\right) + k_{sL} *\left(\frac{S}{D+S}\right)$$

$$WACC = (1-.34)(.12) *\left(\frac{7M}{17.78M}\right) + (.1628) *\left(\frac{10.78M}{17.78M}\right)$$

$$= .12989 \approx \boxed{.13}$$

Note: Notice when we have taxes the WACC is not the same as the k_{sU}.

Part 3:

1. What should the value of the firm equal if the *Miller '77 theory* is correct? Assume that T_{pd} = 20%; T_{ps} = 28%.

$$V_L = V_U + B\left[1 - \frac{(1-T_c)(1-T_{ps})}{(1-T_{pd})}\right]$$

$$V_L = \frac{(3.5M)(1-.34)(1-.28)}{.15} + 7M*(1-.20)\left[1 - \frac{(1-.34)(1-.28)}{(1-.20)}\right]$$

$$= 11.088 + 5.6M\ [.406]$$

$$V_L = \boxed{13.3616M}$$

Example 2:
Part 1:

Instead of having $7M in debt, we now assume we have $10M in long-term debt.

1. Assuming no taxes, what is the value of the firm, k_{sL}, and the WACC?

$$V = D + E$$
$$V_U = V_L = \frac{EBIT}{k_{sU}}$$
$$= \frac{3.5M}{.15}$$
$$= \boxed{23.333M}$$
$$E = V_L - D = 23.333M - 10 = \boxed{13.333M}$$

2. What should the k_{sL} equal?

$$k_{sL} = k_{sU} + (k_{sU} - k_d) * \left(\frac{D}{S}\right)$$
$$=.15 + (.15 - .12) * \left(\frac{10M}{13.333M}\right)$$
$$= \boxed{.1725}$$

As a check:

$$V_L = \frac{(EBIT - I)}{k_{sL}} + D$$
$$= \frac{(3.5M - 1.2M)}{.1725} + 10$$
$$= \boxed{23.333M}$$

3. Find the WACC.

$$WACC = k_d * \left(\frac{D}{D+E}\right) + k_{sL} * \left(\frac{S}{D+S}\right)$$
$$WACC = (.12) * \left(\frac{10M}{23.333M}\right) + .1725 * \left(\frac{13.333M}{23.333M}\right)$$
$$= \boxed{.15}$$

Part 2:

Now assume the firm pays taxes.

$$V_L = \frac{EBIT\ (1-T_c)}{k_{sU}} + T*D$$
$$= \frac{3.5M\ (1-.34)}{.15} + .34*10M$$
$$V_L = 15.4M + 3.4M = \boxed{18.8M}$$

$$E = V_L - D = 18.8M - 10M = \boxed{8.8M}$$

$$k_{sL} = k_{sU} + (k_{sU} - k_d)(1-T_c) * \left(\frac{D}{S}\right)$$

$$= .15 + (.15 - .12) * (1-.34) \left(\frac{10M}{8.8M}\right)$$

$$= \boxed{.1723}$$

$$WACC = (1-T_c)\, k_d * \left(\frac{D}{D+E}\right) + k_{sL} * \left(\frac{S}{D+S}\right)$$

$$WACC = (1-.34)(.12) * \left(\frac{10M}{18.8M}\right) + (.1723) * \left(\frac{8.8M}{18.8M}\right)$$

$$= \boxed{.12276}$$

Part 3:

1. What should the value of the firm equal if the *Miller '77 theory* is correct? Assume that T_{pd} = 20%; T_{ps} = 28%.

$$V_L = V_U + B \left[1 - \frac{(1-T_c)(1-T_{ps})}{(1-T_{pd})}\right]$$

$$V_L = \frac{(3.5M)(1-.34)(1-.28)}{.15} + 10M*(1-.20)\left[1 - \frac{(1-.34)(1-.28)}{(1-.20)}\right]$$

$$= 11.088 + 8M\ [.406]$$

$$V_L = \boxed{14.336M}$$

Example 3:

Part 1:

1. Now assume that the firm has $20M in debt. Find the value of the firm, k_{sL} and the WACC for the case where the firm pays taxes and when it does not.

$$V = D + E$$

$$V_U = V_L = \frac{EBIT}{k_{sU}}$$

$$= \frac{3.5M}{.15}$$

$$= \boxed{23.333M}$$

$$E = V_L - D = 23.333M - 20 = \boxed{3.333M}$$

2. What should the k_{sL} equal?

$$k_{sL} = k_{sU} + (k_{sU} - k_d) * \left(\frac{D}{S}\right)$$

$$= .15 + (.15 - .12) * \left(\frac{20M}{3.333M}\right)$$

$$= \boxed{.3300}$$

As a check:

$$V_L = \frac{(EBIT - I)}{k_{sL}} + D$$
$$= \frac{(3.5M - 2.4M)}{.33} + 20$$
$$= \boxed{23.333M}$$

3. Find the WACC.

$$WACC = k_d * \left(\frac{D}{D+S}\right) + k_{sL} * \left(\frac{S}{D+S}\right)$$
$$WACC = (.12) * \left(\frac{20M}{23.333M}\right) + .3300 * \left(\frac{3.333M}{23.333M}\right)$$
$$= \boxed{.15}$$

Part 2: Now assume the firm pays taxes.

$$V_L = \frac{EBIT\ (1-T_c)}{k_{sU}} + T*D$$
$$= \frac{3.5M\ (1-.34)}{.15} + .34*20M$$
$$V_L = 15.4M + 6.8M = \boxed{22.2M}$$
$$E = V_L - D = 22.2M - 20M = \boxed{2.2M}$$

$$k_{sL} = k_{sU} + (k_{sU} - k_d)(1-T_c) * \left(\frac{D}{S}\right)$$
$$= .15 + (.15 - .12) * (1-.34) \left(\frac{20M}{2.2M}\right)$$
$$= \boxed{.3300}$$

$$WACC = (1-T_c)k_d * \left(\frac{D}{D+S}\right) + k_{sL} * \left(\frac{S}{D+S}\right)$$
$$WACC = (1-.34)(.12) * \left(\frac{20M}{22.2M}\right) + (.3300) * \left(\frac{2.2M}{22.2M}\right)$$
$$= \boxed{.10405}$$

Part 3:

What should the value of the firm equal if the *Miller '77 theory* is correct? Assume that T_{pd} = 20%; T_{ps} = 28%.

$$V_L = V_U + B\left[1 - \frac{(1-T_c)(1-T_{ps})}{(1-T_{pd})}\right]$$
$$V_L = \frac{(3.5M)(1-.34)(1-.28)}{.15} + 20M*(1-.20)\left[1 - \frac{(1-.34)(1-.28)}{(1-.20)}\right]$$
$$= 11.088 + 16M\ [.406]$$
$$V_L = \boxed{17.584M}$$

Below is a comparison table of values and cost of levered equity.

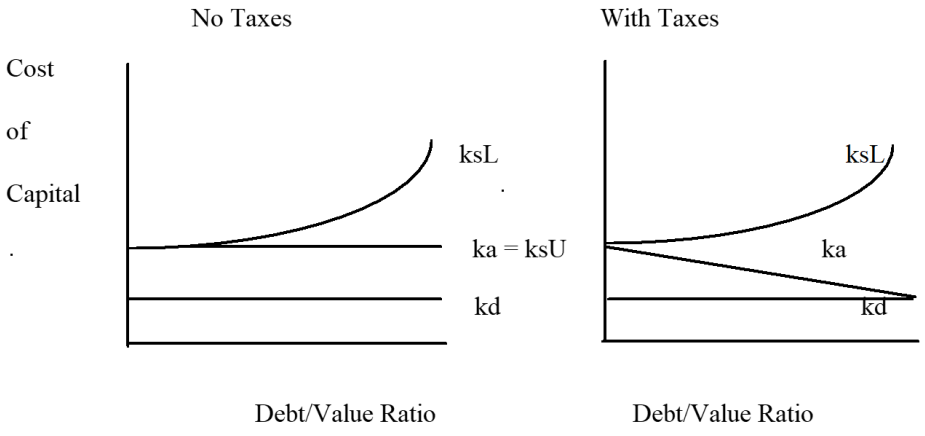
Table 2
Market Values, Cost of Equity and WACC.

	Example 1: Debt = $7M	**Example 2: Debt = $10M**	**Example 3: Debt = $20M**
V_L (no taxes '58)	$23.333M	$23.333M	$23.333M
k_{sL}	16.29%	17.25%	33.00%
WACC	15%	15%	15%
V_L (with taxes '63)	$17.78M	$18.8M	$22.2M
k_{sL}	16.29%	17.25%	33%
WACC	13%	12.28%	10.45%
V_L (with taxes '77)	$13.361M	$14.336M	$17.584M

- The k_{sL} for the firm that pays taxes and the one that does not, are the same. Notice how quickly k_{sL} increases as the amount of debt increases. This is one of the benefits of going through the three examples.
- The introduction of taxes reduces the value of the firm. Notice in *Example 1*, the value of an un-levered firm, was $23.333M, regardless of the combination of debt and equity. When we consider corporate taxes, the value of the firm is smaller and is dependent on the amount of debt used. However, the value of the firm will be smaller and that is due to a "leakage" to the government in the form of taxes (*i.e.*, $23.333M versus $17.78M). Finally, when we recognize personal taxes the value of the firm is even smaller. This is, again, due to another "leakage" to the government (*i.e.*, $17.78M versus $13.36M).
- Sometimes people get confused and conclude that the value of a levered firm will be greater because of the tax shield than the value of the un-levered firm that pays no taxes. That is not the case. While leverage increases the value of a firm that pays taxes, it does not, however, overcome the total impact of taxes. KEEP in MIND that the V_U for the MM'58, MM'63 and the Miller '77 do not represent the same concept or value.

We can graphically look at the relationship between the cost of capital and $\frac{D}{V}$ ratio.

Figure 2
Cost of Capital as Leverage Increases



A Pedagogical Note on the Correlation Between Securities

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Finance theory indicates that when combining two securities the resulting portfolio's risk gets lower as the correlation between the securities' rates of return declines. Hence, all else the same, securities with negatively correlated rates of return are more suitable for diversification than securities whose returns are positively correlated. It is frequently conjectured that two securities whose returns change in opposite directions over time are negatively correlated. Using numerical examples, it is shown that such assertion is not correct in general because, in line with its definition, the sign of correlation between two securities depends on the direction of the linear relation between their returns and not on how their returns change relative to each other over time.

Keywords: correlation between securities, portfolio theory, portfolio diversification, portfolio risk, pedagogy

Introduction

Diversification is an important principle in modern portfolio theory. It suggests that increasing the number of securities leads to a reduction of the resulting portfolio's risk or standard deviation. Markowitz (1952) pointed out that portfolio risk depends on the standard deviations of the individual securities as well as the correlation coefficient (henceforth, correlation) between each pair of securities included in the portfolio; the lower these correlations, the lower the portfolio's risk. As a result, diversification is most effective in reducing risk when the correlation between pairs of securities in the portfolio is most negative.

In several occasions, textbooks and practitioners explain correlation between two securities in terms of how the returns of the two securities move relative to each other over time. For example, Brooks (2019) states that "Negative correlation means that two different securities move in opposite directions over time." Similarly, Faulkenberry (2020) maintains that "When two or more investments move inversely to each other they have negative correlation." However, the calculation of correlation is not simply based on how the two securities move relative to each other over time; instead, it is based on how the performances of the two securities relative to their respective average returns compare to each other over time. Given historical returns for two securities over a number of periods, calculation of their correlation requires assessing whether each security over- or under-performs its historical average in each of the periods. Periods in which both securities over- or under-perform their historical averages promote positive correlation, while periods in which one security over-performs but the other under-performs its historical average, or vice versa, promote negative correlation. The weighted sum of the individual years' contributions provides the correlation between the two securities and its sign depends on whether the impact of periods in which both securities are either above or below their respective averages exceeds that of periods in which one security is above while the other is below its average, or vice versa.

It then follows that although in some instances negative correlation may exist between two different securities that move in opposite directions over time, one can easily provide examples in

which zero or even positive correlation exists between such a pair of securities. This implies that one cannot always unequivocally infer whether two securities are negatively correlated by simply relying on how their returns change relative to each other over time. Instead, in line with the definition of correlation, one can always unambiguously assess its sign by examining how the over- or under-performance of the securities versus their respective averages relate to each other; equivalently, by studying whether large returns of one security are associated with large or with small returns of the other security. Understanding how correlation is calculated enables one realize that it is not counter intuitive for securities whose returns change in opposite directions over time to be uncorrelated or positively correlated. It is the objective of this paper to enable students of finance to correctly assess the sign (and the magnitude) of correlation between two assets.

The rest of the paper is organized as follows. The next section provides a brief review of the relevant portfolio theory and elaborates on the problem addressed in the paper. The following section reviews the definition of correlation between two variables using historical information on their values. Using the definition, the subsequent section provides examples which demonstrate that the correlation between two securities whose returns change in opposite directions over time can be negative, zero, or even positive. The ensuing section provides examples which demonstrate that the correlation between two securities whose returns change in the same direction over time can be positive, zero, or even negative. The final section concludes the paper.

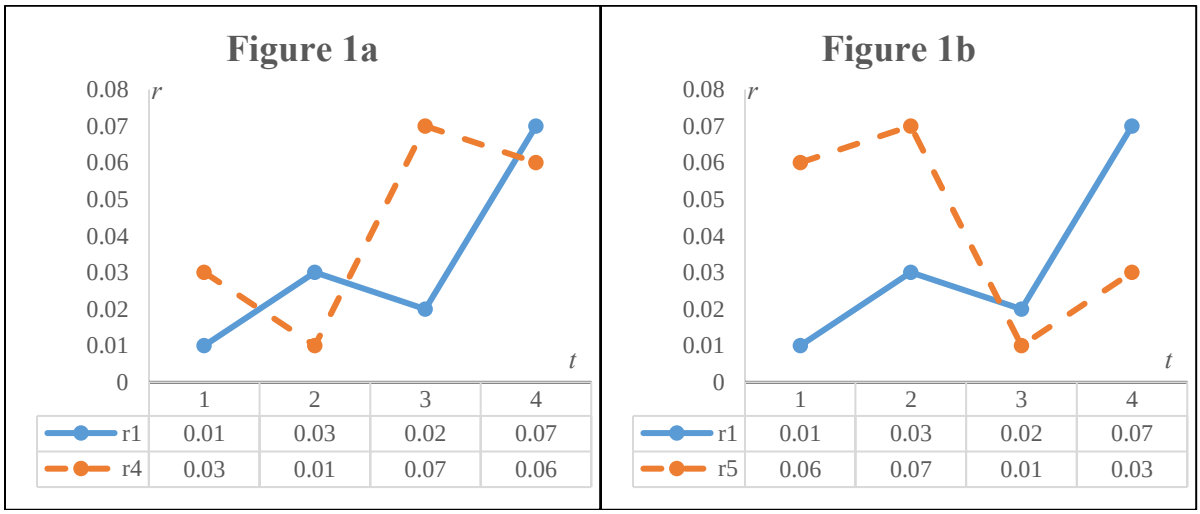
Literature Review and Background

Portfolio theory deals with portfolio selection and the pricing of capital assets under risk. In Markowitz (1952, 1959) investors deem expected return desirable but variance of return undesirable and select diversified efficient portfolios (i.e., portfolios which offer the highest expected return for a level of standard deviation (or risk), or the minimum standard deviation for a given level of expected return). Tobin (1958) and Hicks (1962) show that under homogeneous expectations Markowitz's (1952) model suggests that all investors allocate their funds in a unique portfolio of risky assets and a single risk-free asset; due to differences in their risk tolerance, investors' allocations only differ in the relative proportions of the risk-free asset and the unique risky portfolio. Sharpe (1964), Lintner (1965), and Mossin (1966) develop an equilibrium capital asset pricing model, the main thesis of which is captured by the Capital Market Line which provides a linear relationship between the expected (or required) rate of return of an efficient portfolio and its standard deviation, and the Security Market Line which suggests a linear relationship between the expected rate of return of an asset and its systematic risk (the latter indexed by the asset's beta).

A statistic essential to the construction of diversified portfolios and the pricing of capital assets is the correlation between asset returns. Regarding portfolio construction, the lower the correlation between assets combined into a portfolio, the lower the risk of the portfolio. In other words, diversification has a bigger impact on portfolio risk when combining assets with lower correlation; combining assets with negative correlation results in more effective diversification than combining assets with positive correlation. Regarding the pricing of capital assets, the Security Market Line states that expected rate of return increases linearly with asset beta. To calculate beta one needs to know the asset's correlation with the market portfolio. In other words, the correlation between an asset and the market is critical in calculating equilibrium asset return.

Given its importance in portfolio theory, some textbooks and practitioners use graphs similar to those in Figure 1a and 1b to assess the sign of correlation between two assets. The data tables

at the bottom of each figure provide the rates of return (denoted with *r*) over the past four periods (denoted with t) for two pairs of securities; securities 1 and 4 in Figure 1a and securities 1 and 5 in Figure 1b. Returns are reported on the vertical axis r while time is marked on the horizontal axis t. The piecewise lines in these figures track the movement in the returns of the involved securities from one period to the next over time. It is then maintained that securities 1 and 4 are negatively correlated because, as seen in Figure 1a, their returns change in opposite directions over time (i.e., when the return of security 1 increases, that of security 4 declines and vice versa). On the other hand, it is argued that securities 1 and 5 are positively correlated because, as seen in Figure 1b, their returns move in the same direction over time (i.e., the returns of securities 1 and 5 either both increase or both decline in each period).



Although in some instances the reasoning offered with respect to Figures 1a and 1b may lead to the correct sign of the correlation between pairs of securities, in other instances it may not. In other words, it is possible that securities whose returns change in opposite directions over time are positively correlated, while securities whose returns move simultaneously in the same direction over time are negatively correlated. Actually, contrary to the sign of the correlation between securities 1 and 4 or securities 1 and 5 suggested in the previous paragraph, it will be shown later in this paper that the securities in Figure 1a are positively correlated while those in Figure 1b are negatively correlated. This suggests that the sign of the correlation between two securities cannot be unequivocally inferred simply from the way their returns change relative to each other over time. To avoid incorrect inferences about the sign of correlation, the paper: (i) reviews the definition and intuitively explains the mathematical steps required to calculate correlation; (ii) plots security returns in a different way which, unlike Figures 1a and 1b, always correctly appraises the sign of their correlation; and (iii) uses several numerical examples to enable students understand and correctly assess the sign (and magnitude) of correlation.

Definition of Correlation

Correlation is a statistic that measures the linear relationship between two random variables (e.g., Mood, *et all*, 1974); its value is calculated by dividing the covariance between the two variables by the product of their standard deviations and ranges from – 1 to 1. In general, given

the values of two variables r_1 and r_2 over the past n periods (i.e., given r_{it} for i=1, 2 and t = 1, 2, …, n) the correlation ρ_{12} between these two variables is defined as:

$$\rho_{12} = \frac{\sigma_{12}}{\sigma_1 \sigma_2},$$

where,

$$\sigma_{12} = \frac{\sum_{t=1}^{n}(r_{1t} - \overline{r}_1)(r_{2t} - \overline{r}_2)}{n-1}$$

calculates the covariance between the two variables,

$$\overline{r}_1 = \frac{\sum_{t=1}^{n} r_{1t}}{n}, \qquad \overline{r}_2 = \frac{\sum_{t=1}^{n} r_{2t}}{n}$$

provide the average returns of the two variables, and

$$\sigma_1 = \sqrt{\frac{\sum_{t=1}^{n}(r_{1t} - \overline{r}_1)^2}{n-1}}, \qquad \sigma_2 = \sqrt{\frac{\sum_{t=1}^{n}(r_{2t} - \overline{r}_2)^2}{n-1}}$$

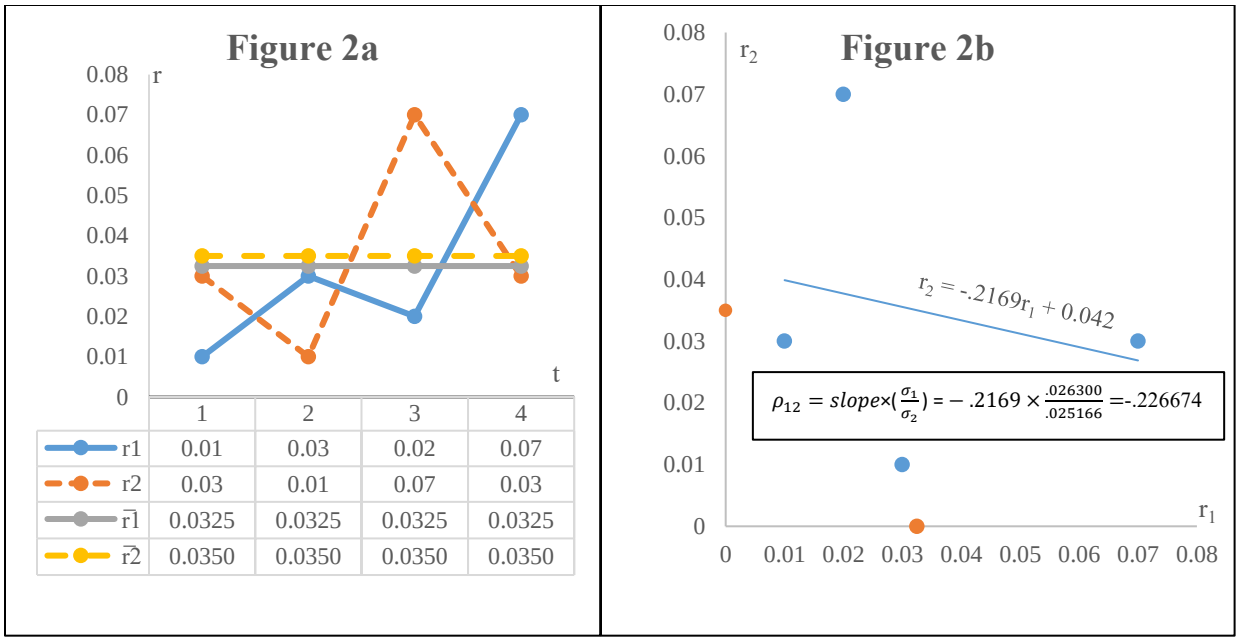
give the standard deviations of the two variables. Since standard deviations are non-negative numbers, it follows that the correlation between two variables has the same sign as their covariance.

It is important to notice from the definition of σ_{12} that the sign of covariance (hence, the sign of correlation) depends on how the deviations of the two variables from their respective averages compare to each other in each period. Intuitively, if r_1 tends to be above $\overline{r}_1$ when r_2 is below $\overline{r}_2$ and to be below $\overline{r}_1$ when r_2 is above $\overline{r}_2$, covariance will be negative; if r_1 tends to be above $\overline{r}_1$ when r_2 is above $\overline{r}_2$ and to be below $\overline{r}_1$ when r_2 is below $\overline{r}_2$, covariance will be positive. Stated differently, if r_1 tends to be large when r_2 is small and to be small when r_2 is large, correlation will be negative; if r_1 tends to be large when r_2 is large and to be small when r_2 is small, correlation will be positive.

Correlation Between Securities Moving in Opposite Directions Over Time

Negative Correlation

Consider the two securities (labeled 1 and 2) in Figure 2a. The first two rows in the data table at the bottom of Figure 2a show the returns, r, of these securities, while the piecewise lines track the change in their returns from one period to the next over time. Time, t, is marked on the horizontal axis, while r is reported on the vertical axis. In essence, Figure 2a provides information on how the rates of return of the two securities change relative to each other over time. The solid piecewise line indicates that r_1 increases from t=1 to t=2, it then declines from t=2 to t=3, to once again increase from t=3 to t=4. At the same time, as the dashed piecewise line shows, r_2 always changes in the opposite direction, although by a different magnitude.



Using the correlation definition from the previous section, Table 1 demonstrates the steps involved in calculating the correlation ρ_{12} between the historical returns r_1 and r_2 of the two securities in Figure 2a. The column labeled t reports the four periods considered in this example, while the next two columns provide the rates of return per period for each of the two securities.

Table 1

t	r_1	r_2	$r_1 - \bar{r}_1$	$r_2 - \bar{r}_2$	$(r_1 - \bar{r}_1)^2$	$(r_2 - \bar{r}_2)^2$	$(r_1 - \bar{r}_1)*(r_2 - \bar{r}_2)$
1	0.01	0.03	-0.0225	-0.0050	0.000506	0.000025	0.000113
2	0.03	0.01	-0.0025	-0.0250	0.000006	0.000625	0.000063
3	0.02	0.07	-0.0125	0.0350	0.000156	0.001225	-0.000438
4	0.07	0.03	0.0375	-0.0050	0.001406	0.000025	-0.000188
$\bar{r}$	0.0325	0.0350					
σ					0.026300	0.025166	
σ_{12}							-0.000150
ρ_{12}							-0.226635

The row labeled $\bar{r}$ gives the average return of each security calculated as the sum of the four period returns divided by 4, the number of periods. Security 1 has an average return of .0325 and security 2 has an average return of .0350; in Figure 2a, the average returns of securities 1 and 2 are represented by the solid and dashed horizontal lines, respectively. The fourth column compares the return of security 1 in each period to its average return (i.e., it calculates the deviation of the security's return from its average return). In periods 1 – 3, security 1 returns less than its average, but outperforms its average in period 4. Similarly, the fifth column shows that security 2 outperforms its average in period 3 but lags behind its average return in the other three periods. The sixth column provides the squared difference between the return of security 1 in each period and its average return. The sum of these squared deviations from the average is divided by 3 (the number of periods minus 1) to give the variance of security's 1 return; the square root of the variance is the security's standard deviation and equals .026300. Similar calculations are reported

in the seventh column to determine the .025166 standard deviation of security 2; the standard deviations of the two securities are reported in the row labeled σ.

In each period, the eighth column calculates the product of the deviations of each security's return from its average. Dividing the sum of these products by 3 (the number of periods minus 1) gives the covariance between the two securities; its value is – .000150 and is reported in the row labeled σ_{12}. Dividing the covariance by the product of their standard deviations gives the correlation between these two securities; its value is –.226635 and is reported in the row labeled ρ_{12}. One should notice that in periods 1 and 2 both securities have returns that are less than their respective averages; hence, these two periods contribute .000176 (= .000113 + .000063) to the calculation of the covariance. In period 3, security 1 lags behind its average, while security 2 exceeds its average; the opposite is true in period 4. Together, periods 3 and 4 contribute –.000626 (= –.000438 – .000188) to the calculation of covariance. Since in absolute terms the negative contribution (associated with periods 3 and 4) exceeds the positive one (attributed to periods 1 and 2), covariance is negative and equal to –.00015 (= (–.000626 + .000176)/3), which leads to a negative correlation of –.226635 (= –.00015/(.026300*.025166)).

As indicated in the previous section of the paper, correlation is an indicator of the degree to which two variables are *linearly related (*i.e., the degree to which they move together in a *linear fashion)*. Instead of using Figure 2a to capture the linear relationship between securities 1 and 2, theory of statistics relies on Figure 2b which plots the return of security 2 (on the vertical axis) against the return of security 1 (on the horizontal axis). The four points in the plot area give the pairs (r_1, r_2) in the four periods; for example, the point closest to the horizontal axis corresponds to t=2 where the return on security 1 is .03 and the return on security 2 is .01. The point on the horizontal axis marks the average return of security 1 (.0325), while the point on the vertical axis marks the average return of security 2 (.0350). Furthermore, Figure 2b plots and gives the equation of the *trendline* (or least squares method line) for the four points in the plot area. This downward sloping line depicts the linear relationship between r_2 and r_1. The vertical intercept of the line (.042) is where the line crosses the vertical axis if extended to the left. The slope of the line (−.2169) is negative indicating that, moving on the trendline from left to right, r_2 gets smaller as r_1 becomes larger. One can then say that securities 1 and 2 move in opposite directions in the sense that, on the trendline, large values of r_2 are associated with small values of r_1 and vice versa.

It is important to differentiate between Figure 2a which contrasts the direction of the changes in the values of r_2 and r_1 (i.e., r_2 increases when r_1 declines and vice versa) over time, and Figure 2b which establishes a linear relationship between the values of r_2 and r_1 (i.e., on the trendline, large values r_1 of are associated with small values of r_2 and vice versa). Based on the definition of correlation, it then follows that Figure 2b should be used to correctly capture it. Regarding the sign and magnitude of the correlation between r_2 and r_1, theory of statistics indicates that ρ_{12} is equal to the slope of the trendline in Figure 2b times the ratio of the standard deviation of security 1 over the standard deviation of security 2 (e.g., see "correlation analysis" in Hughes – Grawoig, 1971). Since standard deviation is always positive, correlation has the same sign as the slope of the trendline in Figure 2b. As shown in the text box in Figure 2b, ρ_{12} is equal to −.226674, practically identical with the value calculated earlier in Table 1 (there is a miniscule difference due to rounding errors in the two calculations).

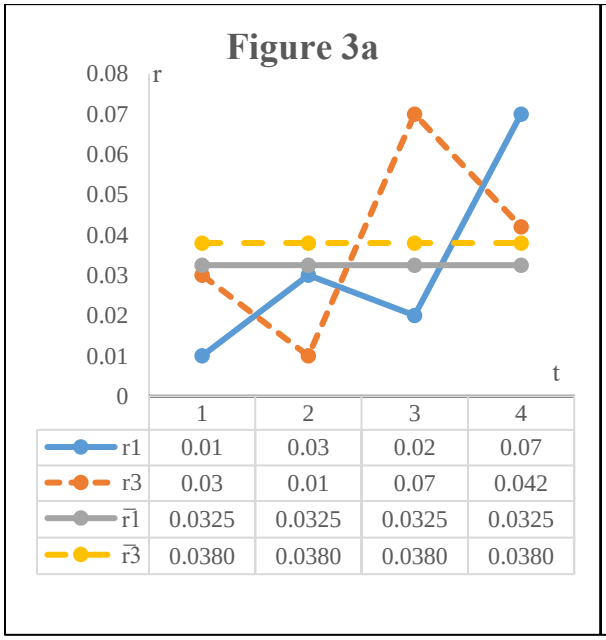
Two "technical" points regarding Figure 2b. First, the sign of ρ_{12} can be unmistakably deduced from the visibly down sloping trendline even if the equation of that line and the equation in the text box are not reported in Figure 2b; these two equations are only used if, in addition to the sign, one also needs to calculate the magnitude of ρ_{12}. Second, as indicated in the previous section of

the paper, calculation of ρ_{12} is based on the deviations of each security's return from its average (i.e., it is based on $r_1 - \bar{r}_1$ and $r_2 - \bar{r}_2$). As a result, Figure 2b could be drawn in terms of $r_1 - \bar{r}_1$ and $r_2 - \bar{r}_2$ instead of r_1 and r_2. This results in a trendline with vertical intercept equal to zero, but the same (−.2169) slope; hence, the sign and magnitude of correlation do not change. Both these points apply to all the examples in the remainder of the paper.

In sum, in this example, negative correlation is associated with two securities whose returns change in opposite directions over time. As shown below, this may not always be the case.

Zero Correlation

Now consider securities 1 and 3 in Figure 3a and the calculation of their correlation in Table 2. Security 1 is the same as in the previous example. Security 3 differs from security 2 (of the previous example) only in terms of the fourth period return; the return for security 3 is .042, while that for security 2 was .030. Despite this difference, Figure 3a clearly shows that like securities 1 and 2, the returns of securities 1 and 3 change in opposite directions over time. The average return and the standard deviation of return for security 1 (same values as in the previous example) and security 3 (.0380 and .025087, respectively) are calculated in Table 2. Furthermore, Table 2 calculates the covariance and correlation between the two securities; both of them are equal to zero. The zero correlation between securities 1 and 3 can be traced to their deviations from their average returns. In periods 1 and 2 the deviations are negative while in period 4 they are positive for both securities; these three periods contribute .0004 (= .00018 + .00007 + .00015) to the covariance calculation. On the other hand, in period 3 the deviation is negative for security 1 and positive for security 3, contributing –.0004 to the calculation of the covariance. When all four periods are considered, covariance is equal to zero (= (–.0004 + .0004)/3), which leads to zero correlation.



	1	2	3	4
r1	0.01	0.03	0.02	0.07
r3	0.03	0.01	0.07	0.042
$\bar{r}1$	0.0325	0.0325	0.0325	0.0325
$\bar{r}3$	0.0380	0.0380	0.0380	0.0380

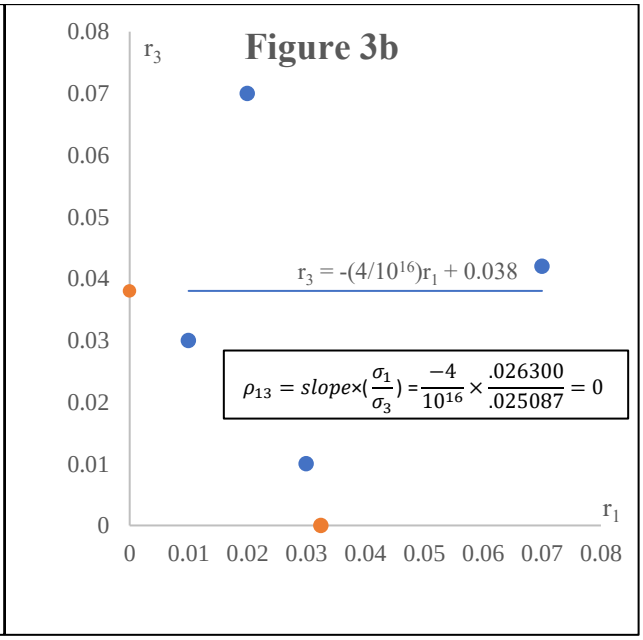


Figure 3b plots the return of security 3 against the return of security 1; the four points in the plot area give the pairs (r_1, r_3) in the four periods. The average return of security 1 (.0325) is marked by the point on the horizontal axis, while the average return of security 3 (.0380) is marked by the point on the vertical axis. Furthermore, Figure 3b plots and gives the equation of the trendline for the four data points in the plot area. The slope of the line is $-4/10^{16}$, which for all practical purposes is equal to zero, implying a horizontal trendline. This suggests there is no linear relationship between r_1 and r_3; in other words, as we move from left to right on the trendline, the value of r_1 gets larger but the value of r_3 does not change. It therefore follows that the correlation between the two securities is zero, the same as the value explicitly calculated in Table 2 or using the correlation analysis formula shown in the text box in Figure 3b.

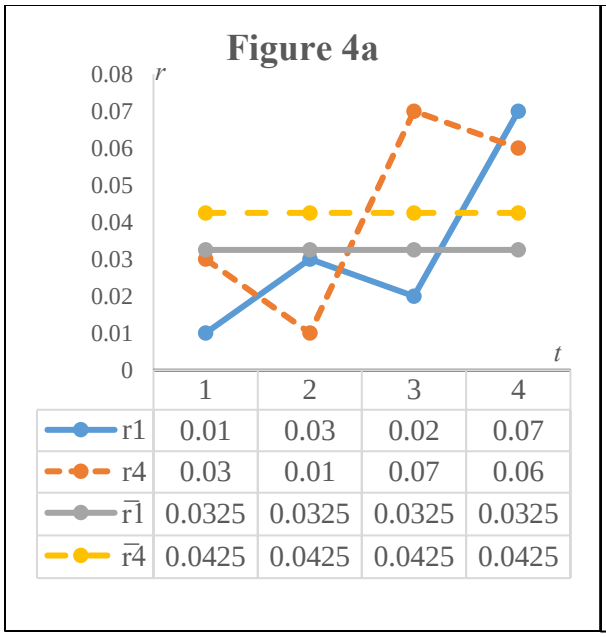
Table 2

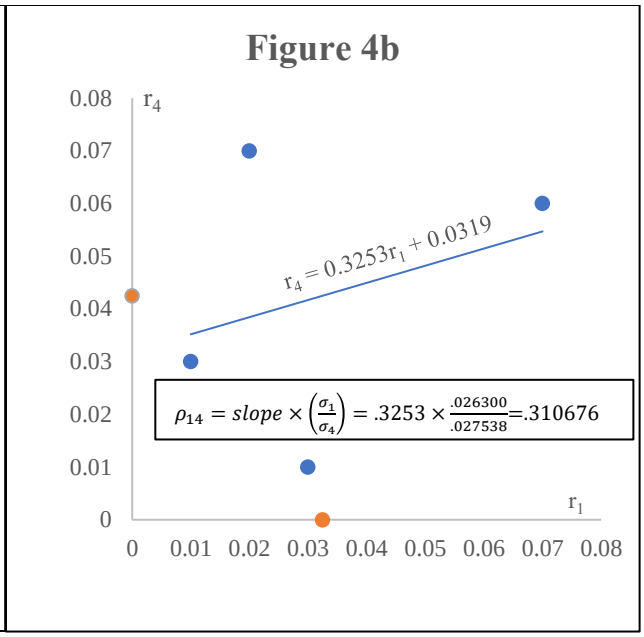
t	r_1	r_3	$r_1 - \bar{r}_1$	$r_3 - \bar{r}_3$	$(r_1 - \bar{r}_1)^2$	$(r_3 - \bar{r}_3)^2$	$(r_1 - \bar{r}_1)*(r_3 - \bar{r}_3)$
1	0.010	0.030	-0.0225	-0.0080	0.000506	0.000064	0.000180
2	0.030	0.010	-0.0025	-0.0280	0.000006	0.000784	0.000070
3	0.020	0.070	-0.0125	0.0320	0.000156	0.001024	-0.000400
4	0.070	0.042	0.0375	0.0040	0.001406	0.000016	0.000150
$\bar{r}$	0.0325	0.0380					
σ					0.026300	0.025087	
σ_{13}							0.000000
ρ_{13}							0.000000

Hence in this example, zero correlation is associated with two securities whose historical returns change in opposite directions over time. As indicated earlier in the paper, Figure 3a is occasionally used to incorrectly suggest a negative correlation between securities 1 and 3, simply because their rates of return change in opposite directions over time. In contrast, Figure 3b correctly assesses no correlation between securities 1 and 3, as also illustrated in Table 2.

Positive Correlation

Now consider securities 1 and 4 in Figure 4a and the calculation of their correlation in Table 3. Once again, security 1 is the same as in the previous two examples. Security 4 differs from securities 2 and 3 (of the previous examples) only in terms of the fourth period return; the return for security 4 is .06 while that for security 3 was .042 and for security 2 was .03. Like the pairs of securities 1 and 2 or 1 and 3, Figure 4a shows that the returns of securities 1 and 4 change in opposite directions. The average return and the standard deviation of return for security 1 (same values as in the previous examples) and security 4 (.0425 and .027538, respectively) are calculated in Table 3. Furthermore, Table 3 calculates the covariance and correlation between the two securities; both of them are positive. The positive correlation between securities 1 and 4 can be once again traced to their deviations from their average returns. As in the previous example, in periods 1 and 2 the deviations are negative while in period 4 they are positive for both securities; these three periods contribute .001018 (= .000281 + .000081 + .000656) to the calculation of the covariance. On the other hand, in period 3 the deviation is negative for security 1 and positive for security 4, and it contributes –.000344 to the covariance calculation. When all four periods are considered, covariance is equal to .000225 (= (–.000344 + .001018)/3), which leads to a correlation of .310673 (=.000225/(.026300*.027538)).





Once again, the four points in the plot area of Figure 4b give the pairs (r_1, r_4) in the four periods, while the point on the horizontal axis marks the average return of security 1 (.0325) and the point on the vertical axis marks the average return of security 4 (.0425). Also, Figure 4b plots and gives the equation of the trendline for the four data points in the plot area. The slope of the line (.3253) is positive, indicating that, moving along the trendline, large values of r_4 are associated with large values of r_1, while small values of r_4 are associated with small values of r_1. It therefore follows that the correlation between the two securities is positive and, using the correlation analysis formula in the text box in Figure 4b, its value is practically identical with that explicitly calculated in Table 3.

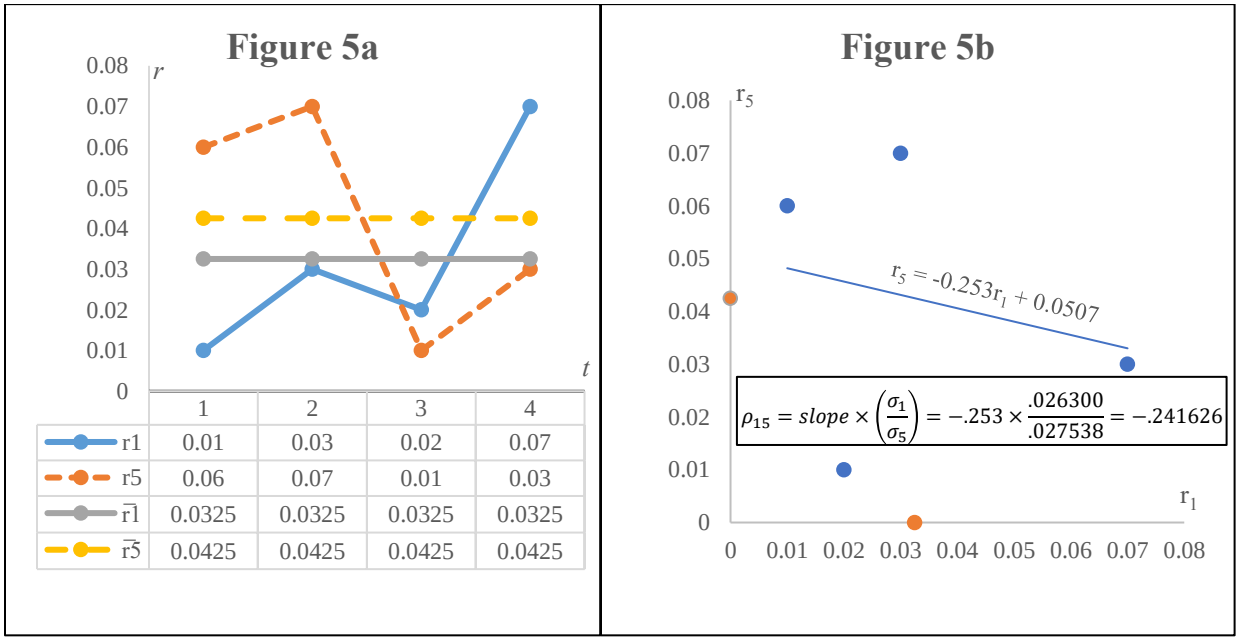
Table 3

t	r_1	r_4	$r_1 - \bar{r}_1$	$r_4 - \bar{r}_4$	$(r_1 - \bar{r}_1)^2$	$(r_4 - \bar{r}_4)^2$	$(r_1 - \bar{r}_1)*(r_4 - \bar{r}_4)$
1	0.01	0.03	-0.0225	-0.0125	0.000506	0.000156	0.000281
2	0.03	0.01	-0.0025	-0.0325	0.000006	0.001056	0.000081
3	0.02	0.07	-0.0125	0.0275	0.000156	0.000756	-0.000344
4	0.07	0.06	0.0375	0.0175	0.001406	0.000306	0.000656
$\bar{r}$	0.0325	0.0425					
σ					0.026300	0.027538	
σ_{14}							0.000225
ρ_{14}							0.310673

Hence, in this example positive correlation is associated with two securities whose historical returns change in opposite directions over time. The reader will notice that securities 1 and 4 are the same as those in Figure 1a in the second section of the paper. As indicated in that section, inferring from Figure 1a (equivalently, Figure 4a) a negative correlation between these two securities simply because their rates of return change in opposite directions may be misleading; indeed, Figure 4b verifies that point by correctly assessing a positive correlation between securities 1 and 4.

Correlation Between Securities Moving in The Same Direction Over Time

The three examples in the preceding section show that securities whose historical returns change in opposite directions are not necessarily negatively correlated. At the same time, it is as important to notice that negative correlation may exist between securities whose returns change in the same direction over time. As an example, consider securities 1 and 5 in Figure 5a and the calculation of their correlation in Table 4. Security 1 is the same as in all previous examples, while security 5 is a new security. Figure 5a shows that the returns of both these securities increase from t=1 to t=2, decline from t=2 to t=3, to once again increase from t=3 to t=4. The average return and the standard deviation of return for security 1 (same values as in the previous examples) and for security 5 (.0425 and .027538, respectively) are calculated in Table 4. In addition, Table 4 shows that the correlation between these securities is negative. In periods 1 and 2 the deviation of security 1 from its average is negative, while that of security 5 is positive; the opposite is true in period 4. These three periods contribute –.000932 (= –.000394 –.000069 –.000469) to the calculation of the covariance. At the same time, in period 3 the deviations of both securities from their averages are negative, contributing .000406 to the calculation of the covariance. When all four periods are considered, covariance equals –.000175 (= (–.000932 + .000406)/3), and correlation equals –.241635 (= –.000175/(.026300*.027538)).



As in the previous examples, Figure 5b plots r_5 against r_1 and develops the trendline for the four (r_1, r_5) pairs in the plot area. The slope of the line (−.253) is negative, indicating that, moving on the trendline from left to right, small values of r_5 are associated with large values of r_1. It therefore follows that the correlation between the two securities is negative, and the correlation analysis formula in the text box confirms its value explicitly calculated in Table 4.

Table 4

t	r_1	r_5	$r_1 - \bar{r}_1$	$r_5 - \bar{r}_5$	$(r_1 - \bar{r}_1)^2$	$(r_5 - \bar{r}_5)^2$	$(r_1 - \bar{r}_1)*(r_5 - \bar{r}_5)$
1	0.01	0.06	-0.0225	0.0175	0.000506	0.000306	-0.000394
2	0.03	0.07	-0.0025	0.0275	0.000006	0.000756	-0.000069
3	0.02	0.01	-0.0125	-0.0325	0.000156	0.001056	0.000406
4	0.07	0.03	0.0375	-0.0125	0.001406	0.000156	-0.000469
$\bar{r}$	0.0325	0.0425					
σ					0.026300	0.027538	
σ_{15}							-0.000175
ρ_{15}							-0.241635

This example shows that negative correlation is associated with two securities whose historical returns change in the same direction. Once again, the reader will notice that securities 1 and 5 are the same as those in Figure 1b in the second section of the paper. As indicated in that section, inferring from Figure 1b (equivalently, Figure 5a) a positive correlation between these two securities simply because their rates of return change in the same direction may be misleading; indeed, Figure 5b verifies that point by correctly assessing a negative correlation between securities 1 and 5. Moreover, it can be easily verified that if, all else the same, the t=4 return of security 5 is changed to .044 (or to .05) the correlation between securities 1 and 5 becomes 0 (or .10843), suggesting that zero or positive correlation may be associated with two securities whose returns change in the same direction over time.

Security 5 has identical average return and standard deviation of return with security 4 in the last example of the previous section. An investor considers investing in either portfolio A comprised of securities 1 and 4, or portfolio B consisting of securities 1 and 5, with security 1 having the same weight in both portfolios. Portfolio B is selected if the investor concludes from Figures 4b and 5b that correlation is negative between securities 1 and 5 but positive between securities 1 and 4. On the other hand, if the investor incorrectly interprets Figures 4a and 5a to imply that correlation is negative between securities 1 and 4 but positive between securities 1 and 5, then portfolio A is chosen. Clearly, using the appropriate graph to assess the sign of correlation between securities is crucial for efficient diversification.

It is frequently pointed out that the correlation between the returns of pairs of common stocks is positive. For example, Brealey, Myers and Allen (2014) state that "Thus most of the stocks that investors can actually buy are tied together in a web of positive covariances that set the limit to the benefits of diversification." Similarly, Ross, Westerfield, Jaffe and Jordan (2019) indicate that "Most pairs of securities exhibit positive correlation." Further, Pollet and Wilson (2010) find that from 1963 until 2006 the average quarterly correlation between all pairs of the 500 largest stocks in the market ranged from .034 to .646 with an average value of .237. Since it is highly unlikely that the historical returns of all pairs of securities in the market have changed in the same direction, these statements and findings support the point demonstrated with the examples in this paper. Specifically, they support the notion that positive correlation may exist between pairs of securities whose historical returns tend to change in opposite directions, as well as between pairs of securities whose historical returns have the tendency to change in the same direction.

Conclusion

Diversification plays an important role in portfolio theory. All else the same, combining securities with negative correlation reduces portfolio risk more than combining securities with zero or positive correlation. It is frequently suggested that the correlation between securities is negative if their returns change in opposite directions, while it is positive if their returns change in the same direction over time. Using numerical examples, it was demonstrated that such claims are not correct in general. It was shown that zero or even positive correlation may exist between securities moving in opposite directions, while zero or negative correlation may exist between securities moving in the same direction over time. This is due to the fact that calculation of correlation is not simply based on how the returns of two securities change relative to each other but, instead, on how the performances of the two securities relative to their respective average returns compare to each other over time. This suggests that when considering two securities for inclusion in a portfolio, one should not try to assess the sign of their correlation by examining how their returns change relative to each other over time but, instead, by exploring the linear relation between their returns.

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Teaching an Updated Undergraduate Fixed-Income Course

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An undergraduate finance curriculum rarely includes a fixed-income course. Designing an undergraduate fixed-income course requires incorporating cutting-edge aspects of debt markets and investments, especially bonds. Instructors must consider not only the current state of debt markets but offer insights on trends and innovations occurring in the debt markets. In addition, course content must consider evolutions occurring in theory and practice. This paper identifies recent developments and innovations in the debt markets that may attract students to take a fixed-income course. These topics involve (1) bond characteristics and risks, (2) bond benefits and performance, (3) behavioral finance, (4) contemporary bond issues, including LIBOR transition and negative interest rates, and (5) trends in debt markets. Fixed-income markets exceed equity markets in both size and trading volume. Thus, a critical understanding of these markets is essential for a well-rounded finance program. We aim to discuss the market's current state and share new innovative ideas, future trends, and changes needed in academic curricula and research streams.

Keywords: *Bond performance, bond investments, bond characteristics, bond markets*

Introduction

Let's try an experiment. Ask your students or the average person the following question: Which markets are the largest: equity (stock) markets or debt (bond) markets? Because respondents are typically more aware of stock than bond markets, they believe equity markets are much larger. The opposite is true when measuring the total value of debt and equity instruments outstanding at the end of a particular period. Both markets are critical to economic activity but for different reasons. In bond markets, participants determine interest rates, which affect consumer spending and

business investment. Stock markets are more closely linked to economic activity. When a country's gross domestic product (GDP) grows, companies often expand and produce more. Such expansion leads to increases in valuations, which, in turn, lead to stock market gains.

Despite the importance of stock and bond markets, fixed income is the proverbial "ugly duckling" of the finance undergraduate teaching curriculum. Equity markets attract students because of their higher profile, the potential for high returns, ease of investment, and data accessibility. Such topics as initial public offers (IPOs), mergers and acquisitions (M&As), cryptocurrencies, sustainable investments, and algorithmic trading dominate the financial news. Consequently, the slower-moving traditional debt markets attract far less attention. However, as previously noted, fixed-income markets are larger than equity markets and provide essential funding sources for corporations and governments. Are students less interested in fixed income resulting in business schools offering fewer courses? Are the few courses offered in fixed income stifling the potential interest of students?

Finance programs usually offer an introductory finance course plus an investments course. The overwhelming focus of the investments course concerns equity investments, asset pricing, and derivatives. When the course includes fixed income, it often constitutes a small portion of the total content. Some schools offer courses covering financial institutions, banking, and similar topics, but the content dedicated to fixed income is low.

We identify recent developments and innovations in the debt markets that may attract students to take a fixed-income course. We also discuss more recent fixed-income instruments that cross over into many investors' environmental, social, and governance (ESG) mandates. One example is the emergence of green bonds to finance more efficient energy usage. Catastrophe (cat) bonds are another example. These bonds allow more efficient risk transfer from natural disasters, which is increasingly important as carbon emissions increase greenhouse gases. Social impact bonds are a third example. These bonds enable private investors to affect society through non-investments, positively reducing juvenile recidivism.

In summary, we discuss areas beyond the topics usually included in a fixed-income or a broader investments course. Finance students ideally should have exposure to both traditional and alternative asset classes before embarking on their careers.

Teaching an updated fixed-income class begins with using current material. Much of this paper coincides with material based on *Debt Markets and Investments*, edited by Baker, Filbeck, and Spieler (2019). We aim to provide a fresh look at designing an undergraduate course incorporating various aspects of debt markets and investments, especially bonds. Our goal is to update the current state of debt markets, share new innovative ideas or future debt market trends, and discuss needed changes in academic curricula and research streams.

Table 1 shows the growth in fixed income outstanding, which illustrates a four-fold increase between 2000 and 2020. Treasury securities comprise the largest component, followed by mortgage-backed securities (MBS) and corporate securities.

Table 1
Debt Outstanding Between 2000 and 2020 (in $billions)
Total Fixed-income Securities Outstanding in the United States from 2000 to 2020.

	Municipal	Treasury	Mortgage-Related	Corporate Debt	Federal Agency Securities	Asset-Backed	Money Markets	Total
2000	1,480.7	2,951.9	4,119.3	3,440.7	1,853.7	701.9	1,614.0	16,162.2
2001	1,603.4	2,968.0	4,711.0	3,862.3	2,157.4	812.0	1,474.0	17,588.0
2002	1,762.8	3,205.3	5,289.4	4,050.1	2,377.7	904.8	1,374.9	18,965.0
2003	1,900.4	3,575.2	5,714.5	4,358.2	2,626.2	995.3	1,292.9	20,462.7
2004	2,876.1	3,945.8	6,301.7	4,573.8	2,700.6	1,100.2	1,399.1	22,897.3
2005	3,098.8	4,170.0	7,218.1	4,646.1	2,616.0	1,281.4	1,644.2	24,674.5
2006	3,284.7	4,328.0	8,389.9	4,889.4	2,631.7	1,656.9	1,958.4	27,138.9
2007	3,550.1	4,522.6	9,386.0	5,328.7	2,905.9	1,963.5	1,788.9	29,445.6
2008	3,666.2	5,783.6	9,467.4	5,511.8	3,208.5	1,829.5	1,599.8	31,066.9
2009	3,850.9	7,260.6	9,352.5	5,641.3	2,726.3	1,712.1	1,138.0	31,681.6
2010	3,968.4	8,853.0	9,258.4	6,283.4	2,537.5	1,507.8	1,057.6	33,466.1
2011	3,930.9	9,928.4	9,075.5	6,322.9	2,326.9	1,359.0	969.3	33,912.9
2012	3,933.2	11,046.1	8,838.1	6,722.4	2,095.8	1,280.3	952.3	34,868.2
2013	3,869.1	11,854.4	8,742.6	7,112.7	2,058.3	1,285.7	951.6	35,874.5
2014	3,827.0	12,504.8	8,842.0	7,450.6	2,028.7	1,349.4	930.4	36,932.9
2015	3,844.3	13,191.6	8,894.8	7,654.0	1,995.4	1,376.6	941.5	37,898.1
2016	3,891.9	13,908.2	9,023.4	8,024.7	1,971.7	1,391.8	884.9	39,096.5
2017	3,906.6	14,468.8	9,304.5	8,372.6	1,934.7	1,457.9	965.9	40,411.1
2018	3,860.5	15,608.0	9,732.3	8,566.8	1,841.6	1,615.6	996.0	42,220.8
2019	3,869.5	16,673.3	10,227.6	8,865.8	1,726.2	1,663.2	1,045.2	44,070.9
2020	3,952.9	20,973.1	11,214.0	9,756.4	1,693.6	1,535.8	986.9	50,112.8

Source: SIMFA (2021). Available at https://www.sifma.org/resources/research/fixed-income-chart/.

Having provided some background about debt securities, we move to five important topics to consider in an undergraduate fixed-income course: (1) bond characteristics and risks, (2) bond benefits and performance, (3) behavioral finance issues, (4) current issues in bond markets, and (5) trends in debt markets.

Bond Characteristics and Risk

Many instructors begin fixed-income courses by defining what bonds are, their key characteristics, how they differ from stocks, how investors obtain returns from fixed-income securities, and what risks are involved in bond investing. Generally, a discussion of bond pricing follows after students learn about the time value of money. Coupon and principal payments are contractual obligations for bond issuers. By knowing their timing and size in advance, students treat them as though their future payment is certain. After introducing the basics of bond pricing,

instructors may ask their students to discuss what risks such investments entail. Key ideas to draw out are that these risks involve: changes in the levels of interest rates; unexpected variation in the timing of cash flows; an issuer's ability and willingness to make payments; the challenges of buying or selling securities when needed; and unanticipated additional costs due to exchange rates fluctuations when payments are in another currency.

Although some investors might view equity markets as relatively risky and bond markets as relatively safe, many risks exist when investing in fixed-income securities. Primary risk categories are interest rate, prepayment, credit, liquidity, and currency risk. *Interest rate risk* is when a bond or other fixed-income investment suffers a loss in value due to a change in interest rates. This risk is further classified as price risk or reinvestment risk. *Price risk* is the risk of loss that investors face when market interest rates increase, and bond prices decrease. *Reinvestment risk* is when market interest rates decrease, and investors reinvest coupon payments at lower rates. These two risks can offset each other to some degree, depending on the changes in the levels of market rates. Although zero-coupon bonds (i.e., bonds that do not pay interest) do not suffer from reinvestment risk, they face substantial price risk. Investors can reduce interest rate risk by buying bonds that mature at different dates. They also can mitigate the risk by hedging fixed-income investments with interest rate swaps and other instruments.

Prepayment risk is the risk of a loss in value associated with a premature return of principal on a fixed-income security. Similarly, *contraction risk* is the risk that borrowers might accelerate their principal prepayment. These prepayment risks are most prevalent in fixed-income securities such as callable bonds, known as *call risk,* and MBS securities when, for instance, homeowners pay off their mortgages sooner than expected. To mitigate these concerns, bonds with payment risk often have prepayment penalties. By contrast, a related risk is *extension risk,* where borrowers might defer prepayments due to market conditions such as rising interest rates since issuers sold the bonds.

Although the risks mentioned above generally result from changes in market interest rates, *credit risk* or *default risk* results from changes in a borrower's financial condition to make payments. *Credit risk* is associated with a loss resulting from a borrower's failure to make a contractually obligated payment or repay a loan. Thus, an investor may suffer losses because the issuing party cannot pay.

In some instances, the demand for specific securities drops. This situation often happens when an investor wants to sell a security without success. *Liquidity risk* arises from the likelihood that bondholders may have to sell a bond below its listed value. This risk can be generalized to any security, describing the possibility that an asset finds no buyers due to a lack of liquidity in its given market. This problem is exacerbated during fast-moving markets or periods of market stress.

Finally, *currency risk*, also known as *exchange-rate risk*, results from changes in the pricing of one currency relative to another. Investors or companies with assets or business operations across national borders expose themselves to currency risk that may create unpredictable profits and losses. In the context of debt markets and investments, issued bonds may have coupon payments and principal in a foreign currency rather than a domestic one. The foreign bond market is where issuers from outside the country issue bonds. For example, Toyota Motor Corporation might issue a US-dollar denominated bond in US foreign bond markets.

In summary, bond investors face various risks that differ from equity investors. Investors should identify, measure, evaluate, mitigate, and monitor these risks. Instructors may ask students to think about and discuss how to manage these risks. How can a bond portfolio manager avoid losses in the portfolio? Such decisions are critical for investment managers entrusted with

generating sufficient returns to cover long-term liabilities, such as pension fund managers, endowment fund managers, and actuaries overseeing insurance funds.

The two main approaches for managing bond-related risks are immunization and cash-flow matching. *Immunization* is a strategy designed to generate funds to satisfy liabilities regardless of changes in future interest rates. Bond investors can immunize their portfolios by holding securities that have a matching duration to the liabilities associated with the portfolio. For example, a bond portfolio manager might know when a single claim will be made on the assets in the portfolio. The present value of the claim on the assets in the portfolio typically decreases if interest rates rise and increases if rates fall. To mitigate the risk of insufficient assets covering the liability, the portfolio manager seeks to match the duration of assets held in the portfolio with the liability duration. Duration-based immunization works relatively well for small parallel shifts in the term structure of interest rates. Investors may use various financial instruments for this immunization strategy, including futures contracts, swaps, and options.

Alternatively, portfolio managers can employ *cash-flow matching*, a technique used to construct a portfolio designed to fund a schedule of liabilities from a portfolio's cash flows, with the portfolio's value decreasing to zero after paying the last liability. For example, a pension fund manager might know the actuarial expectations involving retiring employees associated with a pension fund. To ensure the availability of sufficient funds to meet pension fund obligations, the fund manager seeks to match the cash flows generated by assets in the fund with cash payments made to satisfy the retirees' claims. Intuitively, the process is relatively straightforward. First, choose a financial instrument such as a bond to match the last liability with a sufficient cash flow to pay it off. Then, reduce the remaining liabilities by any other intermediate payments generated from this bond and repeat the process with the next-to-last liability. Although this description is an oversimplification, pension funds, insurance companies, and other financial institutions widely use the method of cash-flow matching for risk management.

Instructors should ask students whether all bond issuers are the same. Will any fixed-income security satisfy a portfolio manager who has known liabilities in the future? Are all bonds created equal? Although investments in the bond markets may entail uncertainty in their outcomes, different market sectors for fixed-income securities appeal to people with varying risk appetites.

With the choice of financial instruments from various fixed-income markets, investors will seek out securities with desirable risk-return characteristics matching their preferences. In many instances, they may lack readily available information for these investors, especially when involving credit risk. Corporate issuers know more about their firms' prospects than external parties do, and so the companies are likely to try raising capital exactly when they are most vulnerable financially. Bond investors know this situation but distinguishing between firms with legitimately good prospects and those teetering on the brink of a financial cliff is difficult. How is this challenge resolved?

One way that bond investors can reduce adverse selection costs is by seeking the opinion of informed third parties. Credit rating agencies play a key role in certifying bond quality based on their probability of default. Three agencies conduct most bond ratings: Moody's Investor Services, S&P Global Ratings, and Fitch Ratings. According to the Corporate Finance Institute (2020), rating agencies engage in the following services: (1) assessing the credit risk of specific debt securities and borrowing entities, (2) covering an array of structured financial products, such as asset-backed securities (ABS), mortgage-backed securities (MBS), and collateralized debt obligations (CDOs), and (3) giving ratings to sovereign borrowers, who are the largest in most financial markets. The sovereign rating given by a rating agency shows a sovereign's ability to repay its debt. Domestic

and international investors can better assess the value of bonds issued by governments from emerging and developing countries when the bonds have received a rating.

One concern is the potential conflict of interest that rating agencies might have. Do issuers pay rating agencies to give them a better rating? According to Podkul (2019), a panel of academics and former credit-ratings-firm executives have urged the Securities and Exchange Commission (SEC) to end the industry's "issuer pay" business model in which entities that issue bonds also pay for ratings. According to Podkul (2020), the SEC is still reviewing this matter.

Credit rating agencies assign ratings to bonds based not on their expected performance but on whether an issuer is likely to default on its payments. Bonds with ratings of BBB– and above are investment grade, while those with ratings of BB+ and below are *speculative grade*, also known as *high-yield bonds* or *junk bonds*. Investors are ultimately responsible for determining which bonds are likely to perform well. They may find good value in some speculative-grade bonds and poor value in some investment-grade bonds.

In general, Caplinger (2019) shows how investment strategies can be along several different lines:

- by sector: Treasury, municipal, sovereign, or corporate bonds,
- by maturity: short-, intermediate-, or long-term bonds,
- by credit quality: investment-grade or high-yield bonds, and
- Treasury Inflation-Protected Securities (TIPS) or those with fixed coupons.

Many mutual funds can only invest in investment-grade bonds, limiting potential returns relative to speculative bonds with higher yields. Mutual funds and exchange-traded funds (ETFs) that invest in high-yield bonds may provide better returns if investors are willing to take on a bond's associated default risks in the fund. Therefore, investors should weigh this risk-return trade-off carefully.

Bond Benefits and Performance

Having reviewed some bond risk characteristics, let's now focus on the benefits of investing in bonds. Instructors need to differentiate between relatively static bond benefits and those that have changed over time. The main benefit of investing in bonds is their ability to generate stable and predictable sources of income. This benefit has not changed, and it explains why investors and portfolio managers use fixed-income products when designing asset-liability, cash-matching strategies, such as ladders, barbells, and bullets. *Ladder strategies* stagger maturities on a consistent periodic basis across time. *Barbell strategies* use a combination of short-duration and long-duration bonds to achieve a target duration. *Bullet strategies* focus on a portfolio of assets with durations centered around the duration of the liabilities.

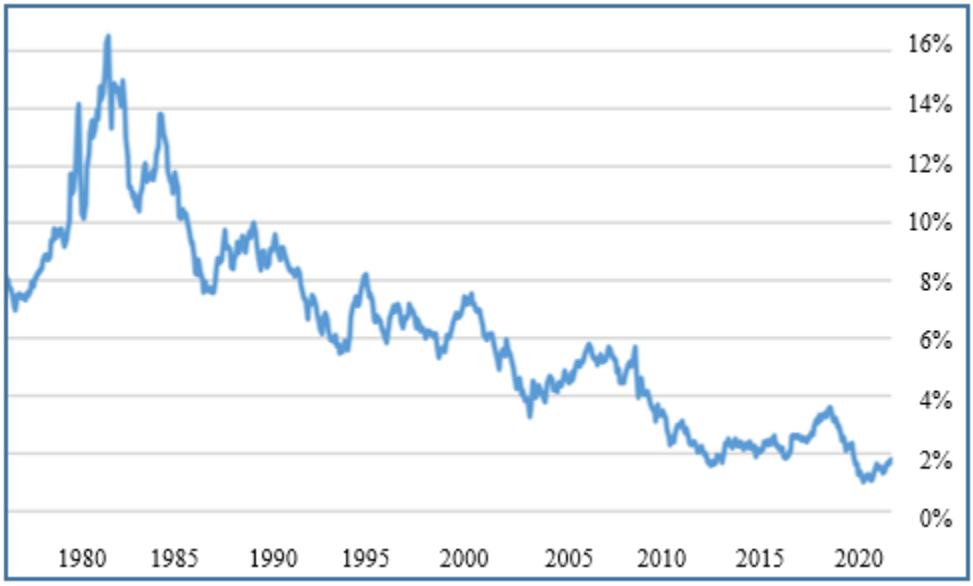
Unlike cash dividends on stocks, bond coupons represent a financial obligation, and bonds are generally considered safer investments than most equities. This lower volatility also means that bonds can help diversify a portfolio or offset exposure to more volatile asset holdings. Moreover, bondholders are not owners. Except for convertible bonds, bondholders are indifferent about a company's stock price if the issuer can meet its debt obligations. In bankruptcy, bondholders are more likely to recoup their initial investment than stockholders.

However, the magnitude of the stability benefit has changed due to the recent low-interest-rate environment. In other words, fixed-income returns remain stable and predictable but are just much lower than they once were. The annual return on bonds was around 6% to 8% before the financial

crisis of 2007-2008, and that number dropped steadily in the subsequent years. Exhibit 2 shows the yield-to-worst (YTW) for the Bloomberg Barclays US Aggregate Bond Index (Agg) since 1975. The *Agg* is a broad bond market index used frequently by investors to track the overall performance of the US bond market. The *YTW* measures the lowest possible yield on a bond, assuming the bond does not default. In the case of callable bonds, YTW equals the lower of yield to call and yield to maturity. Figure 1 shows that the current YTW for Agg has dropped down to 1.5% at the halfway mark of 2021.

Figure 1

Yield to Worst for US Bond Aggregate Index (January 1975–June 2021)



This performance drop has cascading effects. For example, students need to realize that most retirees have historically depended on the bond market as a stable and predictive source of income. However, 1.5% yields are too low for many retirees who picked their retirement date based on higher projected bond returns. In other words, many of these retirees must find additional income sources by going back to work or seeking higher returns in other investment markets.

An excellent exercise is to ask students to create three different $1,000,000 bond portfolios for a hypothetical retired client using a ladder, barbell, and bullet strategies. Ask them to pick five corporate bonds of investment-grade quality and five corporate bonds of high-yield quality for each portfolio. They should calculate the annual income and total duration for each portfolio. They should discuss each portfolio strategy's advantages and disadvantages, including when investors favor one strategy over another. The discussion should include the three main shapes of the yield curve: normal (upward sloping curve), inverted (downward sloping curve), and flat.

This exercise also provides an opportunity to reiterate the inverse relationship between interest rates and bond prices. For example, bonds previously issued during higher interest rates increase in value when interest rates decline. As interest rates have fallen, bonds appeal to issuers, which has created momentary disturbances in bond markets due to shifts in supply and demand. Even in low-interest-rate environments, most bonds remain liquid. Similarly, bonds with lower coupon rates may sell at a discount to those with higher coupon rates. Otherwise, the less competitive

bonds may have to offer other benefits to bondholders like embedded options for convertible bonds or tax advantages for municipal bonds.

However, instructors should stress that the fixed-income and stock markets do not always react the same to different phases of the economic cycle. For example, the economic cycle from the financial crisis of 2007-2008 to the COVID-19 pandemic of 2020 provided the longest bull run in the stock market's history. The stock market rebounded nicely from the COVID-19 pandemic and was at an all-time high on January 2022. However, the bond market has not performed as well.

Behavioral Finance Issues

Students often enjoy discussing behavioral finance. Fixed income provides a great learning opportunity to examine common behavioral issues. For example, bounded rationality plays a role in fixed-income markets. According to Simon (1978), *bounded rationality* states that market participants may make irrational decisions due to information, cognitive, and time constraints. Take credit ratings as an example. Individual investors and some portfolio managers rely on credit ratings because they lack access to the same information as credit rating agencies. This deficiency is an information constraint. Additionally, they do not have the training or ability to assess debt issuers, a cognitive constraint. Finally, they lack the time to review every debt issuer, which is a time constraint.

Trust is an important issue in debt markets. Investors need to trust the information they are given. In other words, information constraints are not just about the "quantity" of information available to investors. These constraints are also about the "quality" of information available to investors. Investors put considerable trust into the "quality" of credit ratings. This trust is vital for investors when analyzing the default risk of firms rated close to the gap between speculative and investment-grade bonds. Considering that corporations pay for their credit ratings, a robust research opportunity presents itself for studying moral hazard and whether credit rating agencies rate BB and BBB bonds consistently at other breakpoints. A moral hazard occurs an economic actor has an incentive to increase its exposure to risk because it does not bear that risk's full costs.

Credit-rating agencies played a major role in the financial crisis of 2007-2008. In the wake of the 2008 housing crisis, many criticized credit rating agencies for giving investment-grade ratings to securitized mortgages like MBS and CDOs. Furthermore, the sudden bankruptcy of Lehman Brothers and the subsequent collapse of Washington Mutual both highlighted substantial flaws in the current credit rating system. The public may never know if and to what extent certain companies may have tried to influence credit rating agencies to provide higher bond ratings. However, the potential for moral hazard is real. Understanding whether investors rely too much on these credit rating agencies and should do more research and analysis on debt issuers' creditworthiness are critical issues to address. Students should understand that other issues, such as regulations and banking requirements, are tied to ratings.

One critical thinking project for students is to assign them roles as analysts for a large fixed-income investor like an insurance company. Instructors should analyze and rank different bond issuances for similar companies. Students should generate a chart comparing all companies in a peer group, such as the following media and entertainment companies in Exhibit 3. This exhibit shows 2017 data for each bond issuance plus updated 2021 data. Instructors can now teach students basic bond concepts such as coupon rate, spreads, and yield. In addition, other variables such as cash flow, leverage, duration, and Moody's and Fitch credit ratings can be included. Table 2 also

provides an opportunity to teach students about credit risk. Look at how many media and entertainment companies are rated at the lowest investment grade level (BBB).

Table 2
Media and Entertainment Bond Comparables (03/03/2017 vs. 12/23/2021)

Company Name*	Market Cap ($billions)	S&P Rating	Coupon Rate (%)	Maturity (Year)	Spread** Year (%)	Yield (%)	Price ($)
Viacom	16.9	BBB−	3.45	2026	1.58	4.06	95.2
ViacomCBS	*20.0*	*BBB*	*3.45*	*2026*	*0.90*	*2.14*	*105.6*
Netflix	60.0	B+	4.375	2026	2.01	4.49	99.0
Netflix	*272.0*	*BBB*	*4.375*	*2026*	*0.72*	*1.97*	*111.25*
Discovery	16.5	BBB−	3.45	2025	1.79	4.27	104.5
Discovery	*12.1*	*BBB−*	*3.45*	*2025*	*0.45*	*1.70*	*105.1*
Scripps	10.0	BBB	3.95	2025	1.26	3.74	101.4
Discovery	*12.1*	*N/A*	*3.95*	*2025*	*1.48*	*2.72*	*103.9*
Time Warner	76.4	BBB	3.875	2026	1.45	3.94	99.5
AT&T	*177.6*	*BBB*	*3.875*	*2026*	*0.85*	*2.09*	*106.5*
21st Cent Fox	55.9	BBB+	3.375	2026	1.16	3.64	97.9
Disney	*279.2*	*BBB+*	*3.375*	*2026*	*1.40*	*2.64*	*103.2*
Disney	176.0	A	3.00	2026	0.57	3.06	99.5
Disney	*279.2*	*BBB+*	*3.00*	*2026*	*0.33*	*1.57*	*105.7*
CBS	27.9	BBB	4.00	2026	1.23	3.71	102.0
ViacomCBS	*20.0*	*BBB*	*4.00*	*2026*	*0.53*	*1.77*	*108.1*

*Note: The company listed owns the bond, but the original ticker issued may or may not change.
**Note: The 10-year spread for 2017 data was updated to a 5-year spread for 2021 data.

Even if investors have high-quality information, students should understand how quickly vital information can change. Look at how many bond issuances changed hands between companies. Netflix is the only company listed that has not officially combined assets with another company on the list by 2021. In March 2018, Discovery completed its acquisition of Scripps Networks. In June 2018, Time Warner merged with AT&T. In March 2019, Disney acquired 21st Century Fox. In December 2019, Viacom and CBS merged to form ViacomCBS.

Moreover, this chart will soon need updating. In 2021, AT&T announced it would offload Time Warner, now renamed WarnerMedia, to Discovery for $43 billion to form Warner Bros. Discovery in 2022. Students need to realize the importance of a peer group and make quick decisions about whether to buy/sell/hold bonds when these deals are announced because debt obligations also pass along during M&As. Another good discussion could be whether other companies, like Comcast (with NBCUniversal's Peacock), Roku, Apple (with Apple TV+), or Amazon (with Amazon Prime Video), would be appropriate within this peer group.

No investor can pay attention to all available information. Investors are also prone to making mistakes resulting from cognitive constraints. Examples of such constraints in fixed income include risk aversion versus debt aversion and manager optimism versus overconfidence. Risk aversion is relevant in debt markets because most investors are risk-averse and see fixed income reducing their future financial uncertainty. Conversely, debt aversion is the reluctance by borrowers to use financial leverage or engage in economically advantageous loans. Research shows that millennials have greater risk- and debt-aversion than previous generations. Regarding

risk aversion, Norman (2018) reports that only 37% of adults 35 and younger are currently invested in the stock market, down from 52% before the 2008 recession. According to Tepper (2018), only 23% of millennial investors prefer investing compared to cash.

Moreover, millennials were the only generation that listed cash as their favorite long-term investment. In other words, trust – or the lack of trust – is probably strongly correlated with the higher risk aversion for millennials. If nothing else, this issue would make for an excellent research opportunity. Millennials are also averse to taking on debt. According to Johnston and Smooke (2017), many millennials developed a sense of mistrust in the markets after watching their family members and neighbors lose their homes and jobs in the wake of the 2008 housing crisis. The authors contend that millennials feel shackled by their debts, especially student loans. Thus, the increased risk and debt aversion associated with millennials likely stem from coming of age during the financial crisis of 2007-2008 and being overwhelmed by student loans. Johnston and Smooke also report that millennials are more likely to teach their kids to shun borrowing, which could significantly affect bond markets in the future if two consecutive generations choose to avoid credit. This research makes for an engaging discussion in class, and students can express whether they or their generation agrees with these trends.

Debt aversion at the corporate level is based on capital structure decisions and the trade-offs between tax benefits of debt versus the risk of default. Kahneman and Tversky (1979) introduce prospect theory, which maintains that debt aversion for managers stems from the issue that potential losses due to financial distress can appear larger than the potential gains due to tax benefits. The firms most likely affected by debt aversion include heavy research and development (R&D) firms because they have a higher-than-average percentage of intangible assets. Examples include large pharmaceutical and biotech firms and several high-tech corporations. The vast majority of the 15 to 20 companies in the S&P 500 index with no debt are biotech, fintech, or other tech-focused companies. Meta, formerly Facebook, is an excellent example of a company with no debt but many intangible assets on its balance sheet.

Optimism and Overconfidence

Two common manager biases dealing with risk and debt aversion are optimism and overconfidence. Interestingly, biased managers are often on the opposite side of the financial leverage spectrum than millennials. These biased managers tend to choose higher debt levels than their rational counterparts in both cases. As evidence, Malmendier, Tate, and Yan (2007) show that optimistic managers are more likely to engage in unsuccessful M&As and avoid external financing. If optimistic managers use external markets, they generally prefer debt over equity.

Graham (2000) shows that optimistic managers still underutilize debt relative to its tax shield capacity. Overconfident managers display some of the same characteristics as optimistic managers. Ben-David, Graham, and Harvey (2007) show that overconfidence in managers can lead to higher investments in acquisitions and greater leverage ratios. An instructor can ask students why they think seasoned managers may behave differently than millennials to spur conversation.

Investors also face time constraints besides information and cognitive constraints. Bond investors are generally not as active as stock investors, so they may not face intense time constraints. Bond investors usually have the luxury of less volatility and the option of waiting until their bond matures. For these reasons, time constraints might not seem like as big an issue for fixed-income markets. However, the major problem is that investors, especially retail investors, are often busy and distracted by other issues and rarely monitor or change their fixed-income

holdings. This time constraint could prevent them from conducting research, making them more susceptible to herding effects. Illustrating the three constraints is easy by asking students to pick between two bond offerings. They soon realize that they need more information, training, and time to make a proper decision.

Status Quo Bias

A final behavioral issue affecting fixed-income investors involves retirement and *status-quo bias*, a preference for their current allocation. Because people are creatures of habit, many want to save and invest in similar ways. This bias can play an important role in retirement and insurance planning because participants often select the default choice for their retirement savings. This status-quo or default bias is important because investors may be inappropriately invested in fixed income based on current and future risk tolerances. Moreover, they may not plan to adjust toward more fixed-income and other wealth preservation strategies as they age.

Current Issues in Bond Markets

This section focuses on current issues in bond markets, including negative interest rates, new bond types, electronification, term structure models, and the transition from the London interbank offered rate (LIBOR).

Negative Interest Rates

Despite recent attention, negative interest rates are not a new phenomenon. Bloomberg reported that negatively yielding debt reached $17 trillion on August 29, 2019. Central banks imposed negative rates in the past to spur economic activity, generally following a period of sharp downturns such as a financial crisis or market crash. Many consider negative interest rates a "drastic" measure of monetary policy. In a negative interest rate environment, borrowers can acquire more debt quickly by essentially borrowing "money for nothing." Banks and depository institutions encourage their clients to withdraw from their accounts and spend or invest those funds because banks incur more costs or fees for keeping sizeable amounts of deposits on account at central banks such as the Federal Reserve. These costs associated with "saving" are used to spur lending and jumpstart economic activity but increase inflation. However, banks are likely to transfer the burden of these deposit costs to their customers and clients, further encouraging them to withdraw their deposits and spend, invest, or borrow more funds. The problem with negative interest rate environments is that they are likely unsustainable. This assumption is based on easing lending restrictions or requirements and an exponential increase in household and business debt acquisition. These issues lead to debt overhang and forming market or pricing bubbles. Easing lending standards leads investors and speculators to borrow more funds to invest in assets in the public markets. Such patterns, coupled with other quantitative easing methods, lead to more cash chasing the same assets and subsequently inflating asset prices and creating a market bubble. Furthermore, savers and bond portfolio managers are incentivized to move their capital to foreign markets to achieve higher rates of return.

A worthwhile conversation with students is to discuss how long negative rates can exist. Unfortunately, no obvious answer exists – look at Japan with negative rates since the 1990s. Some contend that such rates occur because of inaction from the Japanese government. From a rational

viewpoint, nothing is particularly wrong with negative rates if that represents an equilibrium between demand and supply for loanable funds.

New Bond Offerings

Contrary to popular views, the bond market offerings are more varied than equity offerings. The Treasury Department issues new bonds and debt products as US officials seek to attract more investors in domestic bonds. This development occurs as the country's deficit grows and many investors move funds outside US borders to achieve greater risk-adjusted returns. New bond issues with longer-term maturities are emerging, such as 40- and 50-year bonds, and some officials have contemplated 100-year maturity bonds. Although investors are still discussing the efficacy of these new bond issues, sovereign entities worldwide have begun issuing these "ultra-long" term maturity bonds. They intend to lock in low-cost financing for more extended periods to cover their growing deficits (Economist, 2017).

Additionally, central banks have begun to shift away from using LIBOR, which was the main proxy to measure interest rates for years. Now, they use the more robust and accurate secured overnight financing rate (SOFR), which is based on the overnight repo markets used by banks to secure "overnight" loans from one another. Several central banks have already issued floating-rate notes based on SOFR. A more detailed discussion of LIBOR occurs later.

Electronification

Another significant change concerns the electronification of bond markets. The bond trading desks of many investment banks have drastically changed in recent years. With the advent of electronic trading systems and the integration of such systems by major exchanges, the days when traders and portfolio managers had to dial their brokers for price quotes are disappearing. Although many bonds still trade over-the-counter (OTC), the process of pre-trade data aggregation and analysis is now streamlined and directly routed to the order management system (OMS). Increased integration of artificial intelligence (AI), machine learning, and algorithmic trading systems has begun to emerge in financial institutions with greater emphasis placed on engineering and programming talent than previously. For instance, the "Abbie" bond trading system developed by AllianceBernstein has grown to handle about 35% of total trade volume in the bank's fixed-income division.

Growing liquidity demands in the bond markets have triggered the growth in allocation to tech-enabled solutions, forcing firms to find more efficient and effective methods of reducing costs to support this increased demand and competition. For instance, banks have invested heavily in electronic trading systems (OMS), all-to-all networks, alternative trading protocols, central limit order books (CLOBs), and more advanced dark pools. *Dark pools* are private financial forums or exchanges used for security trading, and they are the opposite of "lit" public markets. Although larger trades are still generally handled "by hand," many transactions have become automated, and AI algorithms are given greater responsibility and autonomy in the fixed-income and even equity markets. To a greater extent, this electronification can be seen via the proliferation of fixed-income exchange-traded funds (ETFs) that have increased in popularity and assets under management (AUM) in recent years, enabling retail investors to engage in bond/portfolio trading without intermediaries.

Term Structure Models

Traditional term structure models should be reviewed, including the challenges and improvements over time. Investors and analysts use existing term structure models to model relations between a spot-rate or short-term interest rate (Vasicek 1977; Cox, Ingersoll, and Ross 1985) and longer-term forward rates (e.g., pure expectation and liquidity preference). These models are crucial in valuing and pricing certain financial instruments and derivatives with term structure relations used to build the yield curve. A problem with existing term structure models is that they generally consist of two-factor models that cannot truly model actual term structure relations. Analysts have developed many multi-factor or multi-dimensional models to describe these relations more accurately. Complications arise as multi-factor models shift focus from fitting a relation to forecasting and estimation. The greater a model's dimensions, the more computational work is needed to model stochastic/Gaussian relations, albeit with increased flexibility. The goals of modern term-structure models are to best fit the relation from a sample and provide for better forecasting/robust estimation while being computationally cheap or efficient.

Transition from LIBOR

The shift from LIBOR is significant, given its past prominence. LIBOR refers to an interest rate calculated each day by taking a trimmed average of the interbank interest rates offered by various banks currently surveyed by the ICE Benchmark Administration. The rates used to calculate LIBOR are based on the short-term bank to bank lending rates. LIBOR is then used as a base rate for calculating the rates on other loan types. The loans based on LIBOR range from giant corporate loans to personal mortgages and student loans. In 2012, the LIBOR scandal occurred, or at least was publicly disclosed. This scandal refers to a scheme created by bankers at many of the world's major financial institutions to manipulate LIBOR for a profit. Although discovered in 2012, evidence shows that the scandal dates to 2005. The scandal arose because LIBOR can be easily manipulated due to the small number of transactions each day on which its calculation depends. By influencing the rates on only a few transactions, bankers could influence LIBOR as a whole and subsequently affect the rates on numerous loans worldwide.

Recently, regulators have pushed to stop using and publishing LIBOR as the global benchmark interest rate and use a rate that cannot be easily manipulated. The lead contender is the secured overnight financing rate (SOFR) in the race to replace LIBOR. Since April 2018, the New York Fed has published SOFR daily, and several LIBOR quoting panels ceased as of December 2021. This change cannot be understated and could qualify for the most significant transition in finance history (Cantwell, Gwynne, Patel, Schneider, Tsim, and Lee 2019).

Discontinuing LIBOR is not without precedent in Canada, Sweden, Australia, and New Zealand in 2012. However, the main difference is that these discontinuations were a "big bang" event. The Intercontinental Exchange (ICE) said that LIBOR would be discontinued, and the quotes would stop on a single day. However, ICE has pledged to continue some LIBOR polling after December 2021; the only change is that the regulators no longer compel the tier 1 banks to reply to the poll. The market is split on whether the banks are likely to continue to respond. An argument for responding is that banks have trillions of dollars pegged to LIBOR. An argument against responding is that banks willingly give information to the market that is no longer required. Banks have been harmed in the past by LIBOR manipulation. Whether banks will continue to respond to the poll remains to be seen. If so, both LIBOR and SOFR will co-exist, at least for some time, as proxies for a general risk-free rate.

Most of the market has decided to move new issuance to a daily compounded SOFR set in arrears. However, the adjustable-rate mortgage (ARM) market has decided to move to a daily compounded SOFR set in advance. This change means a dislocation exists in the security and the hedging instrument.

Another significant development in fixed-income markets is OIS/SOFR rates. The overnight indexed swap (OIS) is the rate banks use when initiating an overnight interest rate swap, a financial contract in which the two involved parties agree to exchange a payment when the contract is complete. The exchange payment is calculated by finding the difference between the fixed rate that the parties agree upon and the overnight index rate. This rate is directly correlated to the Federal funds effective rate.

The SOFR is something different. *SOFR* measures the cost of borrowing cash, collateralized by Treasury securities overnight. It is based on actual transactions in the Treasury repurchase market, which is the market where investors loan banks money overnight using Treasuries as collateral. This market is high volume, and thus calculating SOFR is based on far more transactions than is LIBOR. This distinction is the main reason for using SOFR to replace LIBOR as the global benchmark rate post-LIBOR scandal. SOFR is more difficult to manipulate than LIBOR. Thus, transitioning between LIBOR and SOFR is likely to be complicated.

Trends in Fixed Income Markets

Instructors may lose sight of evolving fixed-income market trends, especially when teaching undergraduate students. The discussion of basics such as bond risks, differences between debt and equity instruments, and calculations of bond prices and bond yields, seem all that is possible to cover, especially in the limited time often allotted to fixed income markets. However, an opportunity to capture students' attention is available to instructors. Consider the GameStop short squeeze in spring 2021. Students not interested in dividend discount models became extremely interested in "the little guy" putting one over on the elite. Although not as exciting as GameStop, trends about sustainability, fintech, and exotic issues are sure to spark student attention.

Bail-Ins

Students may view some concepts as truths, such as paying bondholders before stockholders in debt restructurings. However, this situation was not entirely true during the Greek debt crisis. Instructors may want to prompt students to discuss situations when their beliefs about bond markets may not always hold. The debt crisis in the Eurozone and the resulting "bail-in" of Greek debtors, including depositors in Greek banks, were watershed moments in sovereign debt restructurings. A *bail-in* occurs when lenders, such as bondholders or depositors, are forced to bear some costs typically borne first by shareholders. After the financial crisis, a wave of debt restructurings by developed and developing countries occurred. In 2012, Greece had the most extensive sovereign debt restructuring in history. Whether restructurings are beneficial or costly for the debtor country is ambiguous. As Forni, Palomba, Pereira, and Richmond (2016) suggest, restructuring debt can lead to reputational loss, higher spreads, and exclusion from capital markets. Still, it can also support growth by reducing overall debt payments.

Rating Agencies

An issue that often generates discussion in classes dedicated to bonds is rating agencies. Students are often surprised that the borrower pays the rating agency for the rating. In US courses,

issues of global fairness and the repercussions resulting from unfairness are rarely considered. For example, bond ratings and the traditional rating agencies such as Moody's, S&P, and Fitch have come under attack globally. Emerging market borrowers feel the sting of what they consider lower than deserved ratings relative to US and Western European bonds. According to some emerging market borrowers, rating agencies unfairly rate their debt. For example, India, a country with a relatively flat debt-to-GDP ratio and steady economic growth, has its debt rated at BBB–. In contrast, with slowing growth and an escalating debt-to-GDP ratio, China has a rating of AA–, upgraded from A+ in 2010. The rating agencies maintain that developed countries such as the United States have a long history of debt repayments, over 100 years, to support the higher ratings.

As Ferri, Liu, and Stiglitz (1999) note, rating agencies are quicker to downgrade emerging market borrowers, increasing the risk of another global financial crisis. They also examine the Asian financial crisis in 1997 and find that rating agencies fostered panic and contagion in the early stages of the crisis with rating downgrades. As a result of this perceived and perhaps actual unfairness toward emerging market borrowers, the BRICS (Brazil, Russia, India, China, and South Africa) have suggested creating an independent rating agency. However, global investors may view a new rating agency with skepticism. One exercise to explore these issues could be dividing students into small teams, with half acting as parties from rating agencies and a half from emerging market countries making a case for higher ratings. Issues of the costs of lower ratings, including the higher cost of debt and the impact on reputations, could be examined. On the other hand, students could explain why the lower ratings are appropriate.

Fintech

Technology has a profound impact on bond markets. *Fintech* uses technology and computer programs to support banking and financial services. It is likely to move beyond lending, payments, and wealth management and into less explored areas of banking, including financial markets.

Further, this market is a relationship business. Nearly all bond trades, whether electronic or over the phone, occur on "request-for-quote" platforms in which dealers are the only ones authorized to quote buy and sell prices. The problem for investors is that this system is opaque, and dealers have most of the power. However, bond markets are likely to become more transparent in the future. New legal requirements that started in Europe require reporting prices on completed transactions. Also, new trading platforms such as MarketAxess allow some market participants to trade directly, bypassing dealers. Students could debate the benefits and costs of "the old way" versus new possibilities for bond market traders on the buy and sell sides. Instructors often do not discuss how trade and markets embracing new technologies differ for buyers and sellers. Who would lose or gain jobs? Would incomes fall if bond prices were more transparent, and would bond returns be affected?

Exotic Bonds

Many instructors focus on vanilla fixed-income bonds and fail to mention the growing number of "exotic bonds." Exotic bonds have payments tied to various events such as hurricanes and other natural disasters and catastrophes. Catastrophe (cat) bonds are exotic bonds that emerged in the mid-1990s after Hurricane Andrew and the Northridge earthquake. They allow insurers and reinsurers to share the risk of natural disasters with investors. Investors provide capital to insurers and share in the risks in the event of a natural disaster. The investor gets less, not more if a catastrophe occurs. Sometimes, even the principal repayment is reduced due to an event. In the wake of devastating droughts and fires in the Western United States and flooding and hurricanes

in the east, this bond category is likely to grow.

An instructor could divide students into groups to debate the ethics of bonds with cash flows tied to devastating events. Also, they could discuss the impact on yields investors deserve in the wake of an increasingly volatile climate. This issue is novel, given that discussion often centers around yields involving credit risk, not the likelihood of deadly weather events.

Although *fallen angel bonds* are not particularly exotic, credit agencies once rated them as investment grade but later downgraded them to junk bond status. Companies that once had an investment-grade debt that has been downgraded often have better prospects for repaying the debt than those that initially issued speculative-grade debt. This relation means investors may earn higher yields associated with junk bond ratings but potentially not bear a substantial amount of increased risk.

Crossover bonds are another intriguing investment. These bonds straddle the rating spectrum between speculative and investment grade: at the lowest investment grade rating and the highest speculative-grade rating (i.e., in the BBB+ to BB– range). This gray zone, often called the corporate bond market's "sweet spot," allows investors to earn extra yield without additional risk.

Another non-standard instrument is the relatively new class of social impact bonds (SIBs). SIBs are not traditional because the "borrowing" is used to achieve social goals such as reducing recidivism or improving childhood reading. Typically private investors only earn returns from government payments if a specific goal is achieved, saving the government expenses in the future. These "pay for success" bonds greatly appeal to the current generation of students.

Student Loan Debt

One issue sure to get students talking is student debt, the ethics of student loans, and whether student loan debt is the next bubble in the credit markets. Student debt continues to rise and is now the second-highest consumer debt category after mortgage debt. Student debt is now greater than all US credit card debt. The statistics are staggering – overall, student debt in the United States reached $1.75 trillion on January 27, 2022 (Hanson 2022). By comparison, the size of all subprime mortgage debt in 2007 was $1.3 trillion (Marquit 2017).

Student loan debt has serious implications for the United States and the economy, regardless of whether student debt is the next bubble. An instructor could divide students into groups to discuss the personal impacts they foresee regarding their own, friends', or simply societies' increasing student debt. Another option is to create a team assignment where students identify, rank order, and present their findings of the effects of student debt on students in the class. They could then debate which concerns are more detrimental for society. For example, some link the growing student debt levels to millennials delaying major financial milestones such as home ownership.

Consequently, millennials rent longer, rising rental rates. It is also associated with slower purchases of white goods, durable goods that fill homes, such as refrigerators and dishwashers. Evidence also suggests that those with student debt are postponing marriage and families. Student debt payments are consuming a greater portion of millennial incomes. According to the Small Business Administration (Foroohar 2017), millennials are less engaged in entrepreneurship than previous generations and are less willing to take risks. Additionally, those with substantial debt are less likely to undertake the risk of starting a business but more likely to accept a traditional job to pay the bills.

So is student debt the next financial bubble? This question is reasonable given that student debt now exceeds that of subprime mortgage debt leading to the financial crisis of 2007–2008. Many

reasons exist to think that this ballooning problem may cause the next crisis. However, rather than a balloon ready to burst, economist Joseph Hogue likened the student debt problem as more like a leaky balloon (U.S. Student Loan Center 2020). Because one cannot simply declare bankruptcy and walk away from student debt, this situation decreases the likelihood of a significant crash like the one experienced with subprime mortgage debt. Students are more likely to see their wages garnished, so the effect is negative but more prolonged instead of a bursting bubble. Also, the government is responsible for the debt, so it can "afford" a longer collection period than a private, for-profit lender.

Interestingly, some schools, most notably Purdue University, are trying a novel approach to address the student debt problem. The university is using a concept called *income share agreements*. According to Daniels (2017), the president of Purdue University and former governor of Indiana, students sign a contract with an investor that gives the investor the right to a fixed, agreed-upon percentage of the student's income after college in exchange for the funds to attend college. In essence, the student is selling "equity" to raise funds for school rather than borrowing. Although a fascinating and creative solution to the problem, this approach is not for everyone. Finding investors willing to take the risk could be difficult for students wanting to major in less lucrative majors.

Student debt is a prominent topic that instructors could use to help students understand the complexities of debt markets. The approach taken by Purdue is fascinating in the context of agency relationships, a topic that most students learn about in their first finance course. Is it right to incentivize/compensate lenders this way? The topic of student debt has it all.

Student debt involves ethical, financial, and political implications. It also involves human interest issues and the government's role in assisting those wanting to attend college. This subject makes an excellent writing assignment that lets students express themselves on a topic affecting many of them and their friends, and family members.

Summary and Conclusions

Fixed-income securities are critical for our financial markets, exceeding the more popular equity markets in size and trading volume. We explore timely topics surrounding fixed-income securities, including (1) bond characteristics and risks, (2) bond benefits and performance, (3) behavioral finance, (4) contemporary bond issues, like LIBOR transition and negative interest rates, and (5) trends in the debt markets.

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Comparison of a "Dedicated Course" Approach vs. a "Self-Directed" Approach to Spreadsheet Skill Acquisition

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Numerous studies have documented the increasing importance and utility of spreadsheet proficiency for business. Business programs in general and finance and accounting programs in particular struggle with how to best teach students either the basics of spreadsheet use or advanced skills.

In 2015, after several years of observing that students in accounting and finance courses were exhibiting little practical knowledge of spreadsheet use, our faculty agreed on a new approach that we refer to as "Self-Directed Spreadsheet Skill Acquisition," accompanied by an inflexible testing requirement for all students in basic accounting and finance courses to pass a series of spreadsheet skill "demonstration" exercises with a 100% score. That program was described in an article accepted for publication in Advances in Financial Education entitled "A Self-Directed Learning and Demonstration Test Approach to Spreadsheet Skill Development."

This article is a promised follow-up study of the relative effectiveness of offering a dedicated course in spreadsheet skills vs. our "self-directed" approach. We created a regression model to test the effect of the dedicated class and the Microsoft Excel test taken by class participants and a group of control variables. We conclude that the model-predicted improvement in student performance derived from the dedicated course vs. the self-directed approach is minute and may not provide additional value for the increased investment in instructional resources involved.

Keywords: Excel, Self-Directed, Spreadsheet skills, Spreadsheet testing, Excel performance

Introduction

If you walk through the finance or accounting department at any major corporate office, you will see computer screens filled with Excel spreadsheets outlining financial results, budgets, forecasts, and plans used to make big business decisions.
-Investopedia

Review of Literature

Numerous studies have documented the increasing importance and utility of spreadsheet proficiency for business applications (Zhao, 1996; Zhao, 2016; Holtzman 2010, Holden, 2000; Dudley, 2010; others), with the disciplines of finance, accounting and engineering making heavy

use of spreadsheets. Business programs in general, however, and finance and accounting programs in particular, struggle with how to best teach students either the basics of spreadsheet use or advanced skills such as financial modeling and data manipulation (Davies et al, 2013; Hannafin n.d. & Hannifin 2010).

At the time that spreadsheets were first introduced (in 1979 with the introduction of *VisiCalc*) computer instruction primarily took the form of teaching programming skills, particularly Fortran and COBOL. For most of the 1980's "students had to learn a programming language in order to benefit from computers" (Baker & Sugden, 2007). Spreadsheets (Lotus 1-2-3, Quattro, SuperCalc, VP-Planner, and ultimately Excel) changed that paradigm. Morishita *et al* (2001, 296) observe:

> *Our experience in computing was that it took a very long time to learn computer languages and it was sometimes hard to obtain proper results in a limited time. The spreadsheet, however, is rather easy to use and almost instantaneous numerical simulations are possible.*

In effect, learning spreadsheet use has over the past 15 years largely replaced curricular requirements in both business and engineering programs to learn a programming language. "There is no longer a need to question the potential for spreadsheets to enhance the quality and experience of learning that is offered to students" (Baker & Sugden 2007, 32).

The recognition that the acquisition of spreadsheet skills is a valuable component of a business education appears to have become widespread since the turn of the century, but the actual incorporation of spreadsheet skills into the learning environment has been slow to materialize. As of 2011, Payne and Tanner could report from their survey of finance coursework that:

> *The modal finance professor determines 100% of the students (sic) overall grade through individual in-class tests…In-class tests comprise 34% to 65% multiple-choice questions and 34% to 65% open-ended problems. Students can use financial and non-financial calculators and financial tables for the exams (Payne & Tanner 2011, 83).*

Payne's recommended solution for the problem of inadequate attention to spreadsheet instruction was that business schools should offer a "dedicated technology-oriented finance (course) and…require a tech finance course as part of their undergraduate finance major" (Payne and Tanner 2011, 83). Based on a study of program requirements and syllabi at 469 AACSB schools, she had found that "fewer than 1% of AACSB-accredited business school offer a dedicated course in financial technology applications" let alone require such a course as part of their finance curriculum" (Payne and Tanner 2011, 82). It is probably not a stretch to extrapolate from Payne's findings for finance majors, where spreadsheet skills have a heightened import, to conclude that business schools for non-finance majors (marketing, management, etc.) are likely to incorporate spreadsheet instruction to an even lesser extent.

In an article accepted for publication in *Advances in Financial Education* ("A Self-Directed Learning and Demonstration Test Approach to Spreadsheet Skill Development") one of the authors of this article (Borden) presented the concept and structure of a program at the University of Nebraska at Kearney. That program combined an inflexible Excel testing requirement for all business students, the expectation that students would learn a required set of Excel skills on their own, access to online Excel skill video tutorials, and unlimited attempts at different versions of the tests. Results for 1,218 students were reported, and a follow-up article analyzing comparative data for students who completed a 3-credit course on Excel skills and took the Centiport Microsoft

Proficiency Exam or the GMetrix Multi-Project Excel Exam was promised. This is that promised follow-up article.

Development of the Program

At the University of Nebraska/Kearney, our concern has been primarily that business students (not just accounting and finance students) should have at least basic Excel skills by the time they graduate, and we have run the gamut of pedagogical approaches to spreadsheet instruction. Over the past 20 years we have tried (initially) ignoring the issue under the assumption that today's high school graduates are computer literate when they come to us, have required all business students to complete a dedicated class addressing spreadsheet and word processing skills, have attempted to infuse spreadsheet instruction into the curriculum by encouraging faculty to embed it in their courses, and have used commercial testing products to assess student skill levels in spreadsheet use.

As of 2015 other departments in our College of Business were using both a standardized commercial test (both the Certiport Microsoft Proficiency Exam and the GMetrix Multi-Project 3 Excel Exam) to assess spreadsheet skills and requiring students to complete a basic computer proficiency class, but our Accounting and Finance (hereafter "A&F") Department was still anecdotally observing that despite all our efforts students in accounting and finance courses were still coming into our courses exhibiting little practical knowledge of spreadsheet use. Without belaboring the point, academicians probably need little explanation of the internal politics involved in attempting to influence the testing and grading standards employed by other departments; but after several years of attempting to do so our A&F Department decided to utilize its unique position in the curriculum to address the issue directly. The A&F Department offers the only three-course sequence in our curriculum that all business students regardless of major must complete in order: Accounting I, Accounting II, and Principles of Finance. That course sequence enabled us to implement a staged series of spreadsheet skill expectations and exam requirements with successively higher levels of skills built into the "demonstration" exams, and to do so without needing the sometimes-reluctant cooperation of our sister academic units. For a variety of reasons, we decided to implement the Level I exam in the second accounting course (Accounting II), the Level II exam in the Principles of Finance course, and to then defer to future semesters the options of dropping the sequence down to Accounting I and/or incorporating higher-level exercises into advanced accounting and finance courses for our respective majors. The requirement was implemented within the A&F Department for the Spring, 2015 semester. This paper describes the testing process that we implemented and shares the results of our internal assessments of the program's effectiveness relative to alternative instructional and evaluative methodologies.

For details on the "self-directed" approach to teaching Excel skills, the reader is referred to the original article in *Advances in Financial Education*. A short summary of the program, however, is needed here to appreciate the implications of the data presented below. There are six major components of the self-directed pedagogical approach employed, all of which we believe are essential to the success of the concept:

1) **A minimum score of 100%:** Students are advised of the list of techniques they must master, and they may not "cherry pick" the list to pass at 60%. A single missed technique results in failing the test attempt.
2) **Tying the Requirement to a Required Course:** The exam is tied to an underlying course in accounting or finance that is required of all business students and is listed in the course syllabus

as a "necessary but insufficient requirement" for passing their course. In other words, passing the spreadsheet exam does not affect their course grade, but failure to pass it means failing the course.

3) **Multiple Attempts:** Students may attempt different versions of the exam as many times as they want until they achieve a 100% score, with no penalty for multiple attempts.
4) **Transparent Technical Requirements:** The entire list of technical Excel skills that students must demonstrate is published and distributed to all students in the target courses. There are no "hidden" requirements.
5) **No Instructor Pedagogy:** Zero class time and zero instructional assistance is provided to students to acquire the targeted skills. Students must acquire the skills on their own, and no class time or instructor time is devoted to assisting them to do so.
6) **Blackboard/Canvas Instructional Video Links:** Every student registered for a target course is also required to register for a zero-credit "Lab" course with a Canvas module designed to provide access to tutorial videos and test-feedback with detailed error messages for each attempt at the test. Every required spreadsheet skill is listed, and for each a series of links is provided to YouTube or other online-available instructional videos demonstrating the spreadsheet technique. After each student attempt, the result is posted with the specific Excel techniques missed listed affording the student an opportunity to re-view instructional videos and prepare for another attempt at another version of the test.

Research Question and Methodology

Since the initiation of the requirement, a total of 1,137 students have been subject to the requirement and considerable data has been accumulated on their experience. Our study is based on data accumulated from the first 829 of those students. Because of missing values in the data, our tables report fewer observations.

One research question we did **not** ask is "Do students completing the demonstration exercise in fact have the required spreadsheet skills?" While future assessment might well benefit from addressing the question of the persistence of acquired skills as students take subsequent courses, that students did in fact have those skills after having demonstrated them in order to successfully complete the exercise is in effect a tautological question. The demonstration exercise, in other words, is itself the "test" of student skill acquisition.

Of more interest to us was the question of whether either the dedicated course students were required to take from another department, or the Microsoft exam required by another department were effective means of producing those same skills, in effect testing the relative value of Payne's proposal that a dedicated course should be added to the curriculum vs. the less-resource-intensive mechanism we had devised. Academic politics being what they are, other departments in our College have continued their own approaches to spreadsheet instruction alongside our department's requirements, with the unintended consequence that we have multiple measures of student achievement running concurrently. Our Marketing/MIS department, in particular from 2015 through 2017, utilized both the Certiport Microsoft Proficiency Exam and the GMetrix Multi-Project 3 Excel Exam to allow students to test out of their course teaching basic computer skills. Those students were also required to complete our department's demonstration exams.

Our hypothesis was that:

> "Students who have successfully completed either the dedicated course in computer skills or who have passed either the GMetrix Excel Exam or the Certiport

Proficiency Exam at a level sufficient to test out of the dedicated course requirement will need fewer attempts to complete the Level I Spreadsheet Skills Demonstration Exercise than those who have not."

Upholding the hypothesis would suggest that the dedicated course has instructional value and produces a persistent level of spreadsheet skill comparable to that demonstrated in our testing program.

Chi-Square Analysis

To test the relationship between the number of attempts a student needed to pass the demonstration exercise and whether or not the student previously took the dedicated course or demonstrated Excel competency by passing an Excel test, we created cross-tabulation tables and tested the relationships with two-tailed chi-square tests. In each of these tables we truncated the number of attempts required to pass our test at three, since there were few who needed more than three attempts.

In Table 1 we examined the effect of taking the dedicated class either prior to the semester in which the student passed our test or in the same semester. Results indicate no significant effect of taking the dedicated class on the number of attempts required to successfully complete the demonstration. Table 2 examines the effect of taking the Microsoft Excel test prior to or concurrent with taking our Excel test. Results indicate that having passed the Microsoft exam has no statistically significant effect on the number of attempts required to pass our exam. Table 3 examines whether having taken both the MIS class and having passed the Microsoft exam would affect the number of attempts it takes to pass our exam. Results indicate that there is no significant effect.

Cross-tabulation Tables with Chi-square tests:

Table 1
Cross-Tabulation of attempts with dedicated course

Attempts	**Did not take Course prior or concurrent**	**Took Course prior**	**Took Course concurrent**	**Total**
1	146 65.2%	112 66.3%	53 67.1%	311 65.9%
2	60 26.8%	45 26.6%	22 27.8%	127 26.9%
3 or more	18 8.0%	12 7.1%	4 5.1%	34 7.2%
Total	224 100%	169 100%	79 100%	472 100%
	Value	df	2-tailed significance	
Pearson Chi-Square	.791	4	.940	

Table 2
Cross-Tabulation of attempts with Microsoft Excel Test

Attempts	Did not take Microsoft Test prior or concurrent	Took Microsoft Test Prior	Took Microsoft test concurrent	Total
1	249 64.8%	35 67.3%	27 75.0%	311 65.9%
2	107 27.9%	11 21.2%	9 25.0%	127 26.9%
3 or more	28 7.3%	6 11.5%	0 0.0%	34 7.2%
Total	384 100.0%	52 100.0%	36 100.0%	472 100.0%
	Value	df	2-tailed significance	
Pearson Chi-Square	5.306	4	.257	

Table 3
Cross-Tabulation of attempts with dedicated course and Microsoft Test

Attempts	Did not take both the course and Microsoft Test prior	Took the course and Microsoft Test Prior	Total
1	280 65.9%	31 66.0%	311 65.9%
2	116 27.3%	11 23.4%	127 26.9%
3 or more	29 6.8%	5 10.6%	34 7.2%
Total	425 100.0%	47 100.0%	472 100.0%
	Value	df	2-tailed significance
Pearson Chi-Square	1.093	2	.579

While there is no relationship between passing the dedicated course and the number of attempts it takes to pass the demonstration exercise that can be captured in this chi-square test, we have reason to believe that there may be a relationship that might be captured with a more powerful test. First of all, in the cross-tabulation of the dedicated course and the number of attempts, though there was no statistically significant effect, there is a noticeable difference in the percent of students taking our exam three or more times. Eight percent of students that did not take the course needed

three or more attempts while only seven percent of those taking the course prior and five percent of those taking the course concurrent needed three or more attempts. In addition, our cross-tabulation takes no consideration of grades and groups students that did well in the class with those who barely passed. A test that considers the grade may be more powerful in detecting the benefits of taking the dedicated course.

Regression Analysis

We created a regression model to test the effect of the class and the Microsoft Excel test on the number of attempts required to pass our test. The dependent variable in the model is the number of attempts it takes to pass the demonstration exercise. Independent variables, those measuring the dedicated course and Microsoft test performance and a group of control variables, are described in Table 4. We report the results of two tests. In the first test, we include all of our variables of interest. In the second test, we use backwards step-wise regression to create the model with the greatest predictive ability. In the first test we report, we exclude Course DUMMY because it is correlated with Course GRADE. Because ACT and MACT are correlated, we ran our models excluding one and then the other. When ACT is excluded, MACT remains negative and returns a higher t-statistic. The same is true for ACT when MACT is excluded. We report the model with both included because the step-wise regression with the greatest predictive ability includes them both.

Table 4
Independent Variables

Variable	Definition
MSFT DUMMY	=1 if student passed the Microsoft Excel exam before or during the semester in which he/she passed our Excel test; 0 otherwise.
Course DUMMY	=1 if student passed MIS 182 before or during the semester in which he/she passed our Excel test; 0 otherwise.
Course GRADE	= MSFT DUMMY X grade received in MIS182. Grade is measured on a four point scale with A=4, A-=3.7, B+=3.3, B=3, etc.
ACCT DUMMY	=1 if student is an accounting major; 0 otherwise.
FIN DUMMY	=1 if student is an finance major; 0 otherwise.
MGT DUMMY	=1 if student is an management major; 0 otherwise.
MKT DUMMY	=1 if student is an marketing major; 0 otherwise.
ABUS DUMMY	=1 if student is an agribusiness major; 0 otherwise.
ACT	Overall ACT score.
MACT	Math ACT score.
FEM	=1 if student is female; 0 otherwise.

Results are reported in Table 5 and Table 6 Note that the most powerful predictors of the number of attempts required to pass our exam are the ACT and MACT scores. Students more prepared to do college work need fewer attempts than those less prepared. Course GRADE is also significant, indicating that the higher the grade in the course, the fewer attempts needed to pass our test. However, the coefficient estimate (-.039) is also of interest here. Assuming a student got an A in the course, the model would predict that that student would need -.039 X 4 =.156 fewer attempts to pass the demonstration exercise.

Table 5
Regression Model

Variable	**Estimate**	**t-stat**	**significance**
Constant	3.328	12.375	.000
MSFT DUMMY	.101	1.035	.302
182 GRADE	-.028	-1.295	.196
ACCT DUMMY	-.205	-1.785	.075
FIN DUMMY	.245	0.656	.513
MGT DUMMY	-.130	-1.137	.256
MKT DUMMY	-.222	-1.738	.083
ABUS DUMMY	-.107	-0.973	.331
ACT	-.031	-1.672	.095
MACT	-.043	-2.609	.009
FEM	-.015	-0.193	.847
R-square	.139		
Adjusted R-square	.116		
F	6.050		
Significance	.000		
N	386		

Table 6
Backwards-Stepwise Regression Model

Variable	**Estimate**	**t-stat**	**significance**
Constant	3.204	12.845	.000
Course GRADE	-.039	-1.806	.072
ACT	-.032	-1.771	.077
MACT	-.039	-2.418	.016
R-square	.123		
Adjusted R-square	.116		
F	17.856		
Significance	.000		
N	386		

Conclusions

One limitation of our study is that we did not address the relative quality of the dedicated course approach as a potential contributor to the effectiveness of a dedicated course vs. our self-directed approach. It is perfectly possible that a dedicated course utilizing different pedagogical techniques or with more intensive hands-on practice would produce superior results for the dedicated course approach. In order to test that proposition one would need to choose a quality metric, or several such metrics, and potentially perform a series of comparisons possibly to determine if there are quality thresholds above which a dedicated course might provide a cost-and-resource effective alternative to our self-directed approach. We will refrain from making specific suggestions regarding what qualitative improvements to a dedicated course might improve student performance but want to note that there are a wide variety of pedagogical approaches that could be employed and that our study is limited to the dedicated course techniques utilized in coursework offered at our institution.

While the hypothesis was upheld in our regression analysis, the model-predicted reduction in the number of attempts is minute. Thus, we conclude that a dedicated course may not provide any additional value for the increased investment in instructional resources involved, relative to our self-directed approach, particularly considering the opportunity cost of 3 credit hours in the curriculum relative to other potentially valuable courses. The self-directed approach, in other words, does not need to be superior to a dedicated course to be a preferable alternative given the opportunity cost and resource utilization associated with a dedicated course. We also suggest that there is a *per se* benefit to students in developing self-instructional skills, though any such benefits are not captured in this study. We conclude that the self-directed instructional methodology employed is a more cost-effective means of accomplishing the objective of student acquisition of spreadsheet skills.

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Documentary Film in the Financial Crime Classroom: An Active Learning Activity

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The purpose of this paper is to describe a pedagogical activity used in training UAE university finance majors in a financial crime class and art majors taking a documentary film seminar. Using the fraud triangle and fraud diamond theories, the finance majors conduct a financial crime investigation, using potential fraud by Multilevel Marketing Firms (MLMs) as the subject of investigation. Once the financial crime class has finished the evidence collection process they transfer it to their documentary film teammates for use in the development of a documentary film. We demonstrate through this experience how students in both finance and the arts can share perspectives through collaboration, as well as providing an opportunity to obtain hands on experience with the principles of fraud investigation. In addition, we illustrate to the finance students the importance of media in broadening the audience for finance related issues. Limitations include the caveat that the course has only been taught at one university in the United Arab Emirates, although the exercise described in this paper is transferable to any related university level classroom.

Keywords: Active Learning, Arts, Collaboration, Financial Crime, MLM

Introduction

Fraud and other financial crimes are extremely costly for economies worldwide. Given a number of high-profile fraud cases in the United Arab Emirates, such as the Abraaj Capital scandal, the UAE has experienced an expansion of financial crime teams at financial sector companies and an increase in demand for anti-financial crime professionals. Accordingly, a major research university in the UAE introduced a financial crime course in the fall semester of 2018. The purpose of this paper is to describe a collaborative active learning semester project for college students in a financial crime class offered in the School of Business Administration in the Fall of 2020 to apply film class offered in the College of Art and Design. The focus of the project on the finance component of the project is on the process of interviewing, control of and documentation of evidence, and summary of the findings of the fraud investigation related to Multi-Level Marketing (MLM) firms. The documentary film class then obtained the media evidence collected by the financial crime group they were paired with. The exercise was conducted in light of the academic evidence on active learning and would be useful in any curriculum that covers fraud investigation, including classes in auditing and internal controls.

The project outline (provided in Appendix A) is distributed to the students in the fraud/financial crime class at the beginning of the semester along with the syllabus; a corresponding project description is provided for the documentary film class. The exercise is then developed over the semester, beginning with the course content regarding the widely used Cressey's (1953) Fraud Triangle and subsequent Fraud Diamond theory by Wolfe and Hermanson (2004). We then discuss practical aspects of MLMs and the legal challenges they have confronted due to both misrepresentation of material facts regarding product quality and operating pyramid schemes. In the following three weeks, the principles of fraud investigation are discussed in class, using the Association of Certified Fraud Examiners (ACFE) course materials after obtaining the relevant permissions from ACFE. The collaboration could be extended to any country, as anti-fraud and anti-financial crime is relevant worldwide, and MLMs also have a global presence.

The Arts and Finance Education

Business majors tend to have a learning style that is both visual in nature and kinesthetic based on the VARK Model; they enjoy hands-on activities and find them useful for assimilating new information (Tennent, Becker & Kehoe, 2005). Finance majors prefer the security of data, quantitative analysis, regression tables, and black and white answers with little tolerance for ambiguity. They tend to have personality types that correspond to Myers-Briggs personality traits, extraversion, intuition, thinking, and judging (ENTJ). Intuitive students in finance outperform sensing (S) students and thinking (T) students outperform feeling (F) students. Perceiving (P) students appear to self-select out of finance in general; 89% are judging (J) and prefer planning, systematic orientation, and order to openness and flexibility. Finance faculty themselves tend to be overwhelmingly intuitive, thinking, and judging (Ziegert, 2000). Worthington and Higgs (2003) find that finance majors like numbers and quantitative approaches to problem solving. On the other hand, of the business disciplines, finance majors also tend to be more innovative (Wolf & Cates, 2004). Taken together, the research on the personality features and learning styles of finance majors lends itself to situations requiring visual stimulation and hands on, problem solving, and analytical activities.

In order to increase student participation in and ownership of education, the literature on active learning indicates that the traditional lecture method of pedagogy may not lead to the best outcomes in terms of student understanding and retention of content. The SoTL research indicates that a more cooperative approach, relying on student engagement, yields better outcomes in terms of knowledge attainment, and there are many practical collaborative assignments that can be provided (Kolb, 1984; Barkley, Major & Cross, 2014). Beyond the traditional lecture format, when active learning is incorporated in the finance classroom, it is usually through case analysis, student led investment groups, financial modelling activities, or trading simulations, to give students an understanding of practical aspects of the finance profession. Moreale and Zaynutdinova (2018) describe an experiential learning activity incorporating the Bloomberg terminal, which is commonly used in industry. Mukherji, Etta-Nkwelle, and Streeter (2018) explore a no cost, open portfolio management simulation using StockTrack software, and find that it improves student participation in the learning process. Krause and Robbins (2020) find that "low stakes" activities (i.e., where actual money is not involved) such as trading room simulations contribute to student learning in a multivariate framework, consistent with the research regarding the preferred learning style of finance majors.

Regarding the use of media in the finance classroom, Stephen (2015) finds that viewing and discussing video clips from the business news offers finance majors an opportunity to consider the course content from a practitioner perspective. Only one other paper, to our knowledge, addresses active learning in the context of financial crime education. Moy and Pactwa (2018) provide a detailed case for use of a PBS Frontline documentary, To Catch a Trader, in a finance classroom. This case provided insights for students regarding the federal investigation of insider trading activity by hedge fund manager Steven A. Cohen. In addition, Assad (2016) used professionally produced finance related documentary films outside of class time to focus students' attention to ethics in finance; students were required to analyze these documentaries in order to obtain real world perspectives. In both of these cases, documentary film is used as a teaching device regarding financial crime, but the students did not contribute to making the documentary, nor was it created through a cross-functional collaboration with documentary film students. Further, the use of a "digital storytelling" approach, which involves scripts written by and then filmed by groups of students for presentation to their class, has been explored in the accounting classroom (Cuumbley & Smith, 2000). However, the digital storytelling techniques applied in the finance classroom have not, to the authors' knowledge, yet been conducted in cooperation with students from the arts, which would support students in learning to cooperate across academic silos.

MLM Fraud Investigation Project Overview

The MLM investigation assignment used in the Financial Crime class was distributed on the first day of class in Fall of 2020. Students were told to form groups of no more than five with whom they would work over the semester on a "fraud investigation" assignment. For a class of 35 students, yielded seven groups. The assignment and some additional web-based resources distributed to the students are provided in Appendix 1.

The objectives of the assignment were to:

(1) Apply the principles of the fraud diamond theory to fraud and financial crime investigation.
(2) Extend the students' knowledge of the determinants of fraud and financial crime.
(3) Provide experiential learning regarding the dynamics of fraud and financial crime investigation.
(4) Learn by doing regarding best practices in the process of fraud and financial crime investigation.
(5) Persuasion skills required for situations involving confrontation between actors in fraud and financial crime investigations, such as interviewees and lawyers.
(6) Analytical skills.
(7) Ability to apply professional judgment in situations requiring subjectivity and ambiguity.
(8) Partnering with team members from outside of the business disciplines in order to generate creative output.

The students were told that the first five weeks of the semester would be devoted to covering the preliminary material regarding the theories of criminology that explain the factors that predict the incidence of fraud, as well as the principles of fraud investigation. For the final seven weeks of the semester, the students would apply the course material to an investigation of their own into a white-collar crime, fraud at MLMs.

Relevant Course Content for Financial Crime over Weeks 1 through 6

The Fraud Triangle and Fraud Diamond Theories

While specific language in various fraud statues differs, at its essence, fraud is generally considered the conscious act of deception for personal gain. The Association of Certified Fraud Examiners (ACFE) provides the following definition: "*A knowing misrepresentation of the truth or concealment of a material fact to induce another to act to his or her detriment"* (ACFE, 2020). Based on the 2020 ACFE Report to the Nations, an annual fraud survey, losses due to fraud exceeded $3.6 billion, resulting in approximately 5% of revenues worldwide lost to fraud. The Report to the Nations indicates that fraud is a problem that impacts businesses of all sizes across industries; no region of the world is unscathed by fraud.

In the process of covering the anti-fraud component of the financial crime class, the Cressey fraud triangle theory, which explains the conditions under which fraud occurs, is heavily utilized. Developed by Cressey (1953) through interviews with 250 convicted embezzlers (referred to as "trust violators"), the fraud triangle paradigm implies that potential white-collar criminals are infrequently sociopaths; rather, they act based on financial motivations and justify these illegal behaviors cognitively. The fraud triangle theory also implies that higher quality internal controls can discourage many potential criminals from carrying out crimes. Subsequent research, such as Albrecht, Albrecht & Albrecht (2006), Lister (2007), and Vona (2008) find results that appear to confirm the importance of non-shareable financial pressures to commit crimes. For example, financial pressures are often of a personal nature, involving greed, high levels of debt, gambling or drug addictions, or divorce. However, they can also arise from improperly constructed compensation contracts that incent fraud, such as tying pay to the creation of new credit card accounts at a bank (Singleton, Bologna, Lindquist & Singleton, 2006).

Building on the Cressey Fraud Triangle, Wolfe & Hermanson (2004) proposed a new paradigm referred to as the Fraud Diamond, which argues that while non-shareable pressure, opportunity, and the ability to rationalize fraud may exist, fraud will not occur unless the capacity to do so exists. The capability element refers to the skill set of the fraudster that equips them to commit fraud, including specialized technological skills or intimate knowledge of internal control weaknesses.

Research supports the conjecture that in the absence of opportunity, or weaknesses with internal controls, fraud is less likely to occur (Rae & Subramanian, 2008). Opportunity can reflect knowledge of managers regarding "cracks in wall" of internal controls Wilson (2004), or accounting and financing structures such as related party transactions which obscure financial relationships between top management team members and the firm (Wilks & Zimbelman, 2004). Capability includes both the technological capability to commit fraud and get away with it as well as the sophistication (intelligence and creativity) to recognize potential opportunities to commit fraud. In support of this fourth element, Beasley et al. (1999) document that CEOs are involved in 70% of public company fraud cases, because their position at the top of the firm makes it difficult to monitor or discipline their behavior. Further, capability encapsulates personality traits such as self-aggrandizement and narcissism, as well as the charisma or persuasive ability to convince others to participate in or cover up the fraud (Rudewicz, 2010).

The class also covered the burden of proof in civil and criminal trials to reinforce the fact that the burden has to be met by the prosecution rather than the defendant in court, and how the fraud examiner provides evidence, but does not give any statement regarding the innocence or guilt of the individuals in the organization under investigation; guilt and innocence are judicial

determinations, and fraud investigators are one part of the process of reaching that determination regarding guilt or innocence.

Multilevel Marketing Firms and Fraud in the MLM Context

The class next addresses the features of multilevel marketing firms (referred to in the UAE as "Direct Sales Organizations") in order to identify the pertinent elements of the Fraud Triangle. In simple terms, an MLM is an entity that arguably has a product, which can be dietary supplements, candles, essential oils, information, cryptocurrency, gold, and so forth. However, the focus of the company, and the true source of the profitability of the firm is to convince people to pay to "join" the company as distributors, members, advocates, consultants, presenters, influencers, or other representatives of the business, whose job is to "sponsor" additional participants, i.e., to recruit others to join the company. In order to create incentives to recruit additional paying members at the next level, the sponsor typically provides some training about the features of the product but primarily on recruitment. Those who are recruited to "join" the company pay a "fee" to the company for the business, business training, sponsorship, as well as a "starter kit" of the product to use for demonstration purposes and potentially sell. In any event, the focus is not on selling the product, but rather for the sponsor to bring in others, often friends and family, to pay the company the "joining fee" and buy the starter kit; some MLMs also require participants to buy a certain amount of product periodically in order to bonuses. Every time a new client is recruited and pays the fee, the levels above them (the "upline") in recruitment receive some percentage of the joining fee or sales of the product. Those recruited, and those they recruit, form the "downline".

MLMs frequently choose a demographic who will be receptive to the recruitment campaign (such as single mothers, recent college graduates, people into sports, and recent immigrant groups). Students were then asked if the necessary and sufficient conditions in the Fraud Diamond and Fraud Triangle for fraud to occur were met, and most were able to make this logical extension. From the fraud triangle perspective, the MLMs identify targets with a common non-shareable pressure, i.e., financial problems that single mothers, recent college graduates, those who are less educated, people recently separated from the military, and recent immigrants, those who want to lose weight or gain muscle, would confront. The top upline MLM participants perceive opportunity through incentive based compensation schemes that promote aggressive recruitment, and rationalization occurs because the upline is exhaustively trained through internal seminars and annual cheerleading sessions that they are giving the target demographic an opportunity to "become an entrepreneur" and "own their own business". From the Fraud Diamond theory, the capability element is reflected in the technological skills that the upline MLM members develop including remote recruitment tactics and the use of social media to host online parties and disseminate information.

Such an operation may not necessarily constitute a pyramid scheme or fraud. However, MLMs have often been associated with the misrepresentation of material claims regarding the features or capabilities of their products. Further, some MLMs have been fined for misrepresenting the income that recruits can potentially gain. The United States Federal Trade Commission, aware of the potential for abuse, provides information regarding how to differentiate a pyramid scheme from a lawful MLM. The recruiter often claims to make an exorbitant income from the business, relies on emotive and high pressure sales tactics, and focus excessively on the recruit developing a network that joins to create your downline that they will support you in cultivating, rather than on selling the product itself.

Principles of Fraud Investigation

After covering the relevant fraud diamond and academic dishonesty literature, over weeks 4 and 5 of the semester, the class then addressed the principles of fraud investigation, including the process of interviewing: choosing interview subjects, information gathering interviews versus confession seeking interviews, and the questions used in each, proxemic control, legal aspects of interviewing, using ACFE Fraud Investigation material. Following this overview, an alumnus of the finance program, who works for a Big 4 auditor in the UAE working in corporate intelligence for the fraud verification division, discussed evidence-gathering techniques using interviews and social media. We then viewed and discussed the documentary film "Betting on Zero", which is an investigation of the tactics employed by the Herbalife MLM in order to understand the concepts of fraud, pyramid schemes, and information content of documentary films.

At this point, the students were told to choose an MLM from a list of twelve active MLM organizations (excluding Herbalife) that are presently highly visible in terms of social media presence (such as through Instagram, Youtube, Facebook, and Snapchat). Of these twelve MLMs, all were globalized in terms of recruitment, although only one operated in the UAE. The students were told to conduct preliminary background research on the founders and history of company, from Securities and Exchange Commission filings if the company is publicly traded, Lexis Nexus legal for court filings regarding litigation, the Reddit /MLM forum, and through the financial press. The groups also gathered evidence of customer complaints regarding the MLM to the Better Business Bureau, FTC, SEC, state attorney generals' offices, and the UAE Direct Selling Association. In addition, the groups reviewed footage from MLM annual meetings and retreats, and identified the target demographic. Further, they familiarized themselves with disclosures made by the company and its affiliates regarding its product, sales and/or recruitment tactics, compensation "levels" and structure, and attempted to obtain income disclosure statements.

Following this information gathering activity, the students identified "affiliates" (i.e., influencers, consultants, developers, sponsors, etc.) who were active in social media to ask for information about the company, product, and services, and to request interviews regarding their interest in the MLM. As the UAE is a two party recording jurisdiction, the students requested permission for the interview to be recorded. This required the teams to conduct more information gathering research regarding appropriate interview candidates through social media and to establish contact with these individuals. The COVID-19 reality confronting the class regarding MLM recruiting being nearly exclusively conducted online worked to the advantage of the Financial Crime students, who were able to attend virtual parties and events that these influencers created and participated in. Each group conducted interviews with five MLM affiliated individuals through Zoom, Skype, WhatsApp, or Facebook Messenger in which they asked questions regarding the business model, the product features and awareness of testing of product features, potential income for entrants into the MLM, mean and median income for the bottom tier and upline levels, and the failure rate during the first year for new consultants in the MLM that the group had chosen. The groups also attempted to move further into the "upline" by asking for recommendations of upline members that would be willing to participate in interviews. Groups also corresponded through asynchronous text messaging with MLM affiliates. The Financial Crime students then compiled their findings, archived them on Google Drive for their corresponding Documentary Film group, and put their findings into a report documenting evidence regarding pyramid scheme behavior and/or product misrepresentation. Names of MLMs chosen by the class groups were changed so that they could not be identified by participants and viewers of the resultant films outside of the class and MLM and identifying information of individuals with

whom class members corresponded were replaced by pseudonyms, although all of the participants consented for the communication to be used in a semester project.

Content for Financial Crime in Weeks 7-14: Integration with the Documentary Film Class

The second part of the semester, beginning in Week 7 involved the collaboration between the Financial Crime and Documentary Film teams. This phase began with a joint meeting held between the two classes and faculty members involved in the collaboration through Blackboard Collaborate. The theoretical framework for the creation of the MLM fraud investigation films involved the concept of "mise-en-scene", which provides a perspective on setting the stage for all components of the documentary film process. As this concept was unfamiliar to the finance audience, it was not extensively explored in the financial crime class, who had come to understand the importance of properly archiving and documenting media evidence that they collected, and that their part of the "mise-en-scene" was the preliminary interviews, evidence gathering and data collection process. The cross-disciplinary participation was through working with the documentary film team to identify the most critical elements of evidence that demonstrated fraud and providing the background for the documentary film development.

Over the course of weeks 8 through 14 of the semester, the financial crime groups worked closely with their documentary film counterparts to coordinate resources and share information and insights into the features of the MLMs they had chosen to work on, the evidence that they had collected regarding fraudulent activity and pyramid schemes, and to put together the evidence into the film process. In the final week of the semester, a screening for the class and for the public was conducted through YouTube, and the documentary film students then received feedback on their component of the work. We also evaluated the survey comments for both classes after the collaboration was completed and the screenings of the films produced through the collaboration between the financial crime students and the documentary film students.

Student Experience and Outcome: Pre and Post activity surveys

The pre-collaboration self-assessment instrument was administered in the week immediately preceding the introduction to the CAAD groups. Around 43% of the financial crime students reported having previously participated in projects with students in other colleges in environmental sciences, engineering, and communications classes, but none had worked on an academic project with CAAD students. Financial crime students tended to take theater, intro to film, and introduction to art as their arts general elective courses; they reported that they found music and the arts interesting, but sometimes felt that these courses were "only theoretical". In general, the Financial Crime class was simultaneously fascinated and apprehensive regarding the partnership with the Documentary Film students.

Comments regarding their thoughts in anticipation of the Documentary Film collaboration were varied, including:

> *"Because SBA and CAAD are two very different fields of study, each college have their abilities from what they have learned throughout their time in AUS, and so we could understand many different types of points of view. Which also gives our documentary more credibility in a way."*

> *"Cross-collaboration can help make things interesting as we will be working with students from different colleges. It can also boost self-confidence and develop stronger*

thinking as in many cases, the two groups may think differently. Moreover, it can also help us boost the creative aspect of the project as it will help put everyone's ideas together in the best possible way. It will also help student think from new perspectives and explore new ideas. In all, it is a great opportunity to learn and grow together."

The students also demonstrated some apprehension regarding the collaboration:

"I think that different perspectives and different ways of viewing things can also be challenging. For example, business students may have more of strategic creativity and critical thinking, unlike CAAD students who would have an artistic vision. Trying to mash ideas together can be problematic. Yet, I believe this really depends on the personality and team spirit of the people you are working with rather than a cross-college issue."

"I would learn more about what the other colleges are taking and since the project is more diverse, we'd exchange ideas so we'd have ideas that maybe CAAD students don't think about or they'd think more of ways where maybe like this scene was proof of something but we'd tend to focus more on the business terms they use and then we'd figure if the company is a pyramid scheme or not."

Perceived potential challenges included:

"Communication might be hard at first. Communication might be hard at first because it will be the first time working together, no group leader or someone in charge, maybe no time to meet and completely understand everything."

"Time conflicts. Also, working with students from a different college means that they are used to different ways of thinking and approaching a specific situation or problem. So, there might be some conflicts in the way and methods the project is done."

"Because there are no common factors between us (SBA) and for e.g. a student in CAAD, things might be hard in terms of understanding what we are supposed to do and the way to approach it."

SBA students speculated on the talents they have that could benefit a cross functional team:

"I believe I can contribute knowledge from my financial background to fill in pieces of confusion that may occur."

"As business students we're more factual and we handle every situation like a meeting so I feel it would be more structured"

"Being a student in SBA, I believe that I would add practicality, analytical thinking and leadership skills in a cross-functional team."

"SBA students are generally competitive, mostly with ourselves. I believe we would want to bring in evidence and clarity to how MLMs work and have the best outcome whether it's with the research or film."

"I can bring in my knowledge on certain fields of business and Accounting. In addition, I can assist with how the deadlines should be assigned. Considering CAAD students are the more creative ones, I believe I can bring in a more logical understanding of the matter."

"In SBA, we do a lot of analyzing instead of working or artistic works so I believe my critical thinking would be beneficial to the collaboration."

In addition to the quotes described above, we used word clouds to obtain a graphical representation of the text used in the survey responses from the financial crime class prior to the collaboration. The word cloud method illustrates the emphasis on words frequently repeated using larger font in the image that comprises the text for words more frequently used (Mathews, Franzen-Castle, Colby, Kattelmann, Olfert & White, 2015). More frequently used words may also be notated through unique colors (Sillup, Klimberg, Sullivan, Green, Gebrededhin, Garrison & Sillup, 2018) or shapes (Ning, Lin, Zhou, Guo, Zhang, Peng, Deng & Xue, 2018). The word cloud tool is often used in the literature to provide a visual, reader friendly image that reflects complex concepts (Ibrahim, Wang & Bourne, 2017). The pre-collaboration word cloud is provided in Figure 1.

Figure 1

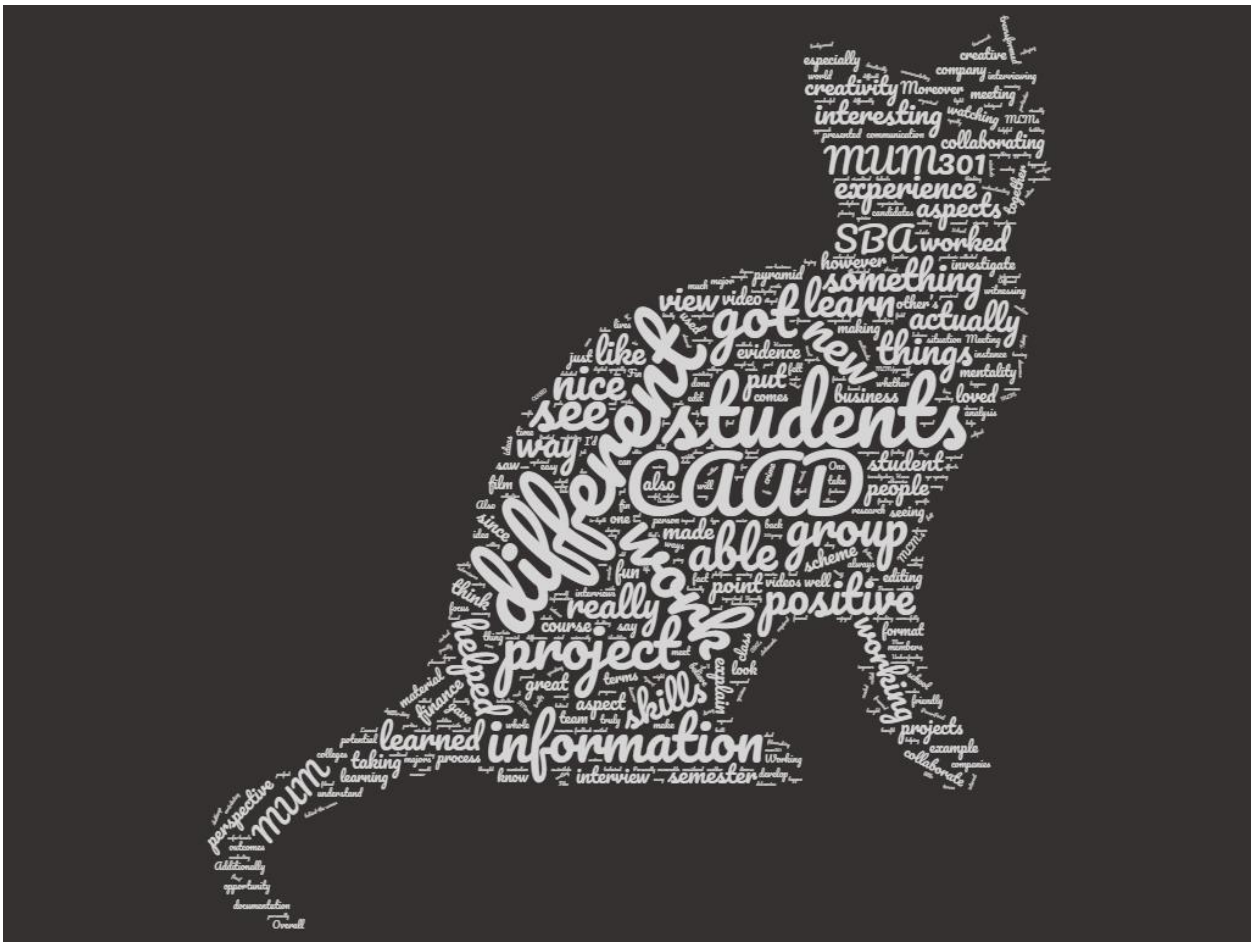
Pre-collaboration SBA word cloud generated from https://www.wordclouds.com/

The most commonly used word in the pre-collaboration survey were students, work, and SBA; learn, new, believe, time, goal, team, business were also frequently stated. This may reflect the focus on the SBA students on the trepidation they may have felt prior to being introduced to the documentary film groups.

Post-Assignment Student Reactions

The word cloud produced from the post-collaboration comments is provided in Figure 2 below:

Figure 2
Post-collaboration word cloud



In the post-collaboration word cloud, we saw a shift in focus from "SBA, Students, and Work" to Students, CAAD, and different; in addition, words such as different, new, information, project, and work featured prominently in the word cloud, reflecting new perspectives gained from the experience. Post collaboration survey comments follow below:

> **"***The positive aspects taking Fin 304 was that I got to know different people from the MUM 301group that I worked with. I actually got to meet one of the group members so they can interview me and take a video of the whole interview that we had, which was nice since all this COVID situation is restricting us from socializing. Another thing is that I actually got to learn MUM things since the person I worked with who was taking MUM showed me the different angles we should focus on and he explained some things about video taking which was very informative."*

"I really liked the idea of working with other students in CAAD, as I got to meet new people and have an idea what they actually do. The thing that really would have helped is to have met our counter group members from CAAD much earlier in the semester rather than just at the middle of the semester when their collaboration with us would be due to submit a rough-cut edit of the film."

"Personally, it was very nice to see our work come to life. It was also eye-opening to see the behind-the-scenes and how much work is put into the videos by MUM students. We also put in the necessary effort to un-finance our findings so that the collaborating students could understand the overall concept of our work."

The feedback from the financial crime class was unanimously positive as a memorable learning experience. It gave the students a new perspective on both financial crime investigation and digital media that they had not expected to participate in as college students. In terms of assessment of learning, 90% of the students met the standard for achieving the course learning objectives covered by the project as well as the objectives of the assignment.

Conclusions and Directions for Future Research

In this paper, we describe an active learning activity conducted in collaboration between a Financial Crime class in the Finance Department and a Documentary Film class in the College of Arts in order to generate not only a standard fraud investigation report but also to contribute towards integrating the concept of creative output within the business curriculum.

An added benefit of the project was that the Financial Crime students were able to appreciate firsthand the space that the arts occupy in the corporate governance system and the role of the free press in exposing unethical and criminal activities by companies. Inasmuch as it is often, the financial press that breaks stories regarding corporate illegalities that are later investigated by the Securities and Exchange Commission (SEC), students in the United States take it for granted that thanks to the press, criminal activity will generally be exposed. To the extent that the press has a less extensive role in the governance of companies elsewhere in the world, this is an aspect of the project that could be emphasized in subsequent collaborations.

The unusual features of the Fall 2020 COVID-19 period created an opportunity to normalize interviews through Zoom, WhatsApp, Skype, or Facebook messenger rather than in person with MLM participants in the United States and Europe, which facilitated recording and archiving of the interview, but at the same time, made the practice of the interview itself – for instance, establishing proxemic control - more difficult.

In upcoming semesters, once students are able to return to campus, the authors intend to refine this assignment through a greater focus on financial crime investigation and interviewing in person. In addition, we intend to explore other setting in which a partnership with the arts could be developed. For instance, a corporate finance class could gather evidence to use in a shareholder activist campaign in partnership with a documentary film class who would then create a film based on the evidence take on the role of a shareholder activist, which could then lend itself to subsequent exploration through documentary film. Finally, the authors intend to add to the finance education literature by combining the skills of financial statement analysis and introduction to art students in the design of a bricolage installation. We hope that this assignment will stimulate interest in greater cross-disciplinary pedagogical research between the faculty of business and the arts.

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Appendix A
Project: Multi-Level Marketing (MLM) and Financial Crime

In this project, we will form groups of 4-6 people and conduct an informal fraud investigation of a MLM in an effort to uncover fraud or pyramid schemes.

Additional MLM resources to watch, read, and consider:

John Oliver MLM segment:
https://www.youtube.com/watch?v=s6MwGeOm8iI&feature=youtu.be

Raw Earth segment on MLMs and pyramid schemes:
https://www.youtube.com/watch?v=lMUtU0tOmNE&feature=youtu.be

Vice Media segment on LuLaRoe:
https://www.youtube.com/watch?v=L6eujSJ0-RU

Caroline Thomson's (2018) Vice News article on MLMs:
https://www.vice.com/en_us/article/43e573/how-to-get-a-friend-out-of-an-mlm-herbalife-amway-younique-?utm_source=reddit.com

Finance guy commentary on MLMs:
https://www.finance-guy.net/streetonomic

Components of Analysis

(1) Legality of MLM versus pyramid schemes
   a. Predication?
   b. What are the potential forms financial crimes committed by MLMs?
   c. What evidence would you need to demonstrate the illegality?

(2) Research
   a. Introduction to company
      i. Company history
      ii. Business model
      iii. Management
      iv. Ultimate beneficial ownership
      v. Target market/demographic
      vi. Product line (if any)
      vii. Trends (https://trends.google.com/trends/?geo=US)
      viii. Social media presence (IG, Facebook, YouTube, pinterest, tik tok)
      ix. Sponsors
   b. Recruiting tactics
   c. Compensation scheme
   d. Distributor expenses
   e. Levels of promotion
   f. Average net payout (mean, median, standard deviation)
   g. Success statistics and evidence for statistics

h. Failure rates
i. Lawsuits
j. Profitability of UBO (if available)

(3) Obtain and store evidence
a. Process of infiltration
b. Recordings of Zoom meetings: https://nerdschalk.com/how-to-record-a-zoom-meeting-without-host-permission-participant/
c. Promotional material
d. Blogs
e. Podcasts
f. Events advertised online and through social media
g. Social media
h. Contact with recruiters
i. Interviews with clients and agents
j. Complaint filings (with FTC, SEC, state attorney general's offices, FTC, BBB, Direct Selling Association)

(4) Report – Appendix
a. Social media information
b. Recruiting materials
c. Recordings/Chats
d. Emails
e. Filings
f. Customer complaints

(5) Report – Document
a. Intro
b. Evidence of financial crimes

Computing Portfolio Variance in Excel: An Alternative Intuitive Formulation

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In this paper, we present an alternative formulation for computing portfolio variance in Excel that provides an intuitive explanation that differs from the standard approach, namely, that the portfolio variance can be thought of as the sum of each security's contribution to the total portfolio variance. This approach has the added benefit of not requiring the use of matrix algebra, something that many students have little or no familiarity with.

Keywords: *portfolio variance, Excel, individual variance*

Introduction

The computation of portfolio variance is critical to understanding the benefits of diversification. Most textbooks begin the illustration of risk and return by looking at the simplest model, a two-asset portfolio. This allows students to see that there are two components of portfolio risk, a component that consists of the risks of the individual assets, and a component that accounts for the level of diversification between the two assets via the covariance between the two assets. Advanced undergraduate and graduate texts often expand the discussion to an n-security portfolio through the use of matrix algebra [see Elton, et.al (2017)]. Students may then be asked to compute portfolio variance in Excel for a portfolio that consists of more than two assets. The problem with this approach is that many students have little or no familiarity with matrix algebra. In this paper, we provide an alternative formulation for computing portfolio variance in Excel that provides a different intuitive explanation for portfolio variance, namely that the portfolio variance consists of the sum of each securities contribution to the total portfolio variance. This approach has the added benefit of not requiring the use of matrix algebra.

Portfolio Risk and Return

Once students gain an understanding of the risks and returns of securities such as stocks and bonds, most finance texts move on to the risks and returns for a portfolio of assets. The origins of computing portfolio risk and return date back to Harry Markowitz's seminal work on portfolio theory [see Markowiz (1952)]. Portfolio expected return is easy to explain as simply a weighted average of the expected returns of the securities in the portfolio.

$$\overline{R_p} = \sum_{i=1}^{N} w_i \overline{R_i} = w_1\overline{R_1} + w_2\overline{R_2} + \ldots + w_N\overline{R_N} \quad (1)$$

where,

$\overline{R_p} = Expected\ return\ of\ the\ portfolio$
$\overline{R_i} = Expected\ return\ of\ security\ i$

The greater difficulty comes in explaining portfolio variance to students. Intuitively, most students would assume that portfolio variance would just be a weighted average of the variances for the securities held in the portfolio. However, the portfolio variance consists of two components, one that accounts for the risks of the individual securities as given by equation (2) and one that accounts for the relationship between each pair of securities as measured by the covariance between each pair as given by equation (3).

$$\sum_{i=1}^{N} w_i^2 \sigma_i^2 \tag{2}$$

$$\sum_{j=1}^{N} \sum_{\substack{i=1 \\ i \neq j}}^{N} w_i w_j \sigma_{ij} \tag{3}$$

where,

w_i = proportion invested in security i
σ_i = standard deviation of security i
σ_{ij} = covariance between securities i and j

Portfolio variance is then written as the sum of the previous equations, with the first term in the equation representing the individual risks each security brings to the portfolio and the second term representing the diversification benefits that come by examining the relationship between each pair of securities.

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{j=1}^{N} \sum_{\substack{i=1 \\ i \neq j}}^{N} w_i w_j \sigma_{ij} \tag{4}$$

To illustrate this, let's consider a three-security example. Expanding equation (4) we get

$$\sigma_p^2 = w_1^2 \sigma_1^2 + w_2^2 \sigma_2^2 + w_3^2 \sigma_3^2 + 2w_1 w_2 \sigma_{12} + 2w_1 w_3 \sigma_{13} + 2w_2 w_3 \sigma_{23} \tag{5}$$

Equation (5) is the standard presentation of portfolio variance, where the first part of the equation consists of the individual variances of the securities in the portfolio and the second part consists of the covariance terms between each pair of securities [see Elton, et.al, (2017)]. In this interpretation, the first three terms with the variances represent the individual risks of the securities in the portfolio while the last three terms with the covariance terms represent the diversification part of portfolio variance.

Consider an alternative formulation to computing portfolio variance.

$$\sigma_p^2 = \sum_{i=1}^{N} w_i \sum_{j=1}^{N} w_i \sigma_{ij} \tag{6}$$

Using this approach for a three-security portfolio, we get:

$$\begin{aligned}\sigma_p^2 = w_1^2\sigma_1^2 + w_1w_2\sigma_{12} + w_1w_3\sigma_{13} + w_2^2\sigma_2^2 + w_1w_2\sigma_{12} + w_2w_3\sigma_{23} \\ + w_3^2\sigma_3^2 + w_2w_3\sigma_{23} + w_1w_3\sigma_{13}\end{aligned} \tag{7}$$

In this version, we have a different interpretation of portfolio variance. Rather than considering the individual risks of each security together and a portion that looks at the total benefits of diversification, equation (7) allows us to decompose portfolio variance into the contribution each security brings to total portfolio risk. Below, equation (7.1), which are the first three terms of equation (7) represents the contribution of security 1 to portfolio variance.

$$w_1^2\sigma_1^2 + w_1w_2\sigma_{12} + w_1w_3\sigma_{13} \tag{7.1}$$

Similarly, the second three terms and the last three terms represent the contributions of the second and third security to the total portfolio variance respectively. This is an alternative presentation of the standard formulation of portfolio variance where the first term consists of the variances of the securities and the second term, the covariance between each pair of securities. As the number of securities in the portfolio increases, the number of covariance terms that each security has will increase at an ever-increasing rate, thus making the covariance terms that make up each security's contribution to the total variance more important. Intuitively, this formulation allows us to think of the risk of a security as its relationship to the other securities in the portfolio rather than its variance.

COMPUTING PORTFOLIO VARIANCE IN EXCEL

A spreadsheet program like Excel can be used to easily compute portfolio variance. Excel includes a ***Covariance*** function in the Data Analysis Pack that can efficiently compute the variance/covariance matrix. It should be noted that Excel computes the population variance and covariance terms. This can be easily converted to the sample variance/covariance matrix by multiplying the variance/covariance matrix by the scalar [n/(n -1)].

There are several approaches for computing portfolio variance. The first is simply to solve for the portfolio variance using equation (4). This approach becomes quite onerous once the number of securities in the portfolio gets beyond 3. Formulating one long expression in Excel can make it extremely difficult to find errors in the formula. Consider a portfolio consisting of four securities. In this case, portfolio variance will consist of ten terms, which can make it difficult to find even a lone typo.

A second approach is to use matrix algebra to compute the portfolio variance. We can define ***W*** as a vector of portfolio weights and ***K*** as the variance/covariance matrix as the following and use matrix multiplication to find the portfolio variance.

$$\boldsymbol{W} = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} \quad \boldsymbol{K} = \begin{bmatrix} \sigma_1^2 & \sigma_{21} & \sigma_{31} \\ \sigma_{12} & \sigma_2^2 & \sigma_{32} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{bmatrix}$$

$$\sigma_p^2 = \boldsymbol{W^T K W} = \sum_{j=1}^{N} \sum_{i=1}^{N} w_i w_j \sigma_{ij} \quad (8)$$

Matrix multiplication in Excel can be performed using the mmult(array 1, array 2) function, which will return the matrix product of two arrays where the number of rows in array 1 equals the number of columns in array 2 as is required by the rules of matrix algebra. Because the matrix multiplication given in equation (8) requires multiplying three matrices, we have to nest the function mmult inside another mmult function. Although this approach works well for computing portfolio variance, many students lack sufficient familiarity with matrix algebra to employ this method. Also, nesting a mmult function inside another can be confusing.

The third approach uses equation (6) to compute the portfolio variance. This approach makes the calculation less onerous than using equation (4) while allowing the computations to be done without the use of matrix algebra.

To solve for the portfolio variance in Excel using equation (6), we set up the spreadsheet in the following way. To illustrate this concept, consider a three-security portfolio.

	A	B	C	D	E	F
1			**Stock 1**	**Stock 2**	**Stock 3**	
2		Weight	w_1	w_2	w_2	
3	**Stock 1**	w_1	σ_1^2	σ_{21}	σ_{31}	
4	**Stock 2**	w_2	σ_{12}	σ_2^2	σ_{32}	
5	**Stock 3**	w_3	σ_{13}	σ_{23}	σ_3^2	
6						
7		Con to Var				

The *covariance* function in the Data Analysis pack can be used to construct the variance/covariance matrix given in cells C3 to E5. It should be noted that the *covariance* function only computes the lower part of the table. The upper part of the table can be filled in by copying the relevant cells and using the *Copy* and *Paste Special* command, which allows for pasting the transpose of the cells.

To compute the portfolio variance using equation (6), we first compute the contribution of each security to the total portfolio variance. We then sum each securities' contribution to get the total portfolio variance. To compute the contribution to the portfolio variance for each security, we use the *sumproduct* function in Excel. The *sumproduct* function returns the sum of the products of corresponding ranges or arrays. In cell C7 we use the following =c2**sumproduct*(\$B3:\$B5,C3:C5). This function will return the contribution of the first security.

$$\begin{aligned} Contribution\ of\ Security\ 1 = \ & w_1[w_1\sigma_1^2 + w_2\sigma_{12} + w_3\sigma_{13}] \\ & = w_1^2\sigma_1^2 + w_1w_2\sigma_{12} + w_1w_3\sigma_{13} \end{aligned} \quad (9)$$

The function can then be copied to columns D and E to find the contributions of the second and third securities. Summing up the contributions of each security to total portfolio variance gives us the portfolio's variance. In addition to allowing for the computation of portfolio variance without the use of matrix algebra, this approach allows us to look at the risk each security brings to the total portfolio variance.

A NUMERICAL EXAMPLE

Consider the following variance/covariance matrix for a five-stock portfolio.

	A	B	C	D	E	F	G
		Weights	20%	20%	20%	20%	20%
1		20%	0.1245	-0.0013	0.002	-0.0072	0.0001
2		20%	-0.0013	0.0623	0.0555	0.0094	0.0468
3		20%	0.002	0.0555	0.0721	0.0333	0.0088
4		20%	-0.0072	0.0094	0.0333	0.0552	0.05124
5		20%	0.0001	0.0468	0.0088	0.05124	0.0587
6							
7	Contrib to Varp		0.00472	0.00691	0.00687	0.00568	0.00663
8	**% Contribution**		15.34%	22.43%	22.30%	18.43%	21.51%
9	Varp = sum(c7:g7)	0.03080					

Notice that Security *A* has the highest variance, nearly twice the value of the next largest variance. To illustrate this concept, let's consider an equally-weighted portfolio. However, because of the low degree of correlation that Security *A* has with the other securities, it makes the smallest contribution to the total portfolio variance, 15.34% even though Security *A* makes up 20% of the entire portfolio. Using the matrix approach for computing portfolio variance would simply result in the total portfolio variance, which makes it impossible to see the benefits a high variance security like *A* brings to the portfolio.

CONCLUSION

Providing alternative intuitive explanations of topics can be important to enhancing student understanding. In this paper, we present an approach for computing portfolio variance in Excel that provides an alternative intuitive explanation for portfolio variance, that does not require the use of matrix algebra. This approach allows students to view portfolio variance as the contribution each security makes to the total variance of the portfolio, which provides a better understanding of how to build a portfolio of assets. Using this approach, students can better grasp the concept that a security should be evaluated in terms of the risk it brings to the portfolio.

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Random Exam Generation for Finance Exams

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In this paper we show how to use the open-source language R and three different Learning Management Systems (LMS) to create multiple-choice Finance exams where all the numerical components of questions are randomized. We show how to generate any number of exams where each question is numerically different, and through the LMS these can be delivered online and graded instantly by the platform. While no method is likely to completely stop academic dishonesty in online exams, randomized exams can be an important part of the toolbox to deter cheating.

Keywords: randomized exams, R language, learning management system, online exams, cheating deterrent.

Introduction

In March of 2020 most universities and colleges across the United States transitioned to remote teaching methods as response to the Covid-19 pandemic. The sudden change to distance learning created many stresses for students and faculty, not the least of which was academic dishonesty (i.e., cheating) during online examinations. In two highly publicized cases, the Georgia Institute of Technology and Boston University investigated allegations of cheating in online examinations where students sought help through Chegg, a subscription-based tutoring website (Flaherty, 2020).

It may be impossible to create online exams that are "cheating-proof" but using technology it is feasible to make exams more resistant to cheating. In this paper we show how to use the open-source language R (R Core Team, 2017) in tandem with a Learning Management System (LMS) – such as Canvas, Blackboard, or Moodle – to create multiple-choice Finance exams where all numerical components of questions are randomized. The process is scalable, so that it is possible to generate a large number of exams where each question is numerically different, and through the LMS platform they can be delivered online and graded instantly by the platform.

The Exams package (Grün and Zeileis, 2009) for R handles the randomization of numerical values for questions. Each exercise is programmed in a separate file and then a set of complete exams is compiled by the R software. All questions have different values and solution choices. We also show how to randomize multiple-choice non-numerical questions by rotating the choices a particular student sees in her exam.

While no method is likely to completely stop cheating during online exams, experiments by Chen, West, and Zilles (2018) conclude that exams with randomized parameters are an effective mitigation tool for academic dishonesty.

This method carries a large upfront cost for the instructor since each question must be written in R code first, but in our opinion the benefits are substantial:

1) Academic dishonesty becomes more difficult.
2) Instructors no longer spend time creating different "versions" of an exam since any number of different exams can be created automatically, thus maintaining consistency across students, class sections, and possibly academic years.
3) There is no need for grading since this is done by the LMS platform.
4) It does not depend on a particular textbook or publisher.
5) Exams or questions can be recycled in future examinations with minimal effort.
6) Creates consistency across semesters and academic years for assessments or outside accreditation (i.e., AACSB).

The biggest hurdle is learning the basics of the R code required to construct the exam. In this article we present a step-by-step example of an exam with two classic introductory Finance numerical exercises, one about Future Value and another one about Net Present Value, and one non-numerical question. We show the code needed to program each exercise in R as a separate file, then compile them into an exam, and finally the steps necessary to upload it to the Canvas, Blackboard, or Moodle LMS so it can be deployed as an online assignment and graded by the platform. These three LMS platforms cover over 82% of students enrolled in higher education institutions in the U.S. and Canada (Hill, 2020), and the workflow we present in this paper can be adapted to create randomized online exams for other LMS platforms that use the Questions and Test Interoperability (QTI) standard or even paper exams that are administered in class.

Literature Review

The problem of academic dishonesty has afflicted schools and universities for a long time. In an early study, Bowers (1964) collected data from questionnaires sent nationwide to ninety-nine colleges. These questionnaires included questions regarding academic dishonesty; from a sample of 5000 students, Bowers found that at least half of them had admitted to some sort of academic dishonesty. McCabe and Treviño (1993, 1997) conducted student surveys about 30 years later, and found that academic dishonesty was still prevalent at universities and colleges across the nation. The authors found that cheating in exams and tests had become more rampant over time, and that academic dishonesty was higher when students perceived higher levels of cheating among their peers.

The International Center for Academic Integrity (ICAI) produces the "ICAI-McCabe Institutional Academic Integrity Survey", based on Donald McCabe's 1990s research, surveying colleges, universities, and students primarily located in the US and Canada, and have found that the problem is not going away. From a sample of roughly 71,000 undergraduate students surveyed between the years 2002 and 2015, around 68% admitted to cheating on tests or written assignments. More so as technology evolves, it seems that ways to participate in academic dishonesty have evolved too. Several websites, such as Chegg and Course Hero, currently operate towards the goal of tutoring students and providing them with personalized help. However, Adams (2021) suggests some students utilize websites like these to complete their coursework instead and use them to answer their online tests. Remote schooling has made certain kinds of academic cheating easier than ever, prompting teachers to change their testing practices to fight academic dishonesty; for example, some instructors require online cameras to be turned on while the student

takes a test remotely (possibly raising privacy concerns), some impose time limits on online tests, and some are changing the type of questions asked in tests (Jargon, 2020).

Academic dishonesty can create widespread issues if not dealt with. Fendler and Godbey (2016) state that "cheating on exams perverts the central purpose of the academic institution, undermines the integrity of grades as a measure of subject matter mastery, and misrepresents the perpetrator as possessing understanding of a subject for which no particular knowledge may exist" (pp.71-72). Moreover, Boehm, Justice, and Weeks (2009) argue that "higher education institutions are affected by the increase in academic dishonesty from the loss of productive time, money and reputation in dealing with the issue" (pp. 54). In their study, Boehm et al. (2009) survey four-year public and private colleges, universities and community colleges in the U.S. and found evidence that improving academic honesty can be achieved through classroom management strategies that are relatively easy to implement, such as using multiple exams.

Chen et al. (2018) conduct classroom experiments and conclude that exams with randomized parameters is an efficient mitigation tool for academic dishonesty. Fendler and Godbey (2016) propose an exam design that helps deter academic cheating, by punishing the cheaters accordingly with little cost to the instructor. They consider different versions of an exam where all questions and identical answer choices are in the exact same order, however questions differ in one minor detail which ultimately makes the correct answer different across versions. Nevertheless, creating different exams manually can be time consuming for faculty, difficult to implement online, and the number of different exam versions can be limited. To the best of our knowledge, our article is the first to show how to create and deploy random exams for business students in a unified framework that can be scaled to any number of different exams.

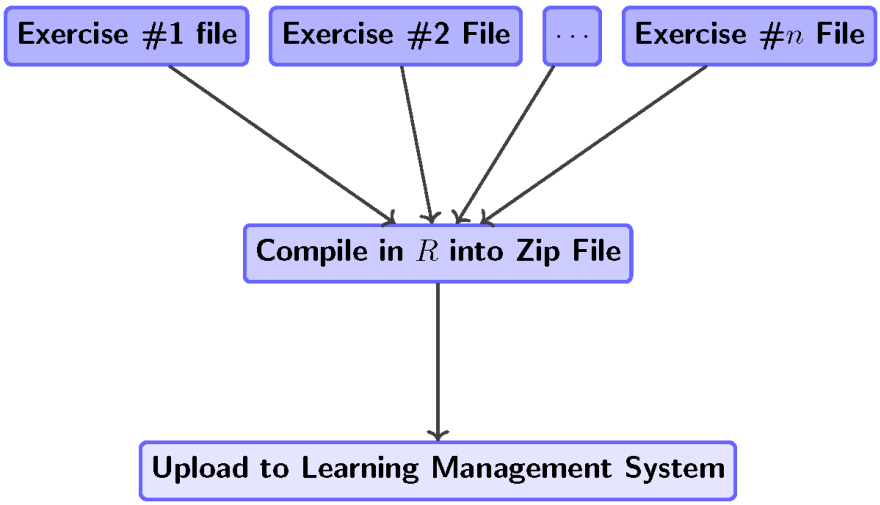
While it may be impossible to create online exams that are "cheating-proof", it is possible to make exams more challenging to cheating with the use of technology. In the next section, we show how to use the open-source language R in tandem with the Canvas, Blackboard, or Moodle LMS to create multiple-choice Finance exams where all numerical components of questions are randomized.

How to Create Randomized Exams with R

R is an open-source programming language popular in academia. The TIOBE popularity index of programming languages ranks R as the 8th most popular language and claims it is due to universities and research institutes embracing R for statistical analysis (TIOBE, 2020). The software is freely available at www.r-project.org

Figure 1 presents the workflow necessary to create randomized exams in R using its Exams library. The first step is to create individual exercise files; in a second step these individual exercise files are compiled into one master file, which is then uploaded to an LMS.

Figure 1
Workflow



Create Individual Exercises

Individual exercises are created in RMarkdown format (file extension .Rmd) which weaves text and code together. Exercise files have at least four well-defined parts: a block of code that works out the problem, the question, the list of answers, and meta information required for compilation.

Table 1 presents an example of an RMarkdown file which creates a simple Future Value (FV) problem. This question is one of the first ones we ask our students when introducing FV: suppose you save *X* amount of dollars in a savings account that pays an interest rate of *Y*% per period, how much money do you have in your account after *Z* periods? By randomizing the choices for the amount *X*, the rate *Y*, and the periods *Z* we can create a unique exercise for each student.

The block of code in Table 1 begins the line after the three consecutive backquotes and the r letter in curly brackets (```{r}) and it ends with the three consecutive backquotes (```). In the block of code, we first select random values for our inputs: the amount *X*, the rate *Y*, and the periods *Z*; in R, the *seq()* function creates a sequence of numbers, while the *sample()* function selects one number at random from this sequence. The correct answer is computed with the well-known formula FV = $X*(1+Y)^Z$ and then we compute three other wrong choices based on common mistakes we have observed students make in the past (for instance, the wrong choice *wrong3* uses the present value formula).

The next part of the file are the lines below *Question* which contain the actual text of the question. We include the inputs used in the block of code by writing `r input`, for example in the text of the question `r X` will be replaced by the amount randomly chosen for *X*. Then the *Answerlist* will list our possible answers, the correct and wrong ones.

Table 1
R Code for a Simple Future Value Exercise

````
```{r}
X = sample( seq(from=1000, to=3000, by=100), 1)
Y = sample( seq(from=0.06, to=0.12, by=0.01), 1)
Z = sample( seq(from=5, to=10, by=1), 1)

correct = X*(1+Y)^Z

wrong1 = X*(1+Y)^(Z-1)
wrong2 = X*(Y)^(Z)
wrong3 = X/(1+Y)^(Z)
```

Question
=======
Suppose you invest today $`r X` in a savings account that earns an interest rate of `r
Y*100`% per period. How much money will you have in your account after `r Z`
periods?

Answerlist
----------
* $`r correct`
* $`r wrong1`
* $`r wrong2`
* $`r wrong3`

Meta-information
============
exname: easyFV
extype: schoice
exsolution: 1000
````

Finally, the last section of the file is *Meta-information*, this part is crucial to ensure the question is compiled correctly in the exam. The meta-information contains the *exname* which is the exercise name, *extype* (schoice refers to single choice), and *exsolution* shows the solution sequence indicating the correct choice in the *Answerlist* with a 1 and all the wrong choices with a 0 (i.e., "exsolution: 1000") indicates that the first choice in *Answerlist* is the correct one, and the subsequent three choices are the wrong ones in that order.

Table 2 includes a second example of an RMarkdown file for a net present value (NPV) exercise.

Table 2

R Code for a Net Present Value Exercise.

````
```{r}
cf0 = sample( seq( from=1000, to=5000, by=100), 1)
cf1 = sample( seq( from=1000, to=5000, by=100), 1)
cf2 = sample( seq( from=1000, to=5000, by=100), 1)
i = sample( seq( from=0.04, to=0.12, by=0.01), 1)

right = cf1/(1+i) + cf2/(1+i)^2 - cf0

wrong1 = cf1/(1+i) + cf2/(1+i) - cf0
wrong2 = cf1 + cf2 - cf0
wrong3 = cf1/(1+i) + cf2/(1+i)^2
```

Question
=======
You are evaluating a project with initial investment (at year 0) of $`r cf0` that is expected to produce annual profits of $`r cf1` at year 1 and $`r cf2` at year 2. What is the net present value of this project if the cost of capital is `r i*100`%?

Answerlist
--------------
* $`r right`
* $`r wrong1`
* $`r wrong2`
* $`r wrong3`

Meta-information
============
exname: easyNPV
extype: schoice
exsolution: 1000
````

This exercise asks for the NPV of a project with a cost of capital of *i*% that requires an initial investment of *cf0* dollars and then generates profits of *cf1* and *cf2* dollars at times 1 and 2, respectively. The code will randomize all inputs and create a unique exercise for each student. Again, the block of code is contained in the lines within the three consecutive backquotes (```); it first samples at random from a sequence of numbers for each input, then computes the right answer using the well-known NPV formula, and finally computes wrong choices.

The actual text of the question is below the line *Question*, where we weave the inputs chosen by the code by writing `r input` in its place in the question. Below the question is the list of answers in *Answerlist* and, lastly, the meta-information.

Non-numerical Questions

There is not much randomization that can be done with non-numerical questions. However, we still would like to ask students some concept questions and deter online cheating at the same time. To address this issue, some concept questions can be programmed to have more than one correct answer. For example, one question that is common in principles of Finance classes is about advantages and disadvantages of project decision rules: Which of the following is a disadvantage of the payback period rule? Possible correct answers are: No guidance as to correct payback cutoff; Ignores cash flows after cutoff; Not necessarily consistent with shareholder value maximization. We can create a question that rotates each of these correct answers and adds several incorrect answers to create many (though not unlimited) versions of this question.

Table 3 shows the code to create this question. In this case there are no randomized numerical inputs so we can skip straight to the question portion. The answer list shows three correct answers and five incorrect choices. In the meta-information, *exsolution* indicates the sequence of these answers, where a correct answer is indicated with a 1 and an incorrect choice is indicated with a 0, therefore 11100000 indicates that the first three options in the *Answerlist* are correct and the subsequent five choices are incorrect in that order. The question will always choose only one correct answer, but *exshuffle* will indicate how many total choices you want to use, e.g., "exshuffle: 4" will signal the question to choose four total answer choices, one correct (from the three available correct choices) and three wrong ones (from the five available incorrect choices). This process will repeat itself in a randomized way and create several combinations of answers for the same question. Clearly the more incorrect and correct choices incorporated, the greater number of different versions for this question.

Table 3

R Code for a Concept Question about Payback period rule.

```
Question
=======
Which of the following is a disadvantage of the payback period rule?

Answerlist
----------
* No guidance as to correct payback cutoff.
* Ignores cash flows after cutoff.
* Not necessarily consistent with shareholder value maximization.
* Hard to compute.
* Relies on an accurate estimate of the discount rate.
* Can be time-consuming to compute.
* Favors liquidity.
* Impossible to compute in some cases.

Meta-information
==========
exname: mcq_payback
extype: schoice
exsolution: 11100000
exshuffle: 4
```

Create an Exam from Exercises

Once individual exercise files have been created, it is necessary to compile them into a proper exam. The Exams package can create exams in a variety of formats, including as pdf files which can be printed for an exam administered in class. In this paper we show how to create an exam file which can be uploaded to the Canvas, Blackboard, or Moodle LMS platforms; these three platforms cover over 82% of students in higher education institutions in the U.S. and Canada with Canvas at the lead covering 40% of students (Hill, 2020). We first show how to upload the exam to the Canvas platform, and then by simply changing a few lines of the R code we show how to adapt it for Blackboard and Moodle.

Table 4 shows the R code needed to compile individual exercises into an exam, and the output is a zip file which can be uploaded to Canvas. The first line of the code – *library(exams)* – loads the Exams package, while the second line – *setwd("C:/Users")* – changes the working directory to the folder where the individual exercise files are located. The third line creates a list of the questions (*myQuestions*) to include in the exam, in this case we include the three exercises from Tables 1, 2, and 3. The fourth line of the code is an optional but, in our opinion, important step: it sets the seed, or number, for the randomization engine. The individual exercises have several random components and if we do not set the randomization seed then it will be impossible to reproduce the exact same set of exams in the future. If we would like to replicate the same set of exams in the future all we have to do is set the seed to the same number.

Table 4
Compile an Exam

```
library(exams)

setwd("C:/Users")

myQuestions = list("easyFV.Rmd", "easyNPV.Rmd", "mcq_payback.Rmd")

set.seed(123)

exams2canvas( file = myQuestions,
              n = 10,
              name = "Exam 1",
             duration = 60,
             maxattempts = 1,
             points = 1 )
```

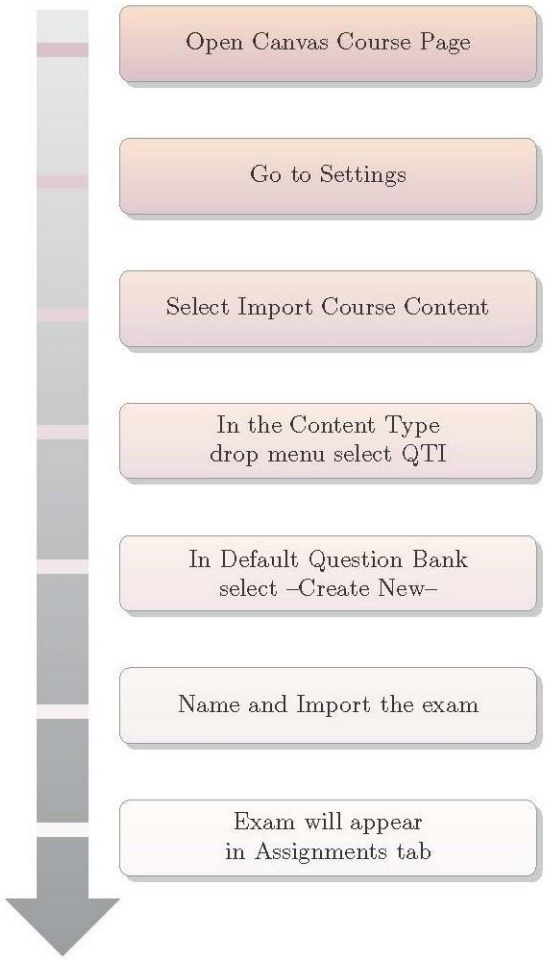
The last command in the code in Table 4 creates the actual exam. The *exam2canvas()* function creates a zip file that can be uploaded to the Canvas platform. There are several arguments for the *exam2canvas()* function, some relate to the exam itself and some to options in Canvas: *file* is the list of individual exercise files that comprise the exam; *n* is the number of exams to be created, for this example we use 10 but any number can be chosen, ideally at least as the number of students in the class; *name* is the title of the exam; *duration* is the length in minutes the students will have to answer the exam in Canvas; *maxattempts* is the maximum number of attempts students have; and *points* is the value of each question.

Deploy in Canvas

The output from the code in Table 4 is a zip file that contains several extended markup language (file extension .xml) files, the name of this zip file is the one specified in the *name* argument of the *exam2canvas()* function. The zip file can be uploaded to Canvas where it will be transformed into an online exam which is graded automatically by the platform. Figure 2 shows the workflow required to upload the exam.

In the Canvas platform, after accessing the specific course page, select Settings from the left-hand side column and then click on Import Course Content from the right-hand side column. In the Content Type drop menu select the "QTI .zip file" option, browse for the zip file created by the *exam2canvas()* function, in the Default Question bank drop menu choose "—Create new question bank—", name the exam, and click on Import. The screen will transfer to a Current Jobs queue which will show the status of the import; once the job is completed the exam will appear in the Assignments tab of the Canvas course page.

Figure 2
Upload Exam to Canvas.



Importantly, the exam is not yet published (that is, the students cannot see it on their end of the platform) so that some details of the exam, such as availability and due date, can be edited by the instructor.

After the instructor is satisfied with the exam and its details, it can be published so that students can also see it when they login to Canvas. The exam will be graded automatically by Canvas with the score of each student linked to the Grades tab. Figures 3 and 4 present two screenshots of the finalized exam created by Table 4 in the Canvas LMS, where each figure represents a different version of the exam.

Figure 3
Screenshot of Canvas exam

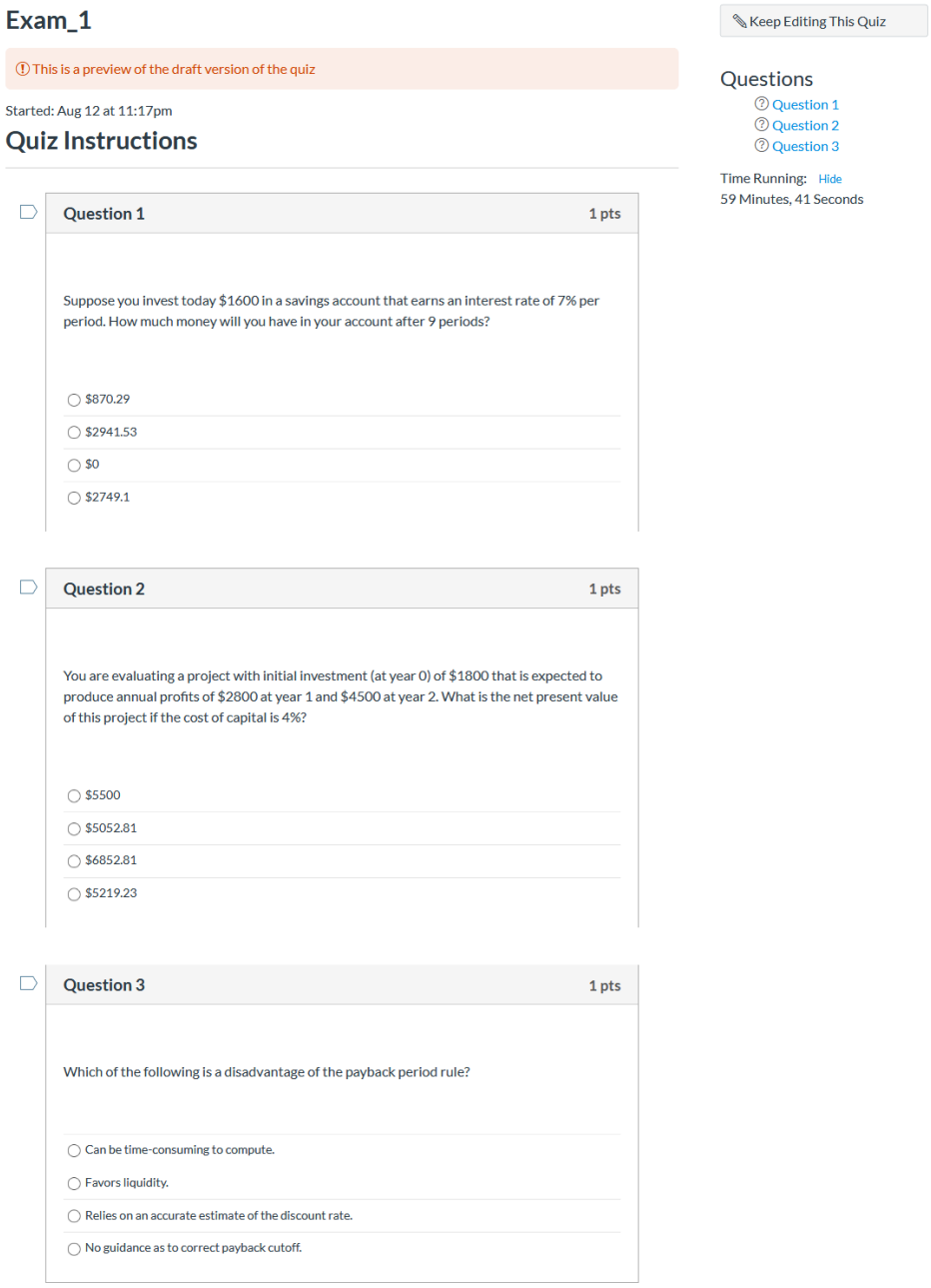
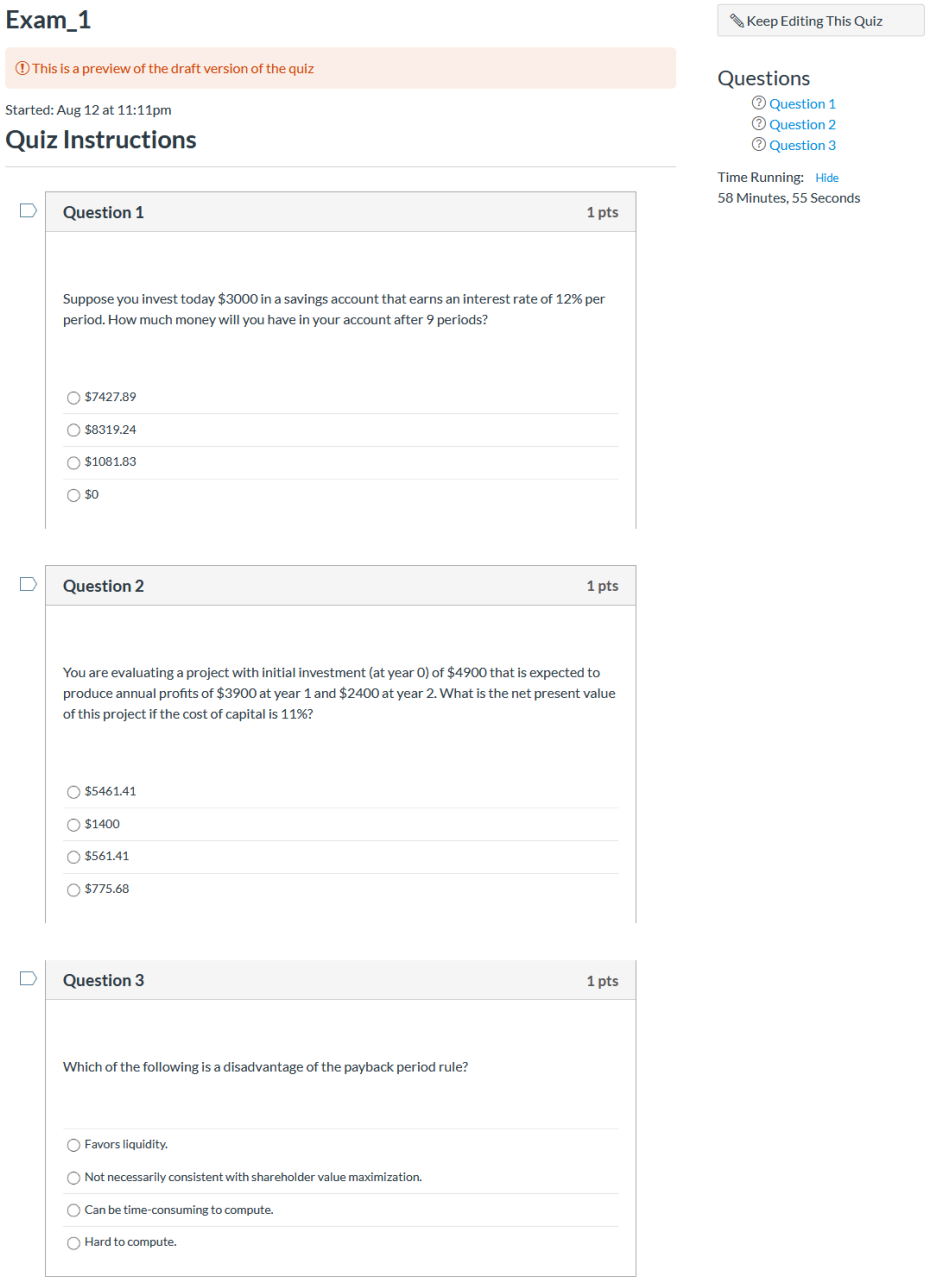


Figure 4

Screenshot of Canvas exam, different version.



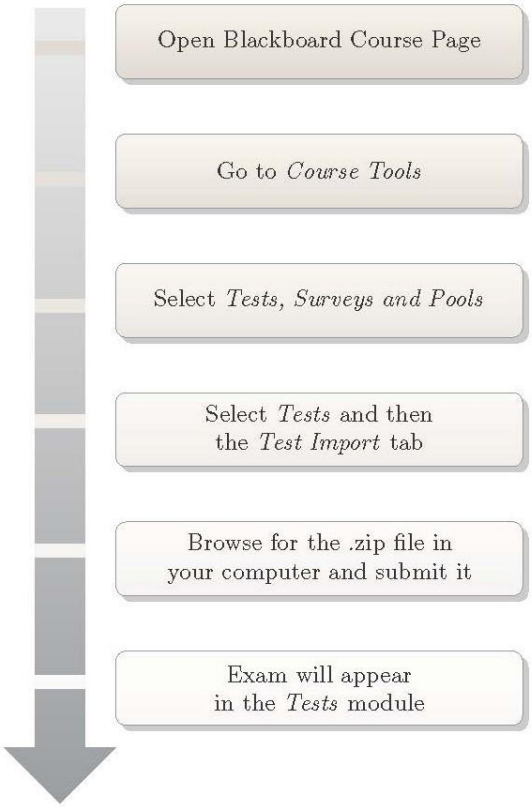
Deploy in Blackboard

It is straightforward to adapt the code from Table 4 to create a randomized exam for the Blackboard LMS since both Canvas and Blackboard use the QTI standard. The only command that changes in Table 4 is the last one where instead of using the *exams2canvas()* function we write *exams2blackboard()* and we even pass the same arguments to the function.

The *exams2blackboard()* function generates a zip file that is imported into Blackboard using the workflow shown in Figure 5. Once the exam zip file has been uploaded to Blackboard, the test

can be assigned to students by hovering to the Assessment tab and selecting Test. Then, in the Create Test page select the uploaded exam file in the Add Test dropdown menu, and finally edit the options (such as due date, etc.) so the exam can be submitted and deployed to students.

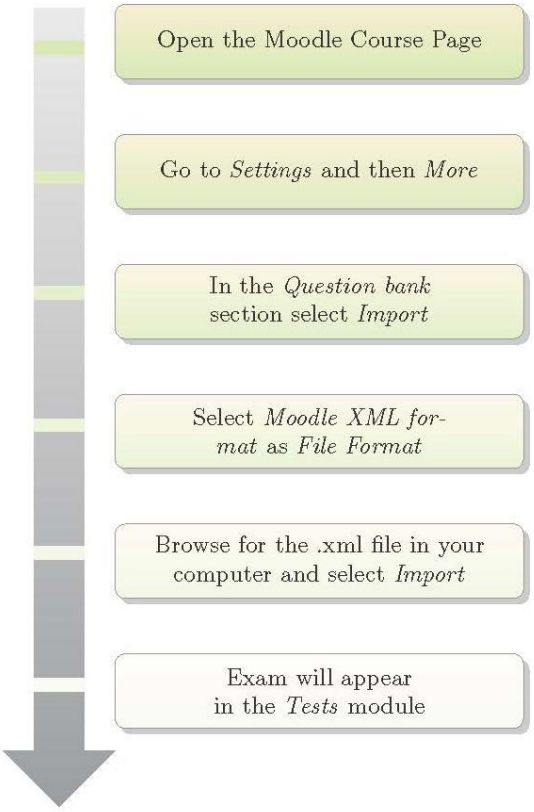
Figure 5
Upload Exam to Blackboard



Deploy in Moodle

We can easily adapt the code from Table 4 to create an online exam that can be uploaded to the Moodle LMS. We use the *exams2moodle()* function instead of *exams2canvas()*, and we do not pass along the arguments for *maxattempts* and *duration*, these options will have to be set manually within Moodle; the rest of the program is unchanged. The *exams2moodle()* function will produce an xml extension file instead of a zip file, and this file can be uploaded to Moodle following the workflow presented in Figure 6.

Figure 6
Upload Exam to Moodle



The process to convert the exam file into a test in Moodle is a bit more tedious, though not difficult. We first must create an online quiz and then we populate it with the questions. We go to the course Settings and select *Turn editing on*, then we select the topic where we want the exam under (e.g., Homework, Quizzes, etc.) and click on *Add an activity or resource* and select the *Quiz* option. In the next screen we can customize the exam, such as name, duration, number of attempts, etc. We then edit the quiz; in the *Add* dropdown menu we select *a random question* and in the *Category* tab we select one of the questions we uploaded to Moodle. We repeat this process for each random question we want to add to the exam. Once we have added all questions, we simply *Save* the quiz and it is ready to be deployed to students.

Conclusion

In this article we show how to use the R software and the three leading Learning Management Systems (Canvas, Blackboard, and Moodle) to generate online exams with randomized components that can help deter academic dishonesty. In addition, the presented method is easily scalable so it can create as many different exams as needed, and the LMS platforms grades the exams instantly. Furthermore, it is possible to combine random exams with additional layers of security to protect academic integrity, such as a lockdown browser which locks down students' computers during examinations and prevents access to unauthorized resources during a test (i.e., browsing for answers in Google). While no method is likely to completely stop academic dishonesty in online exams, randomized multiple-choice exams can be an important part of the toolbox to deter cheating.

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Breakeven, Leverage, and Elasticity

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Breakeven analysis has been a useful tool in many areas of business curricula for decades. Sometimes called cost/benefit or payback analysis, the foundational components of leverage and elasticity can be used to reveal to Undergraduate students the effects of good or poor managerial behavior. Leverage calculations also can be used to better understand the sensitivities of various aspects of operations. Graphical analysis reveals the interrelationships between these two techniques and shows how they can be linked pedagogically.

Keywords: Financial Pedagogy, Breakeven Analysis, Leverage, Elasticity

Introduction

A hundred years in the past, John Dewey observed that an education system ought to supply students with a set of skills that would sustain them throughout their work-life in a world of ever-changing more complex technology. Dewey's 'democratic pedagogy' is, essentially, a set of skills founded on a holistic view that students should know how educate themselves after matriculation, and among the skills necessary students should be able to ask critical questions; they should be able to clarify values; they should be able to think systematically (Tarrant and Thiele, 2016). In the course of their research, academics have aided this lofty goal particularly in the finance discipline.

One note's that nearly sixty years past, finance research began with the basics of the firm's capital structure and weighted average cost of capital (WACC). The basic structure of a firm's balance sheet, and its component parts, were useful tools and provided clearer insights in the manager's decision-making puzzle. Researchers strove to paint a clearer picture of what a manager or entrepreneur should do when certain levels of risk or uncertainty were reached, using the basic components of the balance sheet like operating leverage, elasticity, and breakeven points.

A careful scrutiny of the last six decades of finance research reveals a starting point using basic balance sheet information and two main theories of static trade-offs and pecking order to determine a decision-maker's path for the company. As seminal articles were published, and in order to distinguish themselves, finance researchers began employing ever higher levels calculus to their theories. With the advent of databases and computing power, by the mid-to-late-1990s finance researchers combined theory with data in empirical research, revealing to themselves and other academic readers, that theory and math are only just so helpful. Time and again, the researcher tries to detail how a manager should make decisions using a calculus the manager rarely knows and attempts to teach a finance student without sufficient mathematical skills to allow a proper analysis of basic concepts, like degree of operating leverage, elasticity, and breakeven points.

Two commonly taught concepts in any business curriculum are breakeven analysis and leverage. Breakeven analysis has the advantage of being based on linear concepts, and most

students have little difficulty in grasping the concept and understanding how it can be used. Leverage calculations, however, are more difficult because they are based on relative values and exhibit nonlinear characteristics. Students can better understand these concepts if graphical analysis is employed to illustrate that the two concepts are interrelated. Academic research, as well as higher education pedagogy in introductory finance courses, is bereft of the benefits of graphical analysis. A student's understanding of mathematical concepts is augmented with our new pedagogical approach, which illustrates to students the simplicity of how breakeven analysis elasticity are related to financial statements.

Review of Literature

Breakeven analysis appears in many forms in the business curriculum. Simple breakeven analysis may appear in accounting, economics, or finance courses. Some instructors extend the concept to include cash breakeven analysis to demonstrate the differences between cash flows and accounting values. Even the price-earnings ratio used in finance is little more than a breakeven value. Breakeven analysis and the related leverage values are important and can be useful in today's business environment.

There has been a significant amount of research into the concepts of breakeven and elasticity. Modigliani and Miller (1958) use static, partial equilibrium under atomistic competition in capital markets to establish a foundational theory of valuation of businesses and shares under uncertainty. Solomon (1963) presents theoretical research that a company's cost of capital is dependent on the financial structure and that the leverage effect reveals a clearly definable optimum position where the marginal cost of more debt is on balance with the business' per unit cost of capital.

Ghandhi (1966) investigates the content of leverage and introduces the use of balance sheet and market valuations with income components (net or gross of tax, and net or gross of distributions). Ferri and Jones (1979) develop a firm taxonomy based on the actual financial behavior of the firm. Analysis of managerial decision making involving capital structure, using a static trade-off, pecking order framework, or contingent claims methodologies, allowed financial managers fundamental access to firm valuation (Myers, 1984; Brennan and Schwartz, 1984; Kane *et.al.,* 1984). Applications include capital budgeting (Kim and Kim 1996), credit analysis (Editorial Staff 1995), and pricing strategies (Smith and Nagle 1994). Specific applications can be found for health care management (Boles and Fleming 1996), real estate (Davis 1998, Sherman, Shim and Hartney 1993), and retailing (Holland and Dean 1996). Breakeven analysis did not die with the advent of computer analysis and remains a topic of value to all types of business.

The concept of leverage is also useful in cash flow management (Belt 1993), capital budgeting (O'Brien 1989), general management (Kalkbrenner, Kremer and Smith 1989), government organization (Ciccotello and Green 1995), and small business management (Lortie 1989). Specific applications can be made to health care management (Smith, Frazier and Crone 1994) and hospitality (Rushmore 1998). On a more theoretical level, leverage has an effect on the risk of a firm's equity (Li and Henderson 1991, Huffman 1989), and work has been done to refine methods of estimating leverage values (Lord 1998, Dugan and Shriver 1992, Dugan and Shriver 1989). Leverage and breakeven have been shown to be useful concepts in operating businesses of all types.

Welch (2004) and Barclay *et.al.* (2006) revisit the themes of trade-off and pecking order models for capital structure ratios and firm valuation with a strong application of calculus. Chen *et.al.* introduce a dynamic incomplete-markets model incorporating non-diversifiable valuation

risk and intertemporal decision making that generates empirical predictions in several areas including capital budgeting and firm valuation (2010).

In the 2010s researchers introduced a variety of analysis techniques using a basic trade-off model of operating leverage. Hinterhuber's model incorporated a resource-based view (RBV), which identified resources and capabilities leading to a competitive advantage (2013). Glover and Hambusch introduced fixed operating cost and the possibility of negative future earnings to assist managerial decision making (2013). Models examining the effects of operating leverage on Betas when managers control the cost structure and redefining the mathematical computation of the degree of operating leverage (DOL) that stands in contrast to standard textbook definitions extended the discipline (Houmes *et.al.,* 2012; Kroll and Aharon, 2014). Kizildag revisits pecking order theory to explore the core drivers causing deviations in financial structure over time using leverage proxies (2015). A plethora of data and computing power allows analysis of commodity markets as a first derivative of capital structure and operating leverage, as well as policy analysis for firms post-2008 financial crisis (Henderson *et.al.,* 2015; Iona and Leonida, 2015). More recently, an analysis of future impact on levels of capital expenditures due to asset sensitivity on random product market shocks and a re-recognition that using the operating cash-flow as a proxy for business risk is risky as the relationship between the two does not solely reflect a distressed firm's risk (Aharon *et.al.,* 2019; Elkhal, 2019).

Much of the above-mentioned research has been incorporated in modern business curricula. Curry introduces marketing students studying management decision making to iso-profit pricing, giving illustrative examples from supply-side operations research and manufacturing, emphasizing production constraints but allow that his iso-profit model is spun-off of incremental break-even analysis, margin arithmetic (2004). The complex task of teaching often rests on selecting suitable activities and examples often relying on regional collaboration with business and strategic planning of innovative pedagogy (Kantola and Kettunen, 2012). A picture is worth a thousand words, therefore graphics employed in concert with fundamental finance theory, like forward market efficiency hypothesis, can simplify complex regression analysis to a single loop diagram (Jitmaneeroj, 2014).

Nearly a century past, John Dewey anticipated higher education pedagogy would be developed so as to sustain critical thinking and systems thinking skills relying on communication and collaboration among and between students and their instructors (Tarrant and Thiele, 2016). Our unique pedagogical model of Twenty-first Century introductory finance course combines the use of visual aids with the mathematical component of finance to expand the student's understanding of the mathematical interrelationship between capital structure, degree of operating leverage, and elasticity.

Teaching Breakeven and Leverage

In teaching breakeven analysis and leverage, the following examples from a sample firm illustrate why it is important to show how the concepts are related. While breakeven concerns itself with absolute values, leverage provides relative values. This is similar to the way that net present value and internal rate of return present two different ways of analyzing a capital budgeting problem. In order to demonstrate the interrelationship between breakeven and leverage to students, we employ a simple numerical thought experiment in four stages of analysis of a firm's operational structure. Thus, students will compute and visualize breakeven and leverage subsequently using

these tools for intuitive analysis of our sample firm. The firm being analyzed has the following operational characteristics:

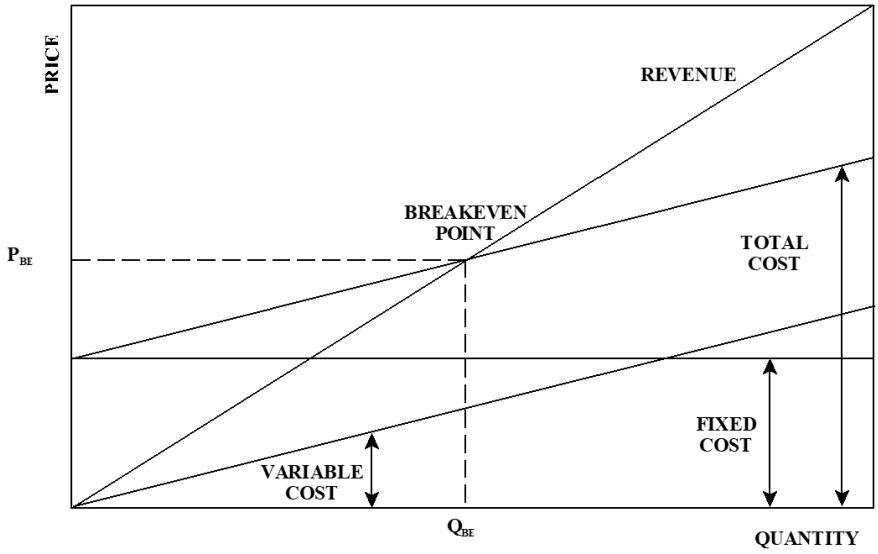
- Selling Price per Item = $20
- Gross Profit Margin = 40%
- Fixed Costs = $1,000
- Annual Interest Payment = $400
- Composite Tax Rate = 30%

The firm is in a market that can support various levels of production at the given selling price. The implicit assumption, of course, is the business' product market is known and any changes in this product market are made only in the long run, leaving aside any changes in the short or medium-run due to a constant fixed-to-variable cost ratio. Students practicing this form of analysis should be able to parameterize a business' fixed cost with the long view towards capturing a high enough fixed-to-variable cost ratio so as to sufficiently represent a variety of real-world businesses. Frequent practice by students applying such analysis to managerial decision making in business within a single industry sector, or a variety of businesses across sectors, facilitates students' ability to understand the challenges managers face in teasing out the various interacting aspects of business. Therefore, a closer focus on degree of financial leverage and degree of operating leverage by managers ought to be an effective way to clarify decisions.

Accounting Breakeven and the Degree of Operating Leverage

We begin our thought experiment with our sample firm with standard accounting breakeven analysis as relates to the top portion of the income statement, the portion of the income statement that reflects the operations of the firm. The standard graphical presentation of the accounting breakeven point is shown in Figure 1.

Figure 1
Accounting Breakeven



Total Revenue is compared to Total Cost, both fixed and variable, and the breakeven point is found where the two values are equal. This breakeven value, in either units or dollars, can then be used as a decision-making variable when compared to forecasts of sales. The accounting breakeven point occurs where the Earnings Before Interest and Taxes (EBIT) is zero; the firm has covered its costs of production but not its interest charges, which are a function of the firm's financial structure. There is more information contained in these numbers. The degree of operating leverage (DOL) also shows a relationship within the top portion of the income statement and measures the sensitivity of changes in EBIT to changes in sales.

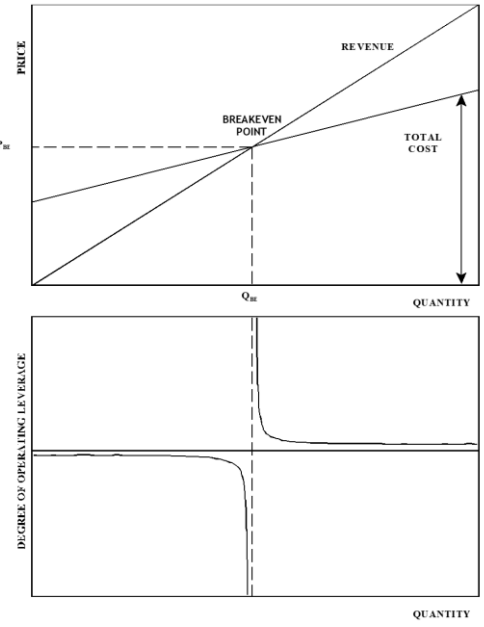
DEGREE OF OPERATING LEVERAGE

SALES
– COST OF GOODS SOLD
GROSS PROFIT
– FIXED COSTS
– DEPRECIATION
EARNINGS BEFORE INTEREST AND TAXES

$$DOL = \frac{\text{PERCENTAGE CHANGE IN EBIT}}{\text{PERCENTAGE CHANGE SALES}}$$

The relationship between the accounting breakeven point and the DOL can be shown by graphing the DOL using the same X-axis as the accounting breakeven graph. The breakeven graph and DOL graph are shown in Figure 2. Note that the DOL graph contains a vertical asymptote that coincides with the breakeven point. This makes sense since near the breakeven point every dollar of EBIT is a higher percentage of the total EBIT, either positive or negative. Note that the DOL graph also has a horizontal asymptote at +1.0; this would be the case for a firm with no fixed or variable costs so that each dollar of sales becomes a dollar of EBIT. The negative sign for the DOL to the left of the accounting breakeven point shows that the firm is losing money at these levels of production while the positive sign to the right of the accounting breakeven point indicates profitability.

Figure 2
Accounting Breakeven Point and the Degree of Operating Leverage



In our sample firm, assume the accounting breakeven volume is 125 items. Each item sells for $20 and contributes $8 towards fixed costs. The volume of 125 items provides the $1,000 necessary to cover the fixed costs. Table 1 shows the firm's EBIT and DOL at various levels of output.

Table 1
EBIT and DOL at Specific Output Levels

Units of Output	EBIT (Operating Profit)	DOL
50	($600)	-0.67
100	($200)	-4.00
125	$0	undefined
150	$200	6.00
200	$600	2.67

At 100 units of output, sales are $2,000. Selling one more item would increase sales to $2,020, a change of 1%. EBIT changes from ($200) to ($192) due to the additional $8 the 101st unit contributes to the fixed costs. This $8 causes the loss to decrease by 4%, and the DOL = (-4%/1%) = -4. Similar calculations can be made at all points along the breakeven curve except at the breakeven point. The existence of the vertical asymptote is easy to understand. At the breakeven point of 125 units, the EBIT is $0. If even one penny is added to or subtracted from this amount, the percentage change of the EBIT is infinite since the calculation requires division by zero.

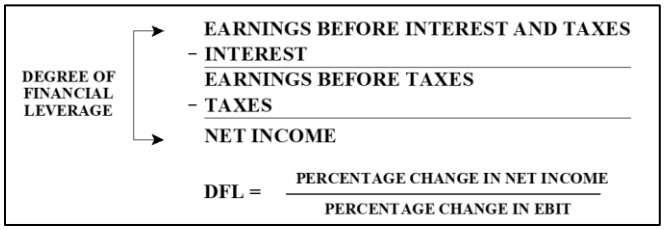
This is a crucial insight that must be presented to the students. When operating near the breakeven point, any change in sales will have a dramatic effect on the DOL since the numbers in the denominator of the fraction are very small. A manager operating near the breakeven point will be able to say that his or her decisions have a large percentage effect on the profitability of the firm, but the absolute level of profitability will be low. A manager operating far to the right of the breakeven point will not be able to affect great percentage changes in profitability due to the already high level of profits. This difference between absolute and relative profitability is the difference between breakeven analysis and leverage calculations.

Knowledge of the breakeven point and DOL gives immediate information concerning the firm's profitability. A negative DOL means that the firm is not covering its fixed costs, and the absolute magnitude of the DOL indicates how close the firm is to the breakeven point. An increase in costs will shift the Total Cost curve upward and the breakeven point to right. For any given volume, the DOL will become less favorable (either a smaller negative value or a larger positive value). An increase in the selling price per item will rotate the Total Revenue curve upward and move the breakeven point to the left (a lower value). The DOL will become more favorable (either a larger negative value or a smaller positive value). Similar arguments can be made for decreases in costs and selling prices.

All Cost Breakeven and the Degree of Financial Leverage

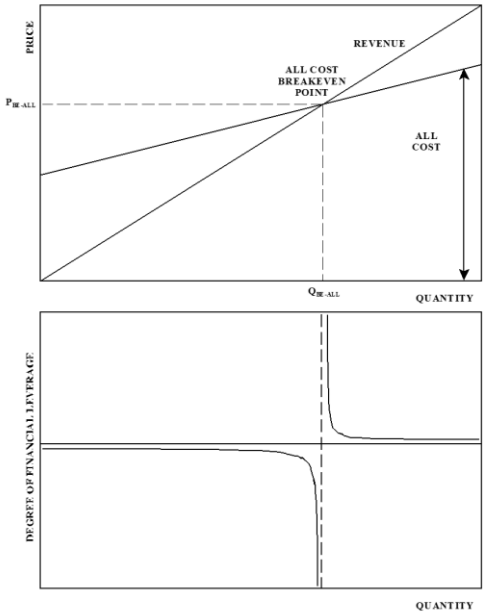
Stage two our thought experiment for our sample firm is the description of the degree of financial leverage (DFL), which is the relationship between values on the bottom half of the income statement. It is illustrated by extending the concept of breakeven to include all variable and fixed costs, including interest and taxes. For the sake of this discussion, the breakeven point

that includes interest and taxes will be called the "All Cost Breakeven Point". One can see the relationship between this point and the DFL by examining the bottom half of the income statement and the formula for the DFL.



When the DFL is graphed on the same X-axis as the all cost breakeven graph, a relationship similar to that of the DOL and the accounting breakeven graph appears. Note that in a manner similar to the DOL, the DFL has a vertical asymptote at the all cost breakeven point and a horizontal asymptote of +1.0 (which would be for a firm with no interest payments and no taxes). The all cost breakeven point and its relationship with the DFL is shown in Figure 3.

Figure 3
All Cost Breakeven Point and the Degree of Financial Leverage



The third stage of our thought experiment involves an alteration to our sample firm that includes a potentially confounding concept of the existence of tax shields. If the firm is able to use a loss on a particular product to create a tax shield for other operations, then the tax shield should be credited to the calculation of net income for that product. The firm's tax rate is irrelevant, however, since it has a constant proportional effect on the Net Income relative to the Earnings Before Taxes (EBT), and thus the percentage change of any dollar of EBT and the Net Income is the same. For simplicity, we have assumed an annual interest rate of zero, taking EBIT to EBT, and address this change in financial structure in stage four.

The all cost breakeven volume is 175 items. Since interest charges are $400 per year and each item has a contribution margin of $8, it takes 50 additional widgets beyond the accounting breakeven point before the firm pays all its costs. The variable cost represented by taxes only

occurs if there are positive earnings, so the existence of taxes does not change the all cost breakeven point. Table 2 shows the firm's Net Income (both with and without a tax shield) and DFL at various levels of output.

Table 2
Net Income and DFL at Specific Output Levels

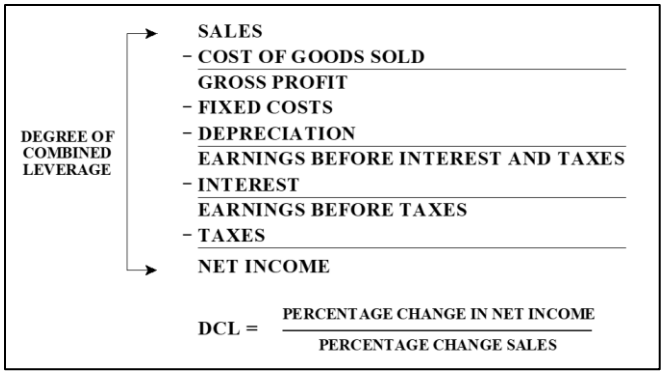
Units of Output	Net Income (With Tax Shield)	Net Income (No Tax Shield)	DFL
100	($420)	($600)	-1.33
150	($140)	($200)	-6.00
175	$0	$0	undefined
200	$140	$140	8.00
250	$420	$420	3.33

At 200 units of output, sales are $4,000. Selling one more item would increase sales to $4,020, a change of .5%. Net Income changes from $140 to $145.60 due to the additional $8 the 201st unit contributes to the EBT which is reduced by 30% due to taxes for an increase in Net Income of $5.60. This $5.60 causes the Net Income to increase by 4%, and the DFL = (4%/.5%) = 8. Similar calculations can be made at all points along the breakeven curve except at the all cost breakeven point.

Stage four introduces a change in the financial structure for our sample firm. The all cost breakeven point and the DFL show the effect of changing the financial structure of the firm by incurring additional interest charges. A change in financial structure that causes interest charges to increase would cause the vertical distance between the Total Cost and All Cost lines to widen. This would have no effect on the accounting breakeven point but would shift the all cost breakeven point to the right. Contrarily, if the firm experiences zero interest payments, while there exists a discontinuity point in the DFL graph at the accounting breakeven point, the function is still continuous at that point, and the effect would be to shift the all cost breakeven point to the left. This illustrates for students that a change in the underlying cost structure or the selling price per unit would affect both cost curves and breakeven points and leverage values. It also illustrates to students how changes in costs and revenues can affect all aspects of the firm and its profitability while purely financial changes do not affect operations but do affect operating profitability.

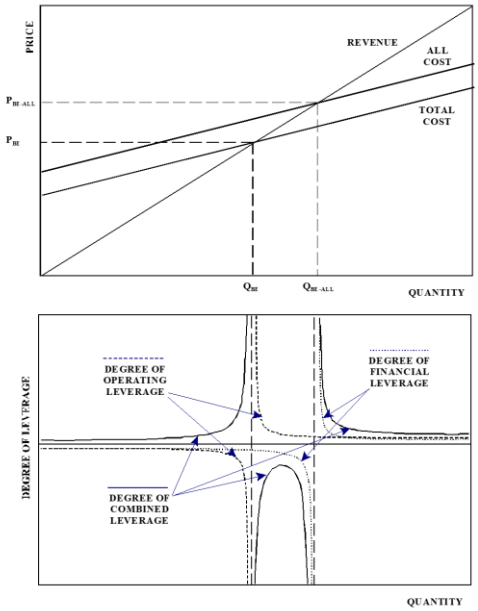
The Degree of Combined Leverage

The culmination of our thought experiment in four stages leads to an analysis of the degree of combined leverage (DCL), which illuminates the overall relationship between sales and the net profit of the firm when the operating and financial characteristics are considered. The simplest way to analyze the DCL is to reveal to students that DCL is the product of DFL and DOL. Since the intuition behind DOL and DFL is the degree of risk involved in operating the business and financial risk, respectively, then it follows that the product of the two allows the firm to ascertain the total amount of risk present in the total cost of running the business.



The graph shown in *Figure 4* combines the dotted vertical lines to represent the accounting breakeven and all cost breakeven points as shown in *Figures 2* and *3*.

Figure 4
Breakeven Points and Leverage Factors



To aid the student's intuition in managerial decisions using *Figure 4*, the breakeven point associated with DOL, Q_{BE} and P_{BE}, means that even though revenues are covering costs, the risk inherent in operations may override the risk inherent in financial obligations. Whereas at the breakeven point associated with $Q_{BE\text{-}ALL}$ and $P_{BE\text{-}ALL}$ reveals a greater amount of revenues is necessary to cover the added risk involved with higher debt levels. Students may ask about the portion of the graph between the two breakeven points. Students will note the DCL asymptote takes the shape of a hill with two vertical asymptotes one at the DOL and one at the DFL, allowing managerial decisions to mitigate pessimistic (more risky) situations, or take advantage of an optimistic (less risky) business situation. The rate at which the DCL value approaches the asymptotic values is different than the DFL due to the effects of the DOL. The value of the DCL lies "further" from the asymptotes than value of the DFL at all points on the graph. The sign of the DCL values is an artifact of the component DOL and DFL values and can surprise students by switching twice from positive to negative to positive.

With respect to practical decisions, it makes sense to find a positive DCL at low levels of production since an increase in sales would cause a decrease in the losses shown by the net income. Students may observe that the negative DCL between the accounting breakeven point and the all cost breakeven point is non-intuitive. In this range, the effect of an increase in sales has a positive effect on EBIT, but since the net income is still negative the DCL retains a negative sign. This shifting of sign illustrates that the DCL can be hard to interpret and may be of limited use in managing a firm.

Thus, students will recognize that managerial decisions based on the degree of combined leverage (DCL), because it is the product of DFL and DOL, could be a bit more difficult to discern as the combination of financial and operating leverage may mask the finer details buried inside fixed costs and financial structures. If our sample firm has a higher level of combined leverage, due to high debt levels (regardless of fixed cost level), the manager will know that this presents a riskier investment to investors. On the other hand, the DCL may aid the manager to balance its operational and financial leverage to better affect the firm's total earnings.

As a final point, students should be trained to recognize that the interrelation between DOL and DFL in *Figure 4* combines the breakeven graph and both the DOL and DFL graphs. In this format, the similarity of the concepts of DOL and DFL are evident. *Figure 4* can be used to illustrate the sensitivity of the DOL and DFL to changes in operating characteristics of the firm. It provides an opportunity for students to experiment with four basic scenarios in which DOL, DFL and DCL asymptotes shift with changes in operating characteristics.

- Scenario 1 is the situation where our firm experiences high fixed costs (keeping low debt levels), which means that changes in operating characteristics would change the DCL in a manner similar to the DFL, because the decreases in fixed and variable operating costs will cause the DCL to "approach" the DFL.
- Scenario 2 is the situation where our firm automates its production line, incurring higher fixed costs while at the same time increasing its debt levels, shifting both the DOL and DFL curves to the right. Or, this could be a situation where the firm changes its capital structure to include more or higher priced debt (this one probably increases the fixed cost, too) and means that the increase in the amount of interest paid on the breakeven graph would shift the DFL curve to the right while the DOL curve would be unchanged.
- Scenario 3 occurs when our firm creates a capital structure that increases its debt while at the same time reducing its fixed cost level. Perhaps the firm is able to borrow funds buy issuing bonds at a reduced interest rate due to its high operating leverage.
- Scenario 4 happens when our firm experiences changes in the variable cost structure that would move both the DOL and DFL curves by keeping low fixed costs and low debt levels, though not to the same degree (the DFL is more sensitive).

Consequently, students will see that the graphical representation in *Figure 4* provides a bird's eye view for DOL, DFL, DCL and their relationship with and around the two breakeven points and becomes a convenient starting point for discussing the above-mentioned implications of the DCL and its behavior for managerial decision-making.

Conclusion

Over the last sixty years, finance researchers have illustrated, analyzed, and modeled the mathematical relationship between common balance sheet components in order to aid an

entrepreneur or the firm's manager, with respect to short- and long-term managerial decisions to guide their business towards success. Teaching undergraduate finance students the finer points of these basic concepts started with the basic finance concepts themselves, migrated to higher levels by hypothesizing static trade-off and pecking order finance theories, evolved into application of advanced calculus to empirically test these theories, and has circled back around to graphically illustrating the basic finance concepts of breakeven, operating leverage and elasticity.

Current literature reveals academicians are returning to basic capital structure concepts, specifically degree of operating leverage, elasticity and breakeven points, reapplying trade-off and pecking order theory to discover relevant information decision-makers need to have on hand to execute successful short-run and long-run business decisions. Application of research in pedagogy follows suit as illuminated in our 'return to basics' pedagogy. Our holistic approach with samples of graphical analysis allows students a new perception of fundamental capital structure finance concepts. Students learning basic financial concepts is completed by assisting them to realize that when they work with either breakeven points or leverage factors, they are in fact working with both, and the information contained therein can lead to better decision-making. Appropriate application of breakeven analytical techniques and the related leverage concepts can provide students, managers, and analysts alike with powerful tool for diagnosing and predicting the behavior of firms.

Perhaps it is timely zeitgeist that new research turns to graphical illustration of basic concepts. Ultimately, traditional breakeven analysis is intimately related to the measures of leverage associated with a firm's income statement and has long been presented as an elementary concept used in simplified situations. The examples of graphical analysis presented herein illustrate for students balance sheet relationships and reveals the interaction between various breakeven points and leverage factors. In addition, our sample assignment exercises, using simple elasticity analysis, illustrate concepts of operating leverage and financial leverage, and expose students to the sensitivities inherent in the top and bottom halves of the income statement. These sample exercises will help students be better business decision-makers as they enter their careers in all areas of business management.

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