A Note on Animating Financial Equations with Scientific Notebook®

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ABSTRACT

Students of finance are often challenged to understand how financial equations respond to changes in key variables. All too often, the pedagogy offered these students includes usage of static graphs. Although there is a plethora of research in other disciplines showing animation provides superior learning outcomes compared to static images, the use of animation to illustrate financial relationships has received little attention in the financial education literature. This paper and the animations shown on the www.financeanimations.com website demonstrate Scientific Notebook’s® ability to animate equations commonly taught in university introductory finance courses.

Introduction

Many equations typically covered in introductory finance courses are actually dynamic relationships subject to changes in key variables. To date, most finance instruction has centered on the use of formulas, verbal narratives, and static images to illustrate these relationships. Unfortunately, this pedagogy does not match the learning styles of many of today’s students. College students are increasingly multimodal and visual in their approach to learning (Metros, 2008). By some estimates, at least 40% of college students are visual learners (Morrison, Sweeney and Hefferman 2003 and Renaldi and Gurung 2008). Using still images to teach dynamic processes unnecessarily complicates the ability of these students to grasp these important financial concepts. This paper helps to resolve this conflict by demonstrating the ability of Scientific Notebook® (SN) to animate financial equations. Animating these equations should improve their comprehension by an increasingly visual student population.

Literature Review

The education and psychology disciplines have rich literatures devoted to image-based learning. Levie and Lentz (1982) review 55 studies and conclude learning of word-based content is enhanced when illustrations are germane to the text. Paivio (1991) suggests learning occurs through both verbal (e.g., text) and nonverbal (e.g., images) channels. Mayer (2003) shows student learning is improved using a combination of words and images compared to using words alone. Carney and Levin (2002) find text-based illustrations improve student learning.

Research on animation also focuses its ability to improve learning. Nichols and Merkel (1996) find an animated tutorial enhances the ability microbiology students to understand the nitrogen cycle compared to still diagrams. Szabo and Pookhay (1996) show the use of animation in a high-school math class produces sharply improved learning outcomes compared to those achieved using still images. Weiss, Knowlton and Morrison (2002) claim animation is most beneficial for explaining complex causal systems which either change through time, respond to “simultaneous influences,” or cannot be seen with the naked eye. Höfler and Leutner (2007) perform a meta-analysis of 26 studies comparing static with animated graphics and find

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animation to be a more effective teaching tool when the animation is germane to the topic being discussed rather than merely decorative. Taylor, Pountney and Malabar (2007) find animation is more effective for teaching matrix manipulation than static illustration. In finance, Biktimirov and Nilson (2007) find a Flash®-based animated game improves learning outcomes for low-GPA students.

Given the demonstrated ability of animation to improve learning, it is surprising it has received so little attention in the financial education literature. This paper helps remedy this deficit by showing SN can be easily employed to animate equations commonly taught in university finance courses.

**Scientific Notebook®**

By combining math software with a word processor, SN allows users to more easily compose journal articles containing complex equations. The math software embedded within SN allows the graphs of equations to be animated. SN’s ability to produce high-quality animations without the need for additional and often complicated programming gives it an important advantage over competing software packages. For students having SN or the free SN plug-in called Scientific Viewer®, animations can be interactively controlled using an slider produced with the animation. SN animations can be exported to a number of formats (e.g., GIF files) so they can be viewed by those not having the SN software. However, the interactive slider is not available when the graphs are exported as GIF files.

**The Animations**

This paper describes animations of the present value, future value, effective annual rate (EAR), stock valuation, bond valuation, capital asset pricing model (CAPM), quick ratio and return on equity (ROE) formulas. At [www.financeanimations.com](http://www.financeanimations.com), a website created for this article, viewers can examine the formulas, their animations, and text-based narratives describing the animations. The animations presented on the website are intended for introductory finance students. Since the purpose of the animations is to examine how formula results react to univariate changes, two-dimensional animations are used. SN (as well as competing software such as Mathematica® and LiveMath®) can also create 3-D animations that examine the effect of changing two variables at a time and would likely be a useful tool for more advanced finance courses. However, the use of 3-D animations may unnecessarily complicate the learning process for introductory finance students already challenged to learn fundamental financial concepts.

The website design follows Paivio (1991) who suggests learning occurs through both verbal (words) and nonverbal (images) channels, Mayer and Moreno (2002) who find that students learn more deeply when narratives are placed in close proximity to animations, and Höffler and Leutner (2007) who show animations are a more effective learning tool when they are germane to the subjects being discussed (i.e., the formulas). By viewing the formulas and narrations in tandem with the animations, students can better understand why the animations behave as they do. Following the narrations, students’ understanding is challenged with sample test questions based on the relationships highlighted in the animations.

**Time Value of Money Animations**

The time value of money animations show the response of future values and present values to rising interest rates and the effect of increased compounding frequency on effective annual rates. By examining the future and present value animations, students can witness the combined effects of increases in time and interest rates on these values. Both the animation and the narration show future and present values react more violently to rising interest rates as they are computed over longer periods of time. The narration explains why this is so. Attempting to illustrate these concepts using static illustrations is awkward at best.

The EAR animation shows 1) EARs rise as compounding frequency rises and 2) the diminishing effect of compounding frequency on the EAR. This second effect is much more difficult to impart by simple reference to the EAR formula or to still graphs of the EAR formula.
Security Price Animations

The security price animations are especially valuable for refuting the notion that security prices rise with required returns. The animations show precisely the opposite effect. The stock price animation shows that prices of stocks with high dividend growth rates are more sensitive to rising required returns than those with lower growth rates. The narrative refers to the denominator in the Gordon Growth model to explain why this is so. Since this concept may be especially confounding for many students, additional clarification is provided using numerical examples.

The bond animation shows the combined effects of rising yields and time to maturity on bond prices. By viewing the animation contemporarily with both the formula and the narrative students learn: 1) that bond prices actually do fall as bond yields rise; 2) that the prices of longer-term bonds fall more than those for shorter-term bonds and 3) the reasons this is so. Again, these effects are difficult to replicate using still graphs.

SML Animations

The two security market line (SML) animations show the effects of rising market risk premiums and rising expected inflation rates on the SML. In the narrative following the market risk-premium animation, students are challenged to find the slope coefficient in the capital asset pricing model (CAPM). Many students initially believe the SML’s slope is the security’s beta. The narrative quickly disabuses students of this notion by showing the slope of the SML is actually the market risk premium. The animation and narrative combine to illustrate and to explain the behavior of the SML in response to increases in investor risk-aversion.

The inflation premium animation shows that the SML shifts up and to the left in a parallel fashion as the inflation premium rises. The narrative also presents a simple numerical example showing the reason SML shifts upward without any change in slope.

Ratio Animations

Two ratio animations are presented. The first is a relatively simple animation of the quick ratio and shows the quick ratio falling as inventory levels rise. The return on equity (ROE) animation is more complex and is based on the second stage of ROE decomposition analysis (ROE = return on assets (ROA) X equity multiplier). The narration accompanying the animation explains the equity multiplier (known to some as the financial leverage multiplier) can be considered a type of debt ratio. The animation shows increasing a firm’s debt levers positive (negative) ROAs to produce even higher (lower) ROEs.

Net Present Value Animation

The final animation shows the effect of increasing cash inflows on the net present value (NPV) profile. The animation shows the NPV profile shifting up and to the right as cash inflows rise. As before, the accompanying formula and narration demonstrate why the profile behaves in this manner. Students are challenged to determine the effect rising cash inflows have on a project’s internal rate of return (IRR). By viewing the animation, students can readily see that IRRs also rise as project cash inflows rise.

Student Response to the Animations

Using a five-point Likert scale, students were surveyed during the spring and summer semesters of 2010 regarding the effectiveness of the animations in facilitating their comprehension of the course material. In response to the statement “The financial animations provided in Course Documents aided my understanding of the financial relationships covered in Fin 301” students were asked to choose from among the following responses:

1. Strongly Agree
2. Agree
3. Neither agree nor disagree
4. Disagree
5. Strongly Disagree.

A total of 46 students responded to the survey providing an average response of exactly 2. This result suggests students find the animations do facilitate learning introductory finance.

Conclusion and Suggestions for Future Research

Finance consists of many dynamic relationships that are not readily captured using static graphs. Animating these relationships should improve student comprehension by allowing students to view these relationships as they respond to changes in key variables.

This paper suggests Scientific Notebook® as the software of choice to animate financial equations. The benefits of animations over static graphs are discussed as well as the advantages of presenting formulas and narrations contemporaneously with the animations. The content at the [www.financeanimations.com](http://www.financeanimations.com) website illustrates how these items might be used together in finance courses. Animations of the future value, present value, effective annual rate, stock valuation, bond valuation, capital asset pricing model, quick ratio, return on equity and net present value formulas are presented and discussed. A Likert scale five-point survey of introductory finance students suggests viewing the animations did in fact facilitate learning.

Animation offers a number of avenues for inquiry. These include the conduct controlled studies to confirm whether animation improves learning outcomes for finance students as it has for students in other disciplines. Another is to integrate Scientific Notebook animations, Adobe® Flash® CS4 Professional graphics and audio narrations into Camtasia presentations to determine whether a much richer multimedia learning experience translates into increased learning outcomes for finance students.

References


