A Research Based General Framework for Effective Simulation Development and Methodology to Validate Economic Fidelity

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Preparing this dissertation was a difficult, time consuming, and very rewarding activity. I learned a great deal about one of my professional passions and have devoted much of the past 25 years working as a simulation developer and user. This work represents a new phase in my evolution.

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Dedication

To Debbie, my wife, everything good is because of you; and Lyle, my father, my first and best math teacher.

Abstract

The three primary objectives of this project were: (1) to identify and codify a framework for best practices in developing a simulation; (2) to construct a prototype or test simulation based on these best practices, and (3) to create a methodology to assess pedagogical efficacy and economic fidelity.

While the current body of knowledge is rich in describing the virtues and pitfalls of computer simulation technology that has existed for close to 60 years, the literature nonetheless lacks a codified set of best practices for developers and objective assessment methods to judge a simulation quality for both the pedagogical effectiveness and economic fidelity. This study addresses both issues and offers a solution that is unique and effective. A General Framework for Effective Simulation Development that is derivative, and an extension of existing research in the business simulation domain. A simulation prototype, SimWrite!, has been developed that is consistent with the 12 elements identified in this framework. Each stage of the development of this test simulation is explicitly tied to the best practices that emerged from the literature. A second assessment tool, The Economic Theory Input-Output Matrix, is presented to enable a user to measure the economic fidelity of a simulation. This tool is based on microeconomic theory that is taught at business schools throughout the globe. Both assessment tools will be applied to the test simulation in a manner that will enable the user to replicate this research with other simulations they are interested in. The products of this dissertation are intended to aid current and future developers make better simulations and faculty users of simulations to better select simulations that will help them to achieve the goal of all involved in teaching business: To produce greater learning for students.

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Chapter One: Introduction and Background

The topical interest of this dissertation is computer simulation specifically designed for business education. Generally, computer simulation is an electronic replica or model of an actual or theoretical state of the world that has been designed to react to input variables and predict a new state. Computer simulation is used for a variety of reasons such as to solve complex mathematical problems that lack a closed form solution, test hypotheticals for planners, and provide meaningful learning experiences for students and trainees.

Computer Simulations in Business Education

Today virtually hundreds of electronic learning tools have been created and deployed in business education, in both college and corporate settings, a few of which are based on gaming practices and mathematical and economic principles. While many of these electronic tools are sometimes labeled “simulations,” very few actually are “true” simulations. A true simulation is a mathematical electronic model whose purpose is to reproduce an actual or theoretical reality. What distinguishes a true mathematical simulation from other types of electronic learning tools is the degree to which it has external validity, or the term that is common to simulation development, *fidelity*. If the design of an electronic learning tool is grounded in mathematical and economic theory, its outcomes will accurately reflect true business consequences and financial outcomes of managerial decision making. Without this fidelity, the outcomes have little or no external validity.

In order to achieve fidelity, the internal mathematical functions of a simulation should mirror economic theory which is rooted in the law of demand, demand elasticity, utility theory, risk aversion, economies of scale, labor theory, equilibrium theory, and law of diminishing marginal returns. These economic functions, as in real business, are nonlinear, interdependent, and require simultaneous solution. Furthermore, the model used to develop the simulation must also reflect the economic reality of industry market structure including degree of competition, ease of entering the market, and product differentiation (Chamberlin, 1939).

Problem Statement

Thanks to the advancements in computer technology and simulation techniques, business students today have the ability to experiment with decisions and simulate the marketplace responses to their strategies and decisions, allowing the business school experience to be a much richer one. However, the learning effectiveness of business simulations being used in the classroom is highly variable (Gosenpud & Washbush, 2010**)**.

In fact, using a simulation that has not been sanctioned in some way as being pedagogically sound, externally valid, and consistent with established economic theory can instill incorrect understanding of how business operates, and to a great extent, undo other learning that takes place in a course or program. This dissertation intends to discover those elements of simulation design that are critical to an effective teaching and learning simulation. A methodology will be created that is rooted in these essential components of design that can be used to assess both pedagogical factors and economic fidelity. These assessment tools will be applied to a test simulation and published as part of this dissertation. Presently, to the author’s knowledge, there is no tool set available for a user of simulation to judge the efficacy of a simulation is an objective manner. The tools are described in detail in Chapter Three and address a critical need within the business simulation community.

Economic theory and behavior is nonlinear. Yet, past researchers have questioned and tested this assumption and found in fact that the developers included linear models (Wolfe & Gold 2007; Pray & Gold, 1990). Thus, this dissertation will address this problem by matching the simulated responses to the theoretical responses predicted by economic theory. The entire economic model will be published in Chapter Four.

Research Objectives

The three primary objectives of this project are: (1) to identify and codify a framework for best practices in developing a simulation; (2) to construct a prototype or test simulation based on these best practices, and (3) to create a methodology to assess pedagogical efficacy and economic fidelity.

Specifically, first, A General Framework for Effective Business Simulation will be created that integrates principles of economic theory, game theory (Von Neumann & Morgenstern, 1944), learning theory (Fink, 2003; Aldrich, 2006; Garris, Ahlers, & Driskell, 2002), and components of computer interface design based on visualization and communication theory (Cooper & Riemann 2003). This framework for best practices will be a model for other simulation developers to ensure a high fidelity, accessible, pedagogically sound, and compelling business simulation that is ready for deployment. At this point, no comprehensive guide to best practices exits in the literature. Some design questions that will be addressed are:

- Is there an upper limit on the number of decision points for learners to consider?
- Is a single period simulation a viable alternative to the -long multi-period simulations emphasized by some commercial vendors of educational simulations?
- Should learners be allowed to “replay” a decision?
- Is a deterministic or stochastic simulation a more effective learning tool?
- Should learners compete against other learners or against a programmed “smart competitor?”
- Can economic fidelity be determined by experimentation?

Secondly, a prototype of a deterministic general enterprise simulation will be created that is consistent with the General Framework for Effective Simulation Development. In a general enterprise simulation, the player assumes general management responsibilities and decision making in all functional areas. A noteworthy advantage of the general enterprise simulation is that instructors have the flexibility to teach within the functional areas of business and it explicitly addresses the cross functional impact of decisions and strategy at the enterprise level. The financial measures are standard measures used in accounting and finance and in many texts including those written by Brigham and Houston (2001), Copeland, Weston and Shastri (2005), Williams, Haka, and Bettner (2005), Berman, Knight and Case (2006), Stern (2010).

The third objective is to create a checklist for developers and users of business simulation to test fidelity using established microeconomic theory and pedagogical efficacy as defined by the General Framework for Effective Business Simulation.

Importance of Research

The majority of college business faculty does not use simulation as a teaching and learning tool for several reasons (Faria, Hutchinson, & Wellington, 2009). For example, many simulations are too time consuming, too difficult to implement and understand, and faculty members are suspicious of matters of external validity and fidelity (Faria & Wellington, 2004). An important product of this research is to build a framework of best practices that will address some of these barriers and establishes a new standard for simulation development that will thus enable faculty members to more confidently select and use a simulation for their courses.

The cornerstone of this framework is the assurance of economic fidelity of simulation. This framework would thus guide developers to build models that are consistent with marketplace behavior as evidenced in economic theory. Specifically, economic theory is based on non-linear relationships requiring exponential mathematical functions that are essential in modeling demand, cost, and productivity functions. While various nonlinear economic models have been published and are widely accessible, the integration of these models into a comprehensive simulation framework will be a unique and important contribution of this dissertation. Since a tool for faculty members to confidently select a simulation for classroom use does not exist, the General Framework for Effective Simulation Development and a structured methodology to test economic fidelity will enable them to do so by establishing a checklist that can be used to evaluate a simulation pedagogically and a structured methodology to test economic fidelity. A checklist to assess pedagogy and Economic Theory Input-Output Matrix identifying the expected economic behavior of input variables (decisions) and outcomes as represented by standard financial metrics will be appended to the this dissertation.

Summary of Chapters to Follow

Chapter Two, Literature Review, will investigate a myriad number of research issues and questions related to this study's objectives. A brief evolution of business simulation presented, as well as barriers of usage by college instructors. Then a number of best practices will be discussed such as how many decisions are optimal and what is the ideal interface design and level of complexity, among others, in order to derive the basis of a General Framework for Effective Simulation Development

Chapter Three, Research Design and Methodology, will seek to achieve the objectives of this study: (1) to establish a General Framework for Effective Simulation Development; (2) to create a demonstration simulation that is consistent with the conditions of a General Framework for Effective Simulation Development**;** and (3) to develop a checklist that can be used by a simulation developer or potential adopter to assess the pedagogical efficacy as defined by the General Framework for Effective Simulation Development.

Chapter Four, Development of the Simulation as an Assessment Instrument, will provide a detailed narrative of the test simulation development, describing design decisions as they relate to the established general framework. Data sources for the hypothetical simulated firm and industry will be used to model economic behavior consistent with industry practices for each decision variable. A glossary of terms and short concept pieces, including graphic representation of key economic relationships, will be created and embedded in the simulation.

Chapter Five, Analysis of Results, will present two levels of simulation assessment. First, a checklist enumerating the twelve element of the simulation framework will be used to critique the simulation. Next, using the Economic Theory Input-Output Matrix established in Chapter Three, fidelity of the model will be tested.

Chapter Six, Discussion and Conclusion, will summarize key conclusions and the "Value Proposition" which will identify the contribution to better teaching and learning this project has provided directly to the producers of business education and. Limitations of the project and suggestions for further research will be discussed.

Chapter Two: Literature Review

The primary purpose of this project is to develop a General Framework for Effective Simulation Development and the existing literature has much to offer. This chapter will explore research relating to the following themes: Evolution of Computer Simulation, Design Classifications and Elements, Barriers to Use, and Principles of the General Framework for Effective Simulation Development.

Evolution of Computer Simulation

Computer simulation literally evolved with a big bang during the 1940's. In converting the theory of nuclear fission into the reality of an atomic bomb, an agglomeration of the top scientists, mathematicians, and engineers of their era converged upon Los Alamos, New Mexico (Rhoads, 1986). In order to detonate the bomb, a system of complex differential equations needed to be solved. To John Von Neumann, the premier mathematician of the time, the only way to solve the problem was using iterative approximation that would require use of a computer which, at the time, did not exist. Using the software model developed by Great Britain's Alan Turing, the scientist that cracked the German Enigma code and the basic architecture still employed today consisting of an input device, central processor, storage, and an output device, Von Neumann and a team at Princeton's Institute for Advanced Study (Dyson, 2012) invented the computer used to solve the math. Stanislaw Ulam, one of the Los Alamos scientists, recognized the power of the computer in solving general quantum physics problems by employing a probabilistic or "Monte Carlo" approach to his work (Goldsman, Nance, & Wilson 2009). The essence of the Monte Carlo Simulation is to identify critical variables in a model and their probability distribution. Through a succession of computer runs, mean outcomes and standard deviations, a confidence interval of returns can be calculated (Eckhart, 1987).

Computer simulations in education from the 1950's to the late 1970's were more of a novelty than standard teachings practice. Simulations were expensive and complex to develop and required collaboration between the subject matter expert (the professor) and the programmer. Computer time was very expensive and difficult to come by. While most universities during this era did have computer facilities, they were usually reserved for scientific research, administrative recordkeeping, transactional processes, and not general education. Another significant flaw was the time lag between the submission of data and the delivery of results. Long hours spent at the computer terminal and seemingly endless runs to find an obscure bug in a language was what simulation frequently meant to students in the 70s (Goldsman, Nance & Wilson, 2009).

The first International Conference on Simulation and Gaming was held June 27 and 28, 1970, in Bonn–Bad Godesberg, Germany and was attended by 40 people (Klabbers, 2009). The participants identified two common elements of what they defined as "serious games:" the element of competition and the elements of gaming.

A few academics recognized the learning potential in a model built to represent an abstract form of economic reality and soon simulation and gaming achieved legitimate academic status at a few research universities fortunate enough to have computing resources and personnel that were able to program and operate them (Goldman, Nance, & Wilson (2009). At that time, however, business simulation was considered a novelty, not an accessible pedagogical tool. Today, however, simulation may still be considered somewhat of a novel teaching approach but it is no longer inaccessible at any college or university. Furthermore, some business school professors are using simulation as more than a teaching game; it has become a tool for exploration, experimentation, hypothesis testing and a student motivator (Halpin, 2012).

Academic market. While more diffuse in academics today, the use of simulation as a teaching tool in business schools is not a new phenomenon. Mary Birshein of Leningrad is credited as the first simulation developer and user when, in 1932, she simulated a typewriter assembly process intended to teach managers more effectively to deal with production problems. From 1932 until 1940, Birshein and her partners developed 40 similar exercises for other types of businesses until her work was disrupted by the outbreak of World War II. Other pencil and paper business simulations were later developed by the Rand Corporation in 1955, the American Management Association in 1956 and, in 1957, Greene and Andlinger developed *The Business Management Game* for the consulting firm of McKinsey & Company (Goldsman, Nance & Wilson, 2009).

Simulation use grew slowly until the advent of personal computer. The first computer based simulation, *Top Management Decision Game,* was introduced at the University of Washington in 1957. By the 1960’s, more than 100 business games were thought to exist in the United States and by 1980, that number had increased to more than 200 (Goldsman, Nance & Wilson, 2009). A survey of universities in Eastern Europe in 1980 listed more than 30 business simulations in use in 22 separate universities (Faria, 2009).

The most comprehensive data regarding simulation usage in the academic market comes from Anthony Faria, a research fellow from the Association of Business Simulation and Experiential Learning (ABSEL), who has been active in this stream of scholarship for 40 years. The following profile of the US academic market is a result of Faria’s research (2009).

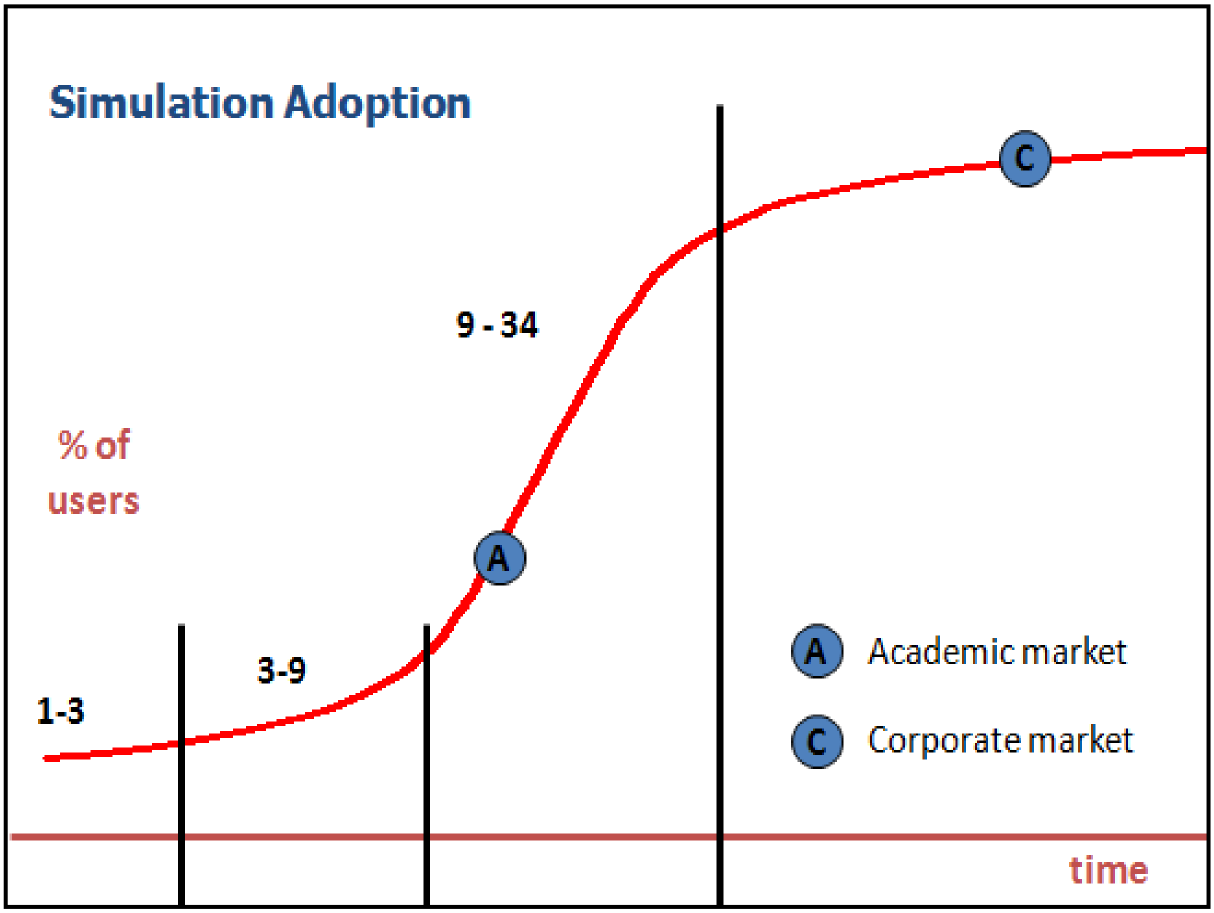
- 86% of surveyed schools (both AACSB and non AACSB) report some use of simulation. Of these schools, 82% use them in undergraduate courses and 58% in graduate courses.

- Of those schools reporting, Marketing and Strategy are the most common courses to employ simulation and each school employs on average two simulations.
- 95% of schools plan to increase their use of simulation.
- 17% of instructors surveyed at degree granting colleges use simulations in their teaching.
- Existing users of simulations are more than 90% likely to continue using them for teaching.

Respondents to Faria's survey further indicated that they used simulations for experiential activities, to practice strategy formulation, and to make decisions.

Corporate market. Today, computer simulations are used pervasively management training and education, and have a unique ability and versatility to teach strategy and decision making. Moreover, usage levels in the corporate market have followed a classic diffusion of innovation pattern since their introduction in the 1980's (see Figure 1). This diffusion pattern has long been used by marketers and includes introduction, early adopters, growth, and maturity patterns over time. That is, simulation is estimated to be employed at 46% of all training programs and expected to continue to grow ("Training Report, 2011). This can be compared to Faria's finding of 17% of business coursework in the academic market.

Figure 1



Acceptance and continued growth in the corporate market is echoed by Jay Jacobson, President of Celemi Inc. (Jacobson, 2008). In May, 2008, Jacobson wrote in *Training*, an industry journal, that he expects the standard teaching and training method of lectures; memorization and information dumps will continue to be supplanted by interactive simulations. Moreover, Jacobson expects simulations will be smaller, will be focused on fewer issues, will cost less to make, and take less time to play (typically 1 to 3 hours at a single session). These may be known as Quick Sims, Micro Sims or the term used in this paper, MiniSims.

Researchers at the Virtual Business Simulation Center, an organization dedicated to researching simulation activity and issues, report that new simulations being developed are 50%

more likely to be in the MiniSims class. Craig Watters, CEO of Management Simulations Inc., makes a similar case in an article he wrote for *Training Magazine* (2006). He also sees the MiniSim as being more generic and focused on single issues such as demand elasticity or capital budgeting methods. An advantage of this greater focus is the generic simulation breaks the connection between a company's practices and beliefs and encourages the players to "think outside the organizational box." Thus, according to Watters, more creative and innovative thinking is encouraged using this class of simulation that is more focused, takes less time, and allows for replay and practice (Training, 2011).

True, high fidelity simulations. The advantage to using a true business simulation is its fidelity. That is, the non-linear relationship between an input (independent) variable such as advertising expenditures and an output (dependent) variable such units sold is built into the algorithms and represent the true economic reality in the marketplace. There are two types of this class of simulation: A deterministic simulation and a Monte Carlo simulation. A deterministic simulation, the focus of this project, is defined as a system of functions representing key business decisions such as price, promotion, marketing, operations, finance and accounting. The functions are interactive and non-linear derived using econometric statistical methods that reflect true business, economic and marketplace dynamics. The functions have no random components and thus each identical set of inputs yields the same output. This type of simulation is commonly used in a teaching and learning setting.

The Monte Carlo simulation is similar except for the introduction of uncertainty using known probability distributions and randomized parameters in selected functions. The Monte Carlo Simulation is popular in a scenario-based setting for decision makers evaluating risk and extreme outcomes (Benninga, 2008).

Design Classifications and Elements

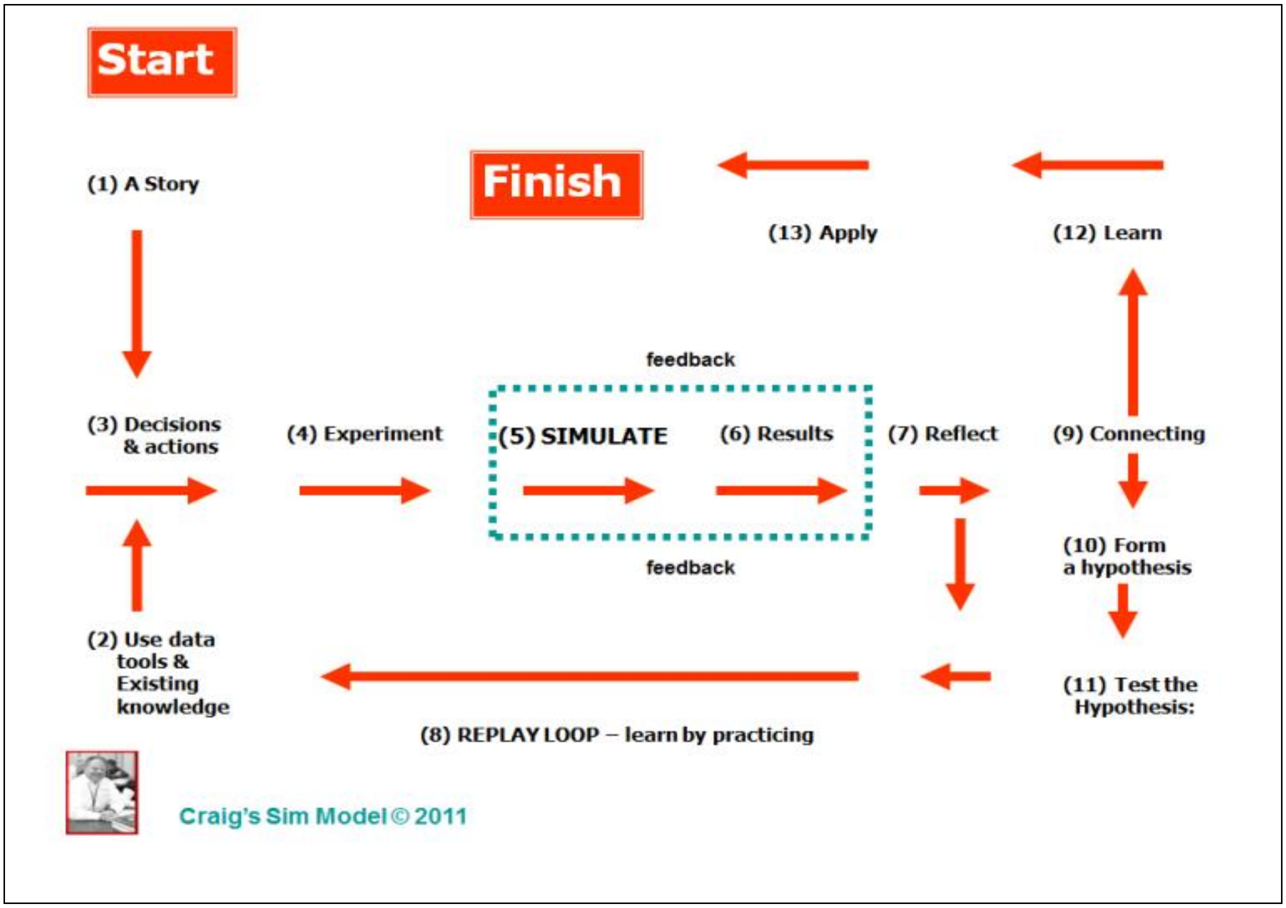
Many teaching simulations can be classified as general enterprise simulations while other simulations have very specific business purposes such as to teach about marketing, human resource management, operations, and financial management simulations. Moreover, within these functional areas, there can be additional specialization. For example, a marketing simulation can be developed around customer relationship management (CRM) issues whereas a financial management simulation can focus on capital structure and the impact on cost of capital. Business simulations are also classified by how long they take to play. A MaxiSim for purposes of this project is defined as a multi-period game and usually is a semester long project within a course. A medium length simulation will consist more than a single decision period but not more than four. A MiniSim, the focus of the test simulation software is a single period game that is intended for repetitive play.

Four critical design elements of an effective teaching and learning simulation need to be identified (Kapp. 2012): (1) The simulation should be structured as a game with rules and have defined moves, objectives and outcomes that are associated with “winning” and “losing.” In fact, students and faculty often refer to simulation as a “game” and frequently the terms are used interchangeably. (2) Players should be engaged in a story line that includes a problem or issue to solve, characters representing a variety of perspectives, and a need for resolution (Juul, 2001; Morgan & Dennehy, 1995; Nentl & Miller, 2002; Thorelli, 1999). (3) The role of feedback (Wiener, 1948), experimentation and practice through repetition is an important element of learning (Gladwell, 2008). Feedback in simulation specifically refers to the results associated with decisions such as units sold and subsequent financial results. The feedback loop as described by Weiner and more contemporary researchers such as Kolb (1984) and Peach &

Roberts (1999), is an important element of adaptive behavior, creativity, and problem solving (De Stobbeleir, Ashford, & Buyens, 2011). (4) The simulation model should incorporate sufficient complexity to ensure an infinite number of outcomes (Cannon, 1995). That is, there is not a closed form solution to the simulation. This should be the case when incorporating multiple simultaneous nonlinear functions in the simulation engine rather than simpler but not externally valid linear functions that can be solved using routine linear programming techniques.

"Sim Model" presented in Figure 2 captures the essence of these elements of simulation pedagogy in the following steps: (1) The player encounters an entertaining and engaging story or scenario requiring a business solution consisting of one or several decisions. (2) The story presents characters, roles, obstacles or tension, and explicit goals and objectives. (3) Next, drawing from existing knowledge, the player will enter a combination of numerical or categorical variables and submit them to the simulation engine. (4) The model will process and return to the player a results report that is either a satisfactory or insufficient solution. The results report will be in the form of standard financial measures. This "authentic assessment" is considered to be the most meaningful form of feedback to the learner (Fink, 2003). (5) The student processes the results and begins establishing cognitive connections between actions and the simulated outcomes. (6) Using the Wiener feedback loop, the player builds on his or her stock of knowledge and continues to reflect, make connections, hypothesize and experiment. (7) Eventually the player achieves agreeable results and new learning presumably occurred in the context of the simulation game. The goal is that this new learning will become part of the student's knowledge stock in a way that can be generalized and applied to real life cases.

Figure 2


Start
(1) A Story
Finish
(13) Apply
(12) Learn
feedback
(3) Decisions & actions
(4) Experiment
(5) SIMULATE
(6) Results
(7) Reflect
(9) Connecting
feedback
(10) Form a hypothesis
(2) Use data tools & Existing knowledge
(11) Test the Hypothesis:
(8) REPLAY LOOP – learn by practicing
Craig's Sim Model © 2011

Fidelity and Validity

Inarguably, a simulation is only an effective teaching tool if the game itself is a valid representation of the world (Chin, 09). It must not only *be* valid, it must be *perceived* by the players as valid. Broadly, there are four types of validity: (1) Content validity or fidelity is how well the internal model behaves like the reality being portrayed; (2) internal validity is evidenced by the simulation performing as intended during use; (3) external validity is present when the causality present in the model's relationships is recognized by the simulation users as they compare the working of the model to their "real world" reality – as they perceive it; and (4) construct validity is the degree to which the variables in the model relate to each other in the proper manner. For example, does an increase in a promotion variable shift the demand curve? Is it modeled in a nonlinear form that captures a diminishing return? Are the financial reports derived from the internal accounting system based on accepted accounting practices and is mathematically accurate?

Feinstein and Cannon (2001) identify a comprehensive and useful list of fidelity and validity issues.

- Accuracy
- Algorithmic validity
- Believability
- Face (or concept) validity – does the model represent the real world
- Content validity
- Predictive validity - does the model predict real world outcomes
- Educational validity – do students understand the game and play with insight – are they learning effectively

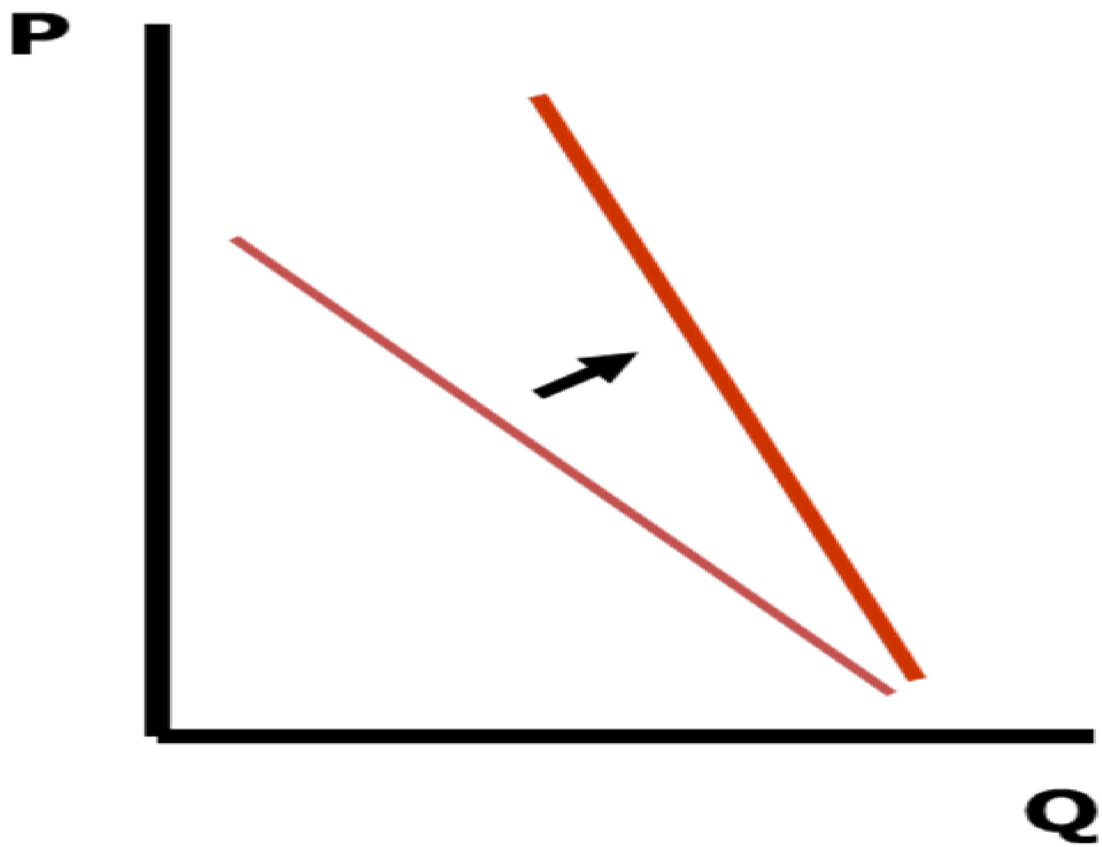
- Empirical validity – does the model fit similar cases when analyzed using objective data
- Event validity – do the predicted responses match actual responses
- Hermeneutics – is meaning generated through interaction – do players have a sense of what is the right and wrong response to actions
- Plausibility – the story and events seem real
- Scientific laws and economic theory can be applied by players to predict outcomes
- Players must have access to the fundamental principles presented in the simulation to build their cognitive apparatus
- Knowledge rather than opinion should guide decision making
- The model should be mathematically accurate. Formulas should be proofed and tested

In an examination of simulation fidelity, Perotti and Pray (2000) identified three common difficulties developers face when developing mathematical models: initial state values, sensitivity of the parameters, and lack of continuity due to the use of step functions. A step function is where a series of linear equations are splined together rather than using a smooth or continuous nonlinear function. The step function presents students with the opportunity to try and optimize the steps – game the game – rather than paying attention to the true relationships captured by a continuous function. Once again it should be pointed out that the prototype simulation developed for this report will be powered by non-linear functions that are consistent with economic theory. Because business relationships can be complex, developers may fail to capture the linkages between the four general families of functions which are production, cost, revenue, and profits (Gold, 2003). Other issues identified by Gold include the degree of market concentration, the economics of resource or input markets, and modeling product differentiation. Specific demand issues include the impact of market segmentation, demographic and income characteristics, and the role of complement and substitute goods. These issues are particularly problematic in a general enterprise simulation where students may have difficulty making sense of cross functional interactions.

In Gold and Pray's classic study (1982), they tested the verisimilitude of eight popular simulations in use at the time. They found seven of eight had price elasticity that increase with price and two of the sims had increasing rather than decreasing returns to marketing input variables. Wolfe and Gold (2007) examined the algorithm used to generate stock price in six commonly used games and determined that each was different. In theory, the stock price should be valued as the sum of equity capital plus the present value of future cash flows discounted at the firm's unique cost of capital, which is a function of market considerations, and the variability of cash flows, entity risk.

The literature does offer useful suggestions to ensure fidelity. Gold has contributed much to the literature over several decades of active and very credible research within the community of simulation developers. The most important function in a general enterprise or marketing simulation is the price demand relationship, the demand curve. Economic theory provides underlying principles that are well known and widely understood regarding the demand relationship. Law of demand elements that must be incorporated in developing the demand curve include the law of diminishing marginal utility, elasticity properties, parameter responsiveness, and demand sensitivity to other modeled variables. A linear demand curve is frequently employed due to mathematical convenience but a nonlinear demand is a truer representation of economic reality. The magnitude of price elasticity should reflect product or service substitutes, complements and differentiation. A multiplicative demand function with the marginal impact of changes in each independent variable as related to other independent variables with discontinuous changes in elasticity is recommended (Pray & Gold, 1990). Figure 3 captures the desired shift in demand when effective promotional decisions are made.

Figure 3



Barriers to Use

ABSEL research fellow, Tony Faria, describes the diffusion of simulation use to be broad in that most universities do have coursework anchored by simulation. However, the use of simulations is not extensive in academics because only a small number of faculty members use them (Faria, 2009). While current users are highly likely to continue, new faculty has not adopted gaming and simulation, or other experiential teaching methods at the rates simulation developers and users have anticipated over the past twenty years.

In an earlier study, Snyder (1997) surveyed faculty that had tried and abandoned simulation, or had never used them, and found that one third of the faculty were not even aware that simulation games existed in their discipline. Several interesting issues were raised. Time constraints were a problem for 29% of the sample, 18% expressing a fear of the complexity and "looking bad," and 12% reported a prior bad experience of that sort. When asked to consider both class time, which is a finite constraint, and additional preparation time, 37% did not feel simulation was worth the effort. Poor class evaluations were perceived to be primarily the fault of the simulation for 23% of the survey group. Similar findings have been reported by Keefe and Cozan (1985). It is encouraging to note, however, that 20% of the disgruntled users would consider another simulation if they had some influence over the game parameters and better vendor support.

Principles of the General Framework for Effective Simulation Development

Derived from a variety of researchers regarding elements of simulation, a General Framework for Effective Simulation Development is proposed to reflect a comprehensive set of best practices. The sections that follow reviews the findings concerning the role of scenarios, complexity, repetition and practice, pedagogy, interface, platform and deployment options, feedback, elements of gaming and play.

The role of scenarios. Throughout history and across cultures, the teaching and learning tool that is often used, and is certainly effective and influential is the story (McGonigal, 2011). In the simulation world, the term "scenario" is commonly used. In developing a General Framework for Effective Simulation Development, there seems to be general agreement that a scenario is an important part of the learning (Morgan & Dennehy, 1995) . A good story will not only entertain the student, but will establish their role in the simulation, identify financial or other goals, and provide background information useful to working the problem.

According to Morgan (1995), a framework for a scenario consists of five sequential components: (1) the setting; (2) the story builds; (3) a crisis or climax; (4) learning takes place; (5) new behavior or awareness. Specific characteristics of the scenarios should: (1) be concrete - the people, actions and events must either be real or highly believable; (2) include knowledge that is common to the culture of the target players; (3) be consistent with the norms of the organizations represented by the players; and (4) have a story that is unique and interesting, but can be generalized to the environment being simulated.

The scenario is also where students discover information and data pertinent to the simulation. In her research, Erdmann (2004) found that students rely most heavily on data they can use to estimate total demand, price and quantity relationships, and factors that affect demand functions. Therefore, the information and data conveyed should include parameter boundaries for the demand function, promotion and advertising functions, capital costs, fixed and variable costs, hints regarding uncertainties suggesting probability distributions of outcomes. Other information should include the potential range of returns to research and development activities, productivity gains for investments, benefits derived from training and development activities, and other information to enable students to assess decision variables more analytically.

Within the scenario, Key Performance Indicators (KPIs) should also be introduced along with current or base case values and simulation goals and industry benchmarks or other reference values. Examples of KPIs commonly used in general enterprise simulations are measures of profitability such as profit margin; net income; measures of efficiency such as unit cost, capacity utilization, asset turnover ratios; measures of risk such as debt ratios, sales variability and market share; and value measures like stock price and customer lifetime value.

Complexity. The multifaceted complexity issue is one of the most researched, and controversial, and perhaps lies at the heart of what makes a business teaching simulation an effective and valuable learning experience (Cannon, 1995; Friesen, Lawrence & Feinstein, 2009).

Teach and Murff (2008) have questioned the real learning value that large, complex games actually offer. The two dominant problems they found are for developers, they difficulty they have detecting programming errors and debugging all the related functionality and for students, the difficulty to interpret and follow the logic of these games.

In 1956, George Miller published his classic paper, *The Magical Number Seven, Plus or Minus Two: Some limits on our capacity for processing information* (Miller, 1956). This discovery is highly related to the simulation complexity issue and, specifically to the number of decisions a player is faced with. According to Miller and prior information theorists, Claude Shannon and Norbert Wiener (Gleick, 2007), the capacity of people to transmit and receive information is a function of the variance of inputs and outputs plus channel “noise” with input and output variance being highly correlated. Variance is the degree of ambiguity experienced by individuals. When confronted with new information and knowledge in a learning mode, the variance or ambiguity is greater. Their hypothesis, which Miller confirmed, postulates that as the number of inputs increase in a high variance state, the number of errors increase and both quantity and quality of the transmitted information is diminished. As the number of alternatives increase, the cognitive demands on memory increases exponentially. Miller and his team found that at six input variables, memory for beginners becomes statistically unreliable. When input is combined with visual stimuli and given added exposure and reflection time, this number may be as high as 10. His conclusion was the average number of inputs most people can process reliably under ordinary circumstances is 6.76, with a standard deviation of .6. Thus, the rule of 7 +/- 2 (which is about three standard deviations and includes over 99% of the population) emerged. This rule of seven plus or minus two is a general and universal human constraint.

The “rule of seven” is supported in other research domains. For instance, the Institute of Management Accountants found managers can work more effectively using less than 10 performance measures (Gjerde & Hughes, 2007). Hall and Cox (1994) found that learning effectiveness peaked at about seven decisions for business simulations. They explicitly cited information overload and the law of diminishing return as an explanation, but their conclusions are certainly consistent with Miller’s. Lawton and Anderson (2007) studied student success and their perception of value derived from a complex simulation employing more than 40 variables and found the students did not associate their success in the class (as evidenced by high marks) and the simulation experience. Miller’s rule of seven would predict this reaction.

Because complexity and fidelity are related, a critical and difficult task of the developer is to find a proper balance between fidelity and complexity. Furthermore, developers need to tailor the level of complexity to the needs and abilities of the students and the instructor using the simulation. This is especially true when developing an andragogical model; that is, a model that draws heavily on user experience with a limited instructor role.

Uncertainty is another dimension of complexity and is defined as the degree of abstraction (Cannon, 1995), or clarity when relating input decisions and outcomes. That is, with multiple decisions, it is not always clear which input is affecting the results and the magnitude of that impact. Uncertainty can be reduced several ways, the most obvious of which is to limit the number of decision variables in accordance with Miller's rule of seven. In addition, it is best to make each decision either independent or, in the case of related variables such as advertising and number of sales reps, model the relationship in a way that is explicitly complementary and intuitive to the player. Another suggestion is to make clear the goals of the game and identification of the key performance indicators. Within the scenario itself, students will find "hints" in the form of benchmarks, historical data, and character related anecdotes helpful. For example, in one simulation, SimMarketing TM, the storyline is about a seasoned executive explaining to a marketing intern the importance of price differentiation when employing a price versioning strategy by stating that "a difference of at least one dollar is necessary to gain the attention of a consumer."

Hall and Cox (1994) tested the relationship between game duration and number of decisions against perceived complexity using a regression and found an extraordinary combined R^2 of 98%. Duration includes not just play time, but requires installation and access to a technology platform, organization of teams if team play is selected, which is usually the case, preparation to play by reading the story and related course content materials, and analysis and a debrief after each round of play.

The paradox of simplicity offered by Cannon (2009) is that the game must be simple enough to play and learn but complicated enough to seem real to the player. Students must learn to use higher order thinking skills in order to develop simplifying mechanisms to cope with information overload, but higher order thinking skills are developed playing the game. Several suggestions are offered how to remedy the complexity problem but retain the fidelity of the simulation and achieve a meaningful learning experience. Two techniques suggested by Cannon are used in SimSales Management, one of five simulations in a marketing series published by

McGraw Hill (Nentl & Miller, 2004). Players are striving to improve a measure known as Lifetime Value (LTV) for the simulated pharmaceutical firm as they manage a five-person sales force. In addition to the company LTV score, the LTV of each sales rep is also provided to the player enabling them to see output at a granular level. A second method found in SimSales Management is "sequential elaboration" where incremental decisions and thus complexity is added at each of the seven decision periods. The more important tasks students work on in the early rounds are repeated in subsequent rounds with a new, more complex task. Sequential elaboration is also effective when simulating related but complementary activities such as making a series of promotion related decisions.

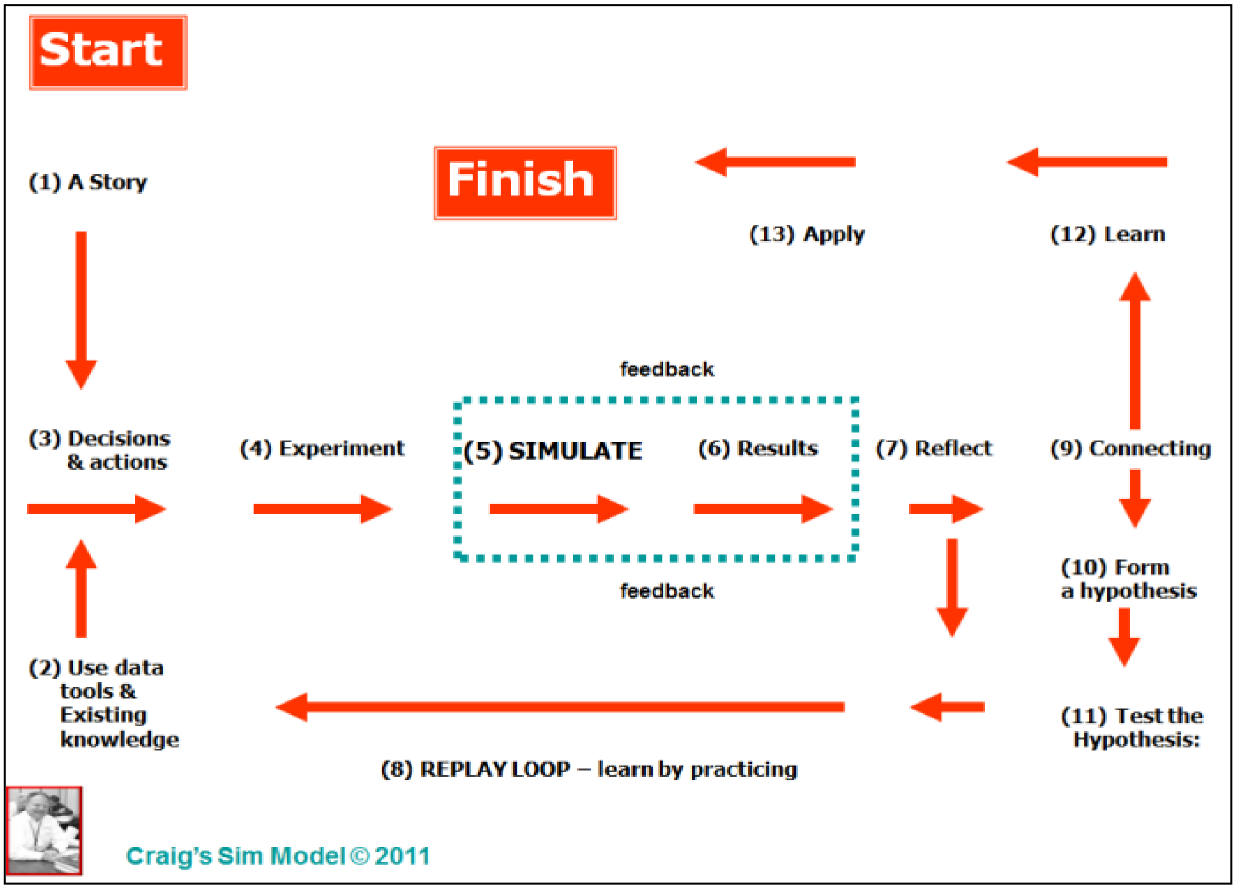
A final remedy to the complexity problem is the MiniSim which has a number of advocates (Fraser, 1980; Teach & Murff, 2008; Watters, 2006). For example, Fraser (1980) was an early campaigner and argued that students would learn more by playing several "limited purpose games," lasting a single class period rather than a semester-long mega simulation. A realistic situation can be simplified to the point where students can understand it, play quickly, and still do a meaningful analysis at a suitable level of learning.

Repetition and practice. Nobel Prize Laureate, Herbert Simon, made the following observation about simulation: "How can a simulation teach us what we do not already know? All correct reasoning is a grand system of tautologies but only God can make direct use of that fact. The rest of us painstakingly and fallibly tease out the consequences of our own assumptions."

Again, the Sim Model introduced earlier has the integral role of feedback and repetition and practice (see Figure 4). Kearney and Pivec (2007) described this process as "recursive learning" where reflection occurs both during and after play and is a derivative of Kolb's (1984)

Experiential Learning Cycle where *we do* (active experimentation), *we feel* (concrete experience), and *we watch* (reflective observation) and *we think* (abstract conceptualization).

Figure 4



Ravulapati (2004) would recognize the four elements of learning by simulation in the Sim Model as it contains an environment (the game itself), learning aspects (business and economic theory), a set of actions (decisions), and a system that responds in a predictable repeatable manner (the algorithms). He prefers this mode of reinforcement learning because players can learn from trial mistakes and make corrections with feedback that they cannot get in a "single shot" simulation. In a single shot simulation, players do not have a replay option. Ravulapati's criticism of the single shot simulation is that in addition to less learning due to the inability to practice and experiment, the chance of being “graded down” affects the risks students will take and affects morale, possibly souring them on the idea of simulation in general. An advantage of the “single shot” simulation of course, is it can be repeated more often. An Ontario-based vendor of sales training games reported that sales reps play their games for an average of 47.3 times and spend 71 minutes interacting with it outside of the formal training session (Weinstein, 2007).

Pedagogy. Simulation, in and of itself, can be a distinct pedagogy. Students in simulation enhanced courses have identified goal setting, information processing, organization and interpersonal skills, sales forecasting, entrepreneurial skills, financial analysis, economic conceptualization, inventory management, mathematical modeling, hiring, training, motivation, enhanced creativity, communication skills, data analysis, strategic planning plus others as part of the learning experience (Wellington & Faria, 2006). Several pedagogical issues should be considered. The role of the facilitator and feedback is critical. (Feedback has been discussed in earlier passages of this paper and will be addressed at length in a separate section). Facilitation of a simulation is different than that of a traditional lecture/discussion class. Unlike the typical lecture format, there is little control over the agenda. An instructor facilitating a lab simulation session will likely to be called upon by the various groups to respond to questions related to all aspects of the simulation. The opportunity to interact with the student discussions provide an excellent assessment of how well the theory and content have been received and is being processed and applied by the students. The debriefing session of every round of each simulation is unique (Markulis, 2004), and facilitation skills are paramount in tethering the discussion to the learning goals.

As discussed previously, simulations can be stochastic such as the Monte Carlo model or deterministic. In an academic setting where new learning is taking place, it has been suggested that the deterministic simulation is preferred (Teach, 1990). Students find in a stochastic simulation the elements of luck (randomness) and uncertainty diminishes the learning experience (Miller, 2012). A case can be made for using Monte Carlo simulation in an executive training session where the purpose is to plan for and mediate unexpected events.

In terms of duration, simulations have been classified as MegaSims, MediSims, and MiniSims, as previously defined. A strong pedagogical case can be made for the MiniSim. Edman (2006) reported great success using MiniSims to demonstrate elements of economic theory that could later be integrated into a more comprehensive lesson. The faster pace of play yields feedback that is immediate and reinforcing (Kearney & Pivec, 2007). A dominate variable can be identified (such as pricing) and a clear relationship can be developed with an outcome or learning goal; for example, connecting demand elasticity to revenue and profits.

A point of controversy that lacks extensive research but is a critical pedagogical concern is whether the simulation algorithms should be constructed such that teams are placed into an industry consisting of its own demand characteristics with each team competing against the others, or are part of a market with competitors consisting of programmed smart agents with the students playing against the machine. These two methods are designated *team competition* and *machine competition,* respectively. With inexperienced learners on a team, playing against other novices may find the strategies used to “win” will not work in the real world with competent and experienced competitors. There is another problem with team competition. Industries are created with a fixed aggregate demand and a limited number of teams competing for market share. This market structure is characterized as an oligopoly (McConnell & Brue, 1999), and the participating teams will behave as participants of an oligopoly, though most industries more closely exhibit characteristics of monopolistic competition. The proper strategy in an oligopolistic market is to acquire market share in order to spread fixed costs and become the low cost producer. This team will become the market leader and the correct economic response of other firms is to follow the leader. This leads to two undesirable consequences. First, the leader typically emerges in an early round leaving the balance of the game predictable, redundant, and not as fun and engaging. Secondly, the non-dominant firms become price takers, not price makers eliminating one of the, if not the most important decision in a simulation game – pricing and demand management.

As early as 1933, the late Harvard Economist, Edward H. Chamberlin, understood the importance of market structure classification and properly analyzing a company beyond sales and revenue with his classical business theory of monopolistic competition. Chamberlin postulated that monopolistic competition is characterized by four factors: (1) a large number of small firms, (2) similar but not identical products, (3) relatively good, but not perfect resource mobility, and (4) customers who have extensive but not perfect product knowledge. Unlike pure competition and monopoly, the bedrocks of microeconomic theory at that point in time, the theory of monopolistic competition described the modern firm where product differentiation, strategy, pricing, investment and other business decisions spell the difference between great success and demise. Although the marketplace may be one of significant competition and similarity of product, Chamberlin recognized that a firm could nonetheless gain competitive dominance by differentiating itself through better management and marketing of products and profits, and by earning above normal "economic" profits. Economic profits are those profits in excess of the opportunity cost, or the market returns to assets of similar risk, of invested capital.

Monopolistic competition theory was widely accepted by educators then and is still prominent in today's business education. This market structure has an industry demand that is not fixed and, in fact, often expands as individual firms differentiate and innovate. Strategically, firms can compete on the basis of price, service, quality, and any number of factors given players more options and a richer, truer experience of the current world of business. A simulation can be programmed react to input decisions as rational firms in a monopolistically competitive industry would, and provided students with a simulation experience more closely resembling the firms and industries they are likely to join.

There are other unambiguous advantages to machine play. It is possible that every team can win if they play well. This is consistent with the notion that a monopolistically competitive market is not a zero sum game. When playing against the machine, students can play at their own pace and on their time schedule. They can replay – an important feature of simulation presented previously in the repetition and practice discussion. Finally, because competition is modeled deterministically, students are able to connect inputs and outputs better and perform better analysis.

Interface, platform and deployment options. An overarching goal for simulation developers should be to make simulations that are accurate, meaningful, fun, and easy to use, allow for experimentation, are engaging enough to encourage repeated play, and provide immediate and useful feedback. Given this tall order, the selection of platform, deployment technologies, and interface decisions are critical.

A simulation interface is a front end intended for a non-technical user that is generally uninterested in the algorithms that comprise the simulation engine. Players want to experiment and "do over" easily. They want to get started quickly and have no need or desire for extended features. They want a suitable level of challenge and an appealing experience. Understanding the "persona" and expectations of the player is a significant advantage. Alan Cooper, developer of the Visual Basic programming language and many books about design likely coined the term "persona" in 1998 when he first published *The Inmates are Running the Asylum* (Cooper, 2004). A persona is an imagined user in the mind of the developer after which a particular software product is being developed. Frequently a persona is a composite. In the case of a business simulation, the person should be a business student.

Working in a digital medium is different than with pencil and paper and possesses some unique challenges. For instance, research shows the screen is less efficient than paper in terms of speed and comprehension. Errors are less likely to be detected as well (Kelton, Pennington, & Tuttle, 2010). Two books, *The Inmates are Running the Asylum* and *About Face 2.0: the essentials of interaction design*, by Alan Cooper (2004,) were very influential in developing a philosophy of interface design. There are two concepts closely related to interface design: density and granularity. Density **i**s the ratio of information present on the screen to the white space. Excessive density implies a complexity that is not intended. The density heuristics range from 25 to 50% of screen usage for text intensive applications. Excessive density can be distracting and detrimental to proper focus. Granularity consists of two dimensions: Service granulation and presentation granulation. Service granulation is the number of tasks expected from an operation such as making decisions on an input screen. Presentation granulation is the degree of detail offered in report and output screens. Much of the information presented in business simulation is financial and accounting data. While most developers are highly educated and trained in their respective disciplines, the tendency has been to forget that their simulations are intended for people learning new material. Developers should be aware of what the learner needs to see in order to understand the concept and still make a connection between the input (decisions and strategy) and output (relevant financial information to them).

There are alternate visualization schemes that can enhance, and perhaps replace, the primary communication mode which is text and numbers. For example, graphs are preferred to data tables by most external users – especially those who are not subject matter experts, which most learners are not (Kelton, Pennington, & Tuttle, 2010).

Another study (Heer & Agrawala, 2006) identified a number of software design patterns that are commonly used proved to be effective in their lab studies. For example, they cited multiple visualizations of data sources, organization by column is preferred to by row, and annotations or expressions can enhance focus and understanding.

Two decisions related to interface matters are the development platform and method of deployment. There are two primary platforms commonly used among academic simulation developers. Some use a high level computer language such as Visual Basic compiled into an ".exe" file. The principal advantage of this type of compiled application is the protection of algorithms and eliminating the need for a user to have a current and fully functional version of Microsoft Excel ™ installed on a machine. Two primary disadvantages have directed other developers, including this author, to abandon the compiled program and instead use a general purpose spreadsheet such as Microsoft Excel ™. One advantage is that Excel ™ is a superior tool for working with mathematics and includes many built-in math and logical functions such as "lookups," "if statements," and branching statements (Tangedahl,1998). It is very time consuming to hard code and debug the formulas and logic in a compiled programming environment. With Visual Basic for Applications (VBA), the developer is able to use the standard tool set of forms and controls to achieve a desired interface. The code snippets are used for mostly navigation, internal communication via dialog boxes and error trapping and validation. A second aspect of compilation turns out to be a significant issue when using simulation with a college network. When installing an .exe file, the computer's registry needs to be accessed and written to. Most college labs where simulation software is to run are very protective of any new applications installed on their networks and likely would require layers of testing and authorizations. The Excel ™ files, on the other hand, were viewed as simple ".xls" files and exempt from scrutiny. The only remaining issue (and only sometimes) is a onetime need for the user to allow access to macros and VBA and this is easy to document in the instructions. Excel ™ also will guide the user to make this change.

Because Excel ™ is recognized as the "software of business," it is seen as an advantage for students to work in an authentic environment (Benninga, 2008). Students frequently will create their own decision support systems using Excel ™ as an enhancement to their simulation experience.

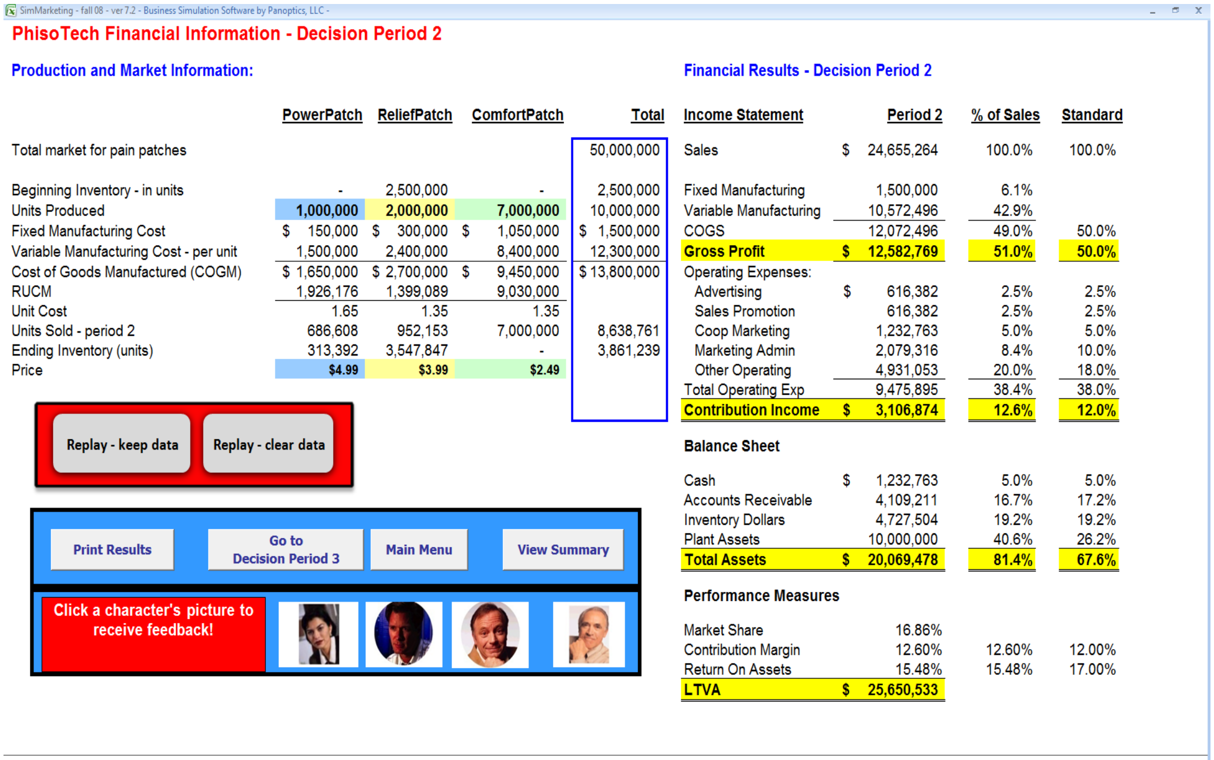
Another logistical concern of developers is deployment and distribution. Simulations are deployed to individual machines and installed and administered by users directly or installed on a server and governed centrally and displayed via a browser. The individual machine model does not preclude the software from being distributed via an internet site. It can also be delivered via email and media such as a CD. Browser deployment has become a popular choice (Rahn, 2009). It is a very efficient way for a developer to manage updates and correct errors. Users can share files and data more readily. Facilitators and developers can capture input data for analysis. Protection of intellectual property can be managed via access codes. Like the compiled application, formulas can be protected and hidden more easily from users. There are, however, several disadvantages to browser based deployment. Of the several software packages that will convert spreadsheets to interactive web applications, there are common problems such as conversion of VBA macros, conversion of controls that function as they are intended too, and most importantly, the developer loses control of screen resolution and operation. Being connected to the web, while far from being a major impediment, is still an additional step the user must undertake to get to the simulation games. Getting connected is not unlikely, but it still is not a certainty as the net is occasionally inoperable in many college environments. Another objection, though less relevant than the past, is speed and performance. A sim running a 35,000 cell matrix computation in a stand-alone environment computes nearly instantaneous. Another strong objection some have to the browser interface and a violation of the sovereign state application philosophy (use of one program at a time with no other open and visible windows) is the browser interface itself with its menu structures and temptations for distraction (Cooper, 2003).

Feedback. Norbert Weiner, the MIT mathematician and originator of Cybernetics, formalized the notion of feedback in 1948. He defined Cybernetics as a control and correcting mechanism. Given a decision making state, a system provides negative feedback for poor results and positive feedback for good results. The decision maker then incorporates the new information provided by the system feedback and makes corrections. An important component of Weiner's cybernetics system is the feedback loop which is continuous until the decision maker is satisfied, exits the loop, and confirms the decision. Bernie Keys, founder of ABSEL, early on championed the experiential nature of simulation as a way for students to try out new ideas and learn through feedback (Peach & Robert, 1999). Public accounting firms have long used simulation in their training and value the "freezing of time" between rounds that allows them to scrutinize feedback and pose reflective questions (Bass & Geary, 1997).

In the early days of mainframe computer based simulation, students analyzed a case, made decisions, and then submitted them to the game administrator. The administrator then took them to the computer facility and entered the decisions via coded punch cards or a terminal and processed the simulation in batch mode. The lag between the decisions students made and their results varied between a day and a week. This process continued when the microcomputer became available as many of the games were not ported over to a real time platform. With current technology, any time lag should be deemed unacceptable. A time lag continues to be somewhat of an issue for team competitions where each team must submit before the algorithms can process the game. With machine play, results, and feedback should be instantaneous.

As computer systems and programming becomes more powerful, it is possible to incorporate contextual and quasi-artificial intelligence in the feedback loop. SimMarketing, another in the McGraw Hill marketing series, offered several characters presented feedback in the form of congratulations and admonitions from the perspective of their functional positions and “in character.” Using nested “if” statements, Juanita Valdez, the Vice President of Sales in the scenario, critiques this team’s pricing strategy and Marketing Manager, Jeb “The Colonel” Sanders, comments on this team’s missed forecasts. Two products were over-forecasted and one product was under forecasted, and the negative business consequences of each resulted. Herb T, the accountant, is concerned about resource use, and the CEO, Lyndon, is complimenting the team on their proper selection of a version strategy, even though his lieutenants have concerns and suggestions for better execution. (See Figures 5 and 6.)

Figure 5



	PowerPatch	ReliefPatch	ComfortPatch	Total
Total market for pain patches				50,000,000
Beginning Inventory - in units	-	2,500,000	-	2,500,000
Units Produced	1,000,000	2,000,000	7,000,000	10,000,000
Fixed Manufacturing Cost	$ 150,000	$ 300,000	$ 1,050,000	$ 1,500,000
Variable Manufacturing Cost - per unit	1,500,000	2,400,000	8,400,000	12,300,000
Cost of Goods Manufactured (COGM)	$ 1,650,000	$ 2,700,000	$ 9,450,000	$ 13,800,000
RUCM	1,926,176	1,399,089	9,030,000	
Unit Cost	1.65	1.35	1.35	
Units Sold - period 2	686,608	952,153	7,000,000	8,638,761
Ending Inventory (units)	313,392	3,547,847	-	3,861,239
Price	$4.99	$3.99	$2.49	

Income Statement	Period 2	% of Sales	Standard
Sales	$ 24,655,264	100.0%	100.0%
Fixed Manufacturing	1,500,000	6.1%	
Variable Manufacturing	10,572,496	42.9%	
COGS	12,072,496	49.0%	50.0%
Gross Profit	$ 12,582,769	51.0%	50.0%
Operating Expenses:			
Advertising	$ 616,382	2.5%	2.5%
Sales Promotion	616,382	2.5%	2.5%
Coop Marketing	1,232,763	5.0%	5.0%
Marketing Admin	2,079,316	8.4%	10.0%
Other Operating	4,931,053	20.0%	18.0%
Total Operating Exp	9,475,895	38.4%	38.0%
Contribution Income	$ 3,106,874	12.6%	12.0%
Balance Sheet			
Cash	$ 1,232,763	5.0%	5.0%
Accounts Receivable	4,109,211	16.7%	17.2%
Inventory Dollars	4,727,504	19.2%	19.2%
Plant Assets	10,000,000	40.6%	26.2%
Total Assets	$ 20,069,478	81.4%	67.6%
Performance Measures			
Market Share	16.86%		
Contribution Margin	12.60%	12.60%	12.00%
Return On Assets	15.48%	15.48%	17.00%
LTVA	$ 25,650,533		

Figure 6

Elements of gaming and play. In 2009, Stuart Brown, M.D. wrote a bestselling book entitled, *Play, How it Shapes the Brain, Opens the Imagination, and Invigorates the Soul*. Through a lifetime of studying, formal education, and experiences he makes a compelling case for play in all aspects of life, including learning. According to Brown, play lies at the center of creativity and innovation. He names purposelessness, a voluntary activity, an inherent attraction, freedom from time, diminished consciousness of self, improvising, and a continuous desire to stay with an activity as the properties of play. All of these properties may not pertain to simulation but to many students and teachers, simulation does consist of many gaming elements and produces many of the beneficial outcomes of play.

Most general enterprise simulations are competitive and designed to teach decision making and strategy. A competitive game is frequently referred to as a “zero sum game.” That is, for every gain captured by one player there is a corresponding loss to be absorbed by the remaining players. In his book, *Game Theory*, John Von Neumann (1944) classifies games as competitive *or* cooperative and business simulations can fall into both categories.

The game*, The Prisoner’s Dilemma* (Camerer, 2003), is an iconic example of a cooperative game. Only when the two suspects collaborate and deny guilt will total returns be optimized An individual maximizes his personal expected value by confessing to a less serious crime and pointing the finger at the other prisoner. “Role play” exercises are used frequently in soft skills training such as team building and fall into the collaborative or cooperative category. In the current business environment of partnerships and integrated supply chains, there is an opportunity for more cooperative simulation games.

Jesper Juul (2001) includes five essentials that characterize a computer game: (1) rules, (2) variable quantifiable outcomes, (3) valued outcomes, (4) player attachment to outcomes and (5) effort. Other elements include challenge, curiosity, user control or influence, fantasy (no real life consequences) and playing a role such as CEO, conflict, closure, mystery, adaptation to changing skill levels, assessment (which in business simulation where the scoring construct uses financial metrics is considered an authentic assessment), progress, sensory stimuli, motivation, the need for cognition, and immediate feedback.

Scott Eberle (2011), Vice President for Interpretation and Play at the Strong Museum in Rochester, New York, and a nationally recognized expert, describes play as a five-step process consisting of anticipation, surprise, understanding, strength, and poise. While he is describing the impact of games on children, this process also describes a business student's transformation when successfully completing a simulation. Furthermore, games attract people of all ages – not just "the millennials" as they are portrayed in popular culture (Rahm 2009). He suggests engagement can be is recognized by observers when there is a competitive team spirit, discussion and debate within the team. According to Rahm, engagement is strengthened when students are presented with focused goals, challenging tasks, an authentic and compelling story, a degree of novelty, and a variety of interesting characters and roles.

Is a business simulation a game? Simulation researchers Wilson, Bedwell, Lazzara, Salas, Burk, & Estock, (2009) define a game as an artificially constructed competitive activity with specific goals, a set of rules, and constraints. A simulation game attempts to represent real phenomena including complex processes through algorithms. A similar definition is offered by Teach (1990) where players face a business related scenario, assume a decision makers role, make decisions that are acted upon by the games algorithms, and receive reports in the format of an accounting system. Many benefits are associated with business simulation games. In keeping with current teaching trends, simulations are an intense active learning experience tapping into a basic human motivator – competition and winning (Wilson, et.al, 2009). Students are not describing knowledge but experiencing it. The goal orientation of business simulation games allow players to understand and set business goals (Seijts, 2004). Students will appreciate the clarity of specific and measureable goals as compared to ambiguity. When students know what needs to be done, they may not know how to do it – this is where the experimental nature of gaming and learning is beneficial. A sim game allows a student to safely fail, affiliate with other students, and affirms hard work and performance in a more visceral manner than test scores. Students will need to practice and hopefully improve their powers of deduction, establish a credible hypothesis, conceptualize complex and abstract ideas, and improve their ability to process visual and spatial information.

In summary, simulated environments have been used to teach business over most of the past eighty years. Computerized simulation was available by the middle twentieth century. These simulations were difficult to program, required expensive time on a mainframe computer, and often took days to get the results. The personal computer provided a cost effective opportunity to bring the business simulation into most classrooms. However, adoption of simulation technology in business schools has greatly lagged usage patterns in the corporate market. A thorough review of existing research suggests there are a number a barriers contributing to the reluctance of business teachers implementing simulation technologies in their courses.

Chapter Three: Research Methodology

Chapter Three begins by explicitly defining an effective business simulation. Then Part 1 outlines the five stages of creating a prototype simulation that will be used to demonstrate the 12 elements of a General Framework for Effective Simulation Development designed as a learning tool. Next, Part 2 identifies the 12 elements of effective simulation design discovered in the extensive literature review, and proposes a 12-point checklist for developers and users. Finally, Part 3 establishes a methodology to test the economic fidelity of a business simulation by creating an input-output matrix of expected economic patterns according to current microeconomic theory (Cowell, 2006; Hubbard & O'Brien, 2010; Marshall, 1920; McConnell & Brue, 1999; Samuelson & Nordhaus, 2003; Veblen 1904).

Propositions of an effective business simulation are summarized below.

- Fidelity is warranted by building a model consistent with established economic theory.
- External validity is ensured by connecting the model parameters to established industry or sector benchmarks.
- The number of input variables or decisions will be limited to a quantity within the brain's cognitive range. This number has been demonstrated to be 7 + or – 2.
- The simulation will generate infinite outcomes allowing the player (the learner using the simulation) to learn by repetition and practice, thus simulating the role of experience.
- The computer interface will be intuitive, friendly, informative, and visually appealing.
- A story line or scenario will accompany the simulation that is engaging and presents a problem or series of issues requiring thoughtful decision making and strategy.
- Players will compete against a "smart" computer rather than other inexperienced and unschooled players. A smart computer is a simulation designed to respond to competitive

moves made by players as actual firms in the market place do rather than tying outcomes to other player moves.

Part 1: Five Stages of Creating a Prototype Simulation

The following outlines the five stages for creating a prototype business simulation that that demonstrates the 12 elements of a General Framework for Effective Simulation Development:

Stage 1: Create an archetypical manufacturing firm. A short scenario for will be written and beginning financial statements will be established. At this level, it is important to establish a set of quantitative goals. Not only is this a sound practice for all organizations, but it establishes critical "game" elements required for a successful simulation experience.

Stage 2: Identify eight business decisions. For a general enterprise simulation such as this prototype, the following decision variables will be used.

- Establish production level or capacity
- Quality, as defined by material grade
- Price
- Promotion dollars or techniques
- Credit terms
- Research and development budget
- Employee development budget
- Selecting the capital structure

Stage 3: Identify a standard output or results report. These will be derived from the income statement and balance sheet and include sales revenue, net income, current assets, fixed assets, current liabilities, long term liabilities, equity, sales per employee, profit margin, return on assets, economic profit, and enterprise value. Performance measures will also be presented graphically.

Stage 4: Create the econometric simulation model. For each variable, a function will be offered that is consistent with established economic theory and general industry or sector benchmarks that connects each decision variable explicitly to financial outcomes. In addition to presenting the functions in equation form, graphs of each relationship will be included.

Stage 5: Program the prototype interface consistent with the General Framework for Effective Simulation Development. Chapter Four will describe this process in detail.

Part 2: 12 Elements of Effective Simulation Design

A primary objective of this project is to establish a General Framework for Effective Simulation Development**.** The existing theory and data used to construct and validate this was uncovered and presented in Chapter Two. The following checklist can be used to guide a simulation developer or a simulation user to assess efficacy, consistent with the General Framework for Effective Simulation Development.

1. Scenario-based. Business simulations should include a scenario that is based on the principles of effective storytelling. The scenario should explicitly prescribe a role for the learner to assume. In a general enterprise simulation, this is likely a general management position or a CEO.
2. Balanced complexity. The number of decisions should be limited to 7 +/- 2 to maximize learning and deter information overload as earlier described by information theorists.
3. MiniSim is preferred to a MaxiSim. The MiniSim is more focused, plays faster, and provides greater course flexibility. The MiniSim also provides an opportunity to introduce multiple simulation experiences in the course.
4. A replay option. This option is preferred to single shot play because practice and reflection are critical components of learning.

5. Feedback should be immediate and contextual. Both good decisions and bad decisions should be acknowledged, with tactful suggestions for improvement.
6. Deterministic is preferred to stochastic. A stochastic or probability-based simulation such as the Monte Carlo Method is excellent as a management planning and research tool. However, with the Monte Carlo Method, students have more difficulty connecting input and output associations.
7. Students should compete against a programmed competitor. Competition programmed into the computer will provide students with a more realistic experience than student-driven competition.
8. The interface should be simple, uncluttered, and intuitive using standard Windows controls. Issues related to bad technical design are a prime barrier to instructors embracing simulation. Navigation should be button-driven and consistent from screen to screen, particularly if multiple forms are used.
9. Graphics and colors are effective but should be used parsimoniously following the density and granularity heuristics.
10. Elements of game play should be incorporated. Each simulation should include stated and quantitative goals and outcomes expressed using business language and measures. The simulation should also provide clearly defined rules of play, present challenging tasks, and be fun to play.
11. Skill and knowledge should be the primary determinants of "winning." Decisions should be based on thoughtful deliberation and application of theory and best practices. Skill and knowledge should improve during game play.

12. High fidelity is critical. Total high fidelity includes content validity (an accurate representation of a particular industry), internal validity (the simulation should perform as intended), external validity (players perceive the game as real and believable), and construct validity (variables relate to each other as intended).

The Business Simulation Assessment Tool presented below represents a checklist for developers and users to determine congruence with these 12 elements of effective simulation development.

A Business Simulation Assessment Tool

		Yes	No	Can't Answer
1	The story or scenario used with this simulation clearly identifies the business goal or goals our team is to achieve.			
2	The number of decisions per round is no more than 10.			
3	The entire simulation can be played in a single class session.			
4	A decision can be replayed.			
5	Results are available immediately after decisions are submitted.			
6	Results are determined only by decisions - not by randomness.			
7	Results are determined by the simulation algorithms rather than other player actions.			
8	Navigation through the simulation uses command buttons.			
9	No screen has more than 4 colors or fonts.			
10	The goals of the game are explicit, quantitative, and based on business measures.			
11	Successful outcomes are associated with more skill and knowledge of the simulation subject matter.			
12	The simulation model will return results that seem realistic and consistent with non-linear economic theory.			

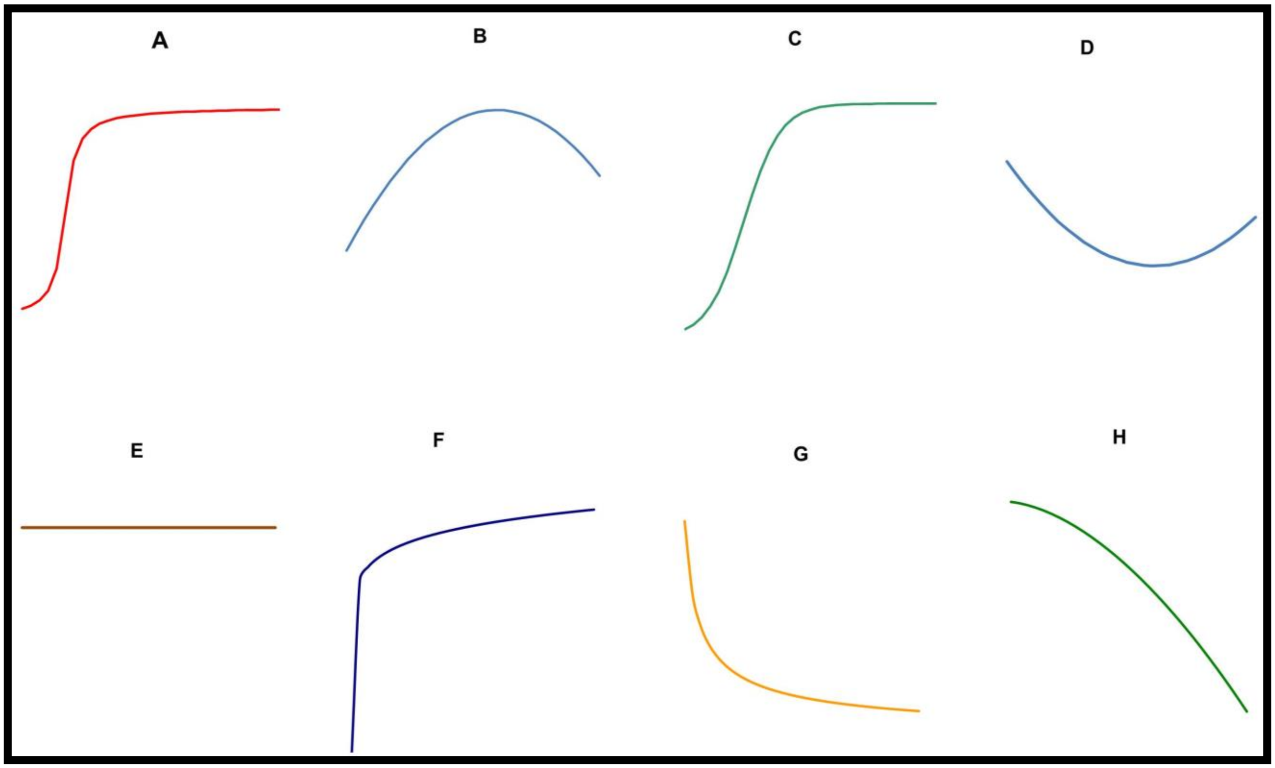
Part 3: A Methodology to Test Economic Fidelity

The prototype simulation should not only incorporate the elements of a pedagogically sound simulation, but mathematically it must be consistent with economic theory. In the table below, the Economic Theory Input-Output Matrix describes the mathematical relationship between input or decision variables and outcomes expressed as common financial measures.

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Units Produced	C	B	C	B	B	B	B
Quality	F	B	F	B	B	B	B
Price	G	B	B	B	B	B	B
Promo Dollars	C	B	C	B	B	B	B
Credit Terms	F	B	F	B	B	B	B
R & D Dollars	A	B	A	B	B	B	B
Training Budget	A	B	A	B	C	B	B
Change in LTD	E	H	E	B	H	H	E

The mathematical relationships are expressed graphically and displayed in Figure 7.An explanation of each function follows.

Figure 7



Technical notes related to each function:

1. A is a logistic function. It is characterized by an increase in the dependent variable as the independent variable increases with two inflection points. It is a function that increases slowly, then speeds up, and then slows down. The relationship between training and productivity is an example of this relationship in that first there is a learning curve effect followed by diminishing returns.
2. B is a parabola and is common to economic theory when explaining maximization behavior. One example is the relationship between price and revenue – there is a profit maximizing price.

3. C is an inhibited growth function. It describes those conditions where an increase in the independent variable is associated with an increase in the dependent variable until the constraining factor. There may be one or two inflection points. An example is advertising and sales units. Units sold are constrained by the production quantity.
4. D is also a common function found in economic theory and describes minimization behavior. The relationship between average unit cost and production quantity will look like D as fixed costs are allocated over more units. Eventually the cost for additional input variables will rise due to demand pressures.
5. E is described as a constant relationship or even as a null relationship. The change in one variable is totally independent of the other. For example, the capital structure decision is independent of the units that can be sold.
6. F is an exponentially dampened positive relationship and represents the classic economic concept known as diminishing marginal returns. An example is the relationship between product quality and units sold. The incremental value of quality will elicit more sales, but from fewer customers.
7. G is an exponentially decreasing function and describes the classic demand curve where demand will increase as price goes down. The demand curve, as graph G indicates is expected to have a concave shape. As the price of a good continues to drop, aggregate demand will increase incrementally for that good as it becomes a preferred substitute.
8. H is a convex exponentially decreasing function. The rate of change in the independent variable increases more than proportionally to the changes of the independent variable. An example is as debt increases, all else held constant; the profit margin will decrease at

an increasing rate. This is related to the interest rate charged to additional borrowing will increase due to the increased risk.

To test for economic fidelity, each decision variable, the independent variable, will be tested over a range of values with other variables held constant. The outcomes for each performance measure listed in the Economic Theory Input-Output Matrix will be captured over that range, plotted, and assessed for economic fidelity.

The general procedures used in this dissertation can be used to test for pedagogical efficacy and economic fidelity have not been published before and can be used generally to assess all business simulations used for teaching and learning.

In summary, Chapter Three explicitly identifies the 12 elements of the General Framework for Effective Simulation Development and describes the construction and use of a derivative checklist that is used to evaluate the pedagogical soundness of a simulation. Chapter Three also describes the creation and application of an Economic Theory Input-Output Matrix that tests the economic fidelity of a simulation. Both tools will be deployed in Chapter Three.

Chapter 4: Development of Prototype Simulation

Chapter Four presents SimWrite!, a prototype test simulation developed for this project. It includes a detailed description of how the test simulation was developed and how the design decisions relate to the established General Framework for Effective Simulation Development. Data sources for the hypothetical simulated firm and industry are identified and used to model economic behavior that is consistent with industry practices for each decision variable.

This chapter consists of ten sections: (1) Selection of Product, Industry and Firm, (2) General Design Considerations, (3) Development of a Scenario, (4) Selection of the Platform, (5) Selection of Input Variables, (6) Building the Simulation Engine, (7) Development of an Embedded Decision Support System, (8) Construction of a Report Module, (9) Creation of a Leaderboard database to capture play history that will display records chronologically or sorted by variable, and (10) The Finished Interface and Navigation depicted by a series of screen shots presenting the finished simulation with a description and interpretation of each page.

1. Selection of Product, Firm, and Industry

A business simulation developed for teaching and learning can be based on a real or imaginary product. However, the use of an actual product provides an opportunity to model and benchmark economic relationships that can be verified in the "real world," thus providing a more realistic learning experience for players. It can also be based on a service firm, trading firm, or manufacturing firm operating within an industry. A manufacturing firm allows for a more comprehensive range of business decisions and financial reporting. This is evident in the presentation of accounting principles in beginning accounting courses and texts where the curriculum begins with a service firm, transitions to a trading firm where inventory is added to the accounting mix, and concludes with a manufacturing firm and management of manufacturing costs.

SimWrite! simulates the activities of a real manufacturing firm of premium priced pens, AT Cross (ticker symbol ATX), a firm that competes in this market and, as a publically traded entity, discloses much financial and operational information useful to the model builder. Industry data can be gleaned by gathering information related to the pen and mechanical pencil industry identified by the North American Industry Classification System (NAICS) code 339941. Industry data was gathered from online sources such as FINTEL, *Yahoo Finance*, and *Biz Stats*.

The fictional firm, Penn's Pens Inc., was created with the following beginning financial information provided to players (see Figure 8). The financial statement values are representative of the industry and have been modified slightly to accommodate specific issues the player will be addressing.

Figure 8

Balance Sheet	PPI		Ind Avg
Cash	500,000	4.5%	
Accounts Reeivable	2,100,000	19.1%	15.0%
Inventory	2,400,000	21.8%	12.0%
Total Current Assets	5,000,000	45.5%	
Total Fixed Assets	6,000,000	54.5%	60.0%
Total Assets	11,000,000	100.0%	
Credit Line	-		
Accounts Payable	2,250,000	20.5%	
Total Current Liabilities	2,250,000	20.5%	21.0%
Long-term Debt	1,250,000	11.4%	22.0%
Equity	7,500,000	68.2%	57.0%
Total Liabilities and Equity	11,000,000	100.0%	
Income Statement			
Sales Revenue	10,000,000	100.0%	100.0%
Cost of Goods Sold	4,500,000	45.0%	55.0%
Sales and Promotion	600,000	6.0%	
Research and Development	250,000	2.5%	
Other Operating Expense	3,550,000	35.5%	27.0%
Interest Expense	80,000	0.8%	
Tax Expense	255,000	2.6%	
Net Income	765,000	7.7%	6.2%
Other Measures:			
Number of Employees	54		
Sales Per Employee	184,000		250,000
Units Sold	400,000		
Profit Margin	7.65%		6.20%
Return on Assets	6.95%		7.75%
Economic Profit	65,000		
Market Value	11,371,622		

2. General Design Considerations

Consistent with the General Framework for Effective Simulation Development, SimWrite! is designed as a single period simulation game that allows multiple replay. The simulation engine consists of algorithms that represent the industry selected and are typical of a firm within that industry, and employ a system of related non-linear and deterministic functions. The model is programmed such that industry demand is fixed and competitors are modeled to react rationally as profit maximizing entities. The interface is minimal, uncluttered, and uses standard Windows controls. Moreover, the interface has been designed to be aesthetically pleasing. In general, an effective interface will be intuitive, provide sequential flow, enable simpler data input, and be visually informative and appealing (Cooper & Riemann, 2003).

3. Development of a Scenario

Consistent with the elements of an effective business simulation is the incorporation of a scenario. The scenario for SimWrite! is written to engage and inform the player. It introduces the firm and the industry, the significant characters and their role in the simulation. Furthermore, the scenario provides historical information and current financial data, raises strategic issues, and sets the simulation goals. See Figure 9.

Figure 9

Company Name: Penn's Pens Inc.

Role: You, the player, have just taken over the family business as CEO with full autonomy.

Market and Product Information: Your Company is a maker of quality gift pens. You emboss them with custom logos and sell through distributors of premium pens. The target market is corporate gifting and sales through college bookstores. You offer several designs and each cost about the same to manufacture. The direct labor cost per unit is $2.50 and material costs range from $6.00 to $8.00. One task you face is to select a standard grade of materials for all products. Target selling price for your specialized niche is between $15.00 and $50.00. A second task is to select a single selling price to all customers. The total market is estimated to be $350 million dollars annually with minimal annual growth. You current market share is less than 3%. The most likely growth strategy is to capture market share from your competitors. Using predictive analytics learned in business school, approximately 11% of annual sales can be associated with research and development spending. The firms with the largest market share are increasingly diversifying into other lines in the general category of "office supplies." You will stick to one product and focus resources – a practice discussed in business school common to highly successful firms.

Issues: Your father Quilton and Aunt Fontaina had a conservative approach to financing and kept long term debt levels low. You are intrigued by Capital Structure Theory that you learned in business school and may want to consider adding leverage to the firm – especially to finance the expected growth. Also, the founders had a very conservative credit policy – sometimes turning down business from existing customers that did not adhere faithfully to the 30 day terms. A legacy of the founders is a no layoff policy. Through natural attrition, employment has dropped from a peak of 75 to 54 current employees. While employee turnover is still less than most firms, it has escalated over the past few years. Productivity is substantially less than the industry standard. A training and development program has been proposed that targets sales and production personnel. You will need to decide the level of funding.

4. Selection of the Platform

SimWrite! is developed using Microsoft Excel tm with a VBA tm (Visual Basic for Applications) interface. Visual Basic for Applications is a programming language integrated into Microsoft Office tm applications allowing the developer to add custom functionality. Excel tm is a superb tool when working with mathematics and modeling. The use of VBA tm for interface design provides access to standard Microsoft Windows tm controls and features.

5. Selection of Input Variables

SimWrite! is designed as a general enterprise simulation; that is, the player has responsibility for all functional areas of the firm and is accountable for goals established at the enterprise level such as net income, return on assets, and market value. Therefore, in selecting the game decisions, all functional areas (marketing, finance, human resources, finance, and technology) must be represented. The decisions must enable the player to resolve issues and achieve goals presented in the scenario, and be in compliance with the General Framework for Effective Simulation Development. This includes the seven +/- two decisions (Miller, 1956). The decisions and constraints that are programmed into the simulation using validation controls are:

- **Units Produced** must be a positive value less than 1,500,000 units.
- **Quality** is represented by the grade of raw materials used and is limited to $6, $8, and $10. These values are consistent with industry data found in FINTEL's *Industry Metric Profile* (2012) for the targeted market segment.
- **Sales Price** can range from $15 to $50 (FINTEL's *Industry Metric Profile, 2012*).
- **Promotion Dollars** in this industry must be a positive value less than $5,000,000. The industry benchmark was collected from a database (advertising-to-sales ratios for the largest ad spending industries) and published by *Business to Business Advertising & PR, 2012.*
- **Credit Terms** are based on general manufacturing firm practices and corroborated by FINTEL's *Industry Metric Profile* (2012), and *BI Essentials Comparisons* (2012).

- **Research and Development** spending is benchmarked proportionally to AT Cross data publish in their audited 2011 10K filing for 2012. It must be a positive value less than $2,000,000.
- **Training and Development** spending is selected as a percentage of payroll dollars and can range from nothing to 10% of payroll (Huselid, 1995). An empirical range of spending is based on the 2011 Training Industry Report (2011).
- **Issue / Retire Long-term Debt** is bounded by -$1,250,000 which will bring the balance to 0, and a maximum issue of $8,000,000 which will place the firm at excessive risk according to financial theory (Brigham & Houston, 2001).

6. Building the Simulation Engine

Of the various activities in developing a business simulation, whether for use as a teaching and learning tool or as a forecasting model, the system of formulas or algorithms that comprise the simulation engine is most critical. The model must be representative of the industry being portrayed to ensure credibility (external validity), the functions must properly perform as expected (internal validity), and the interaction between decision variables and reported outcomes must be consistent with economic theory (fidelity). To ensure a simulation meets these criteria, the developer must use multinomial functions depicting the true nonlinear associations found in economic behavior (Gold, 2003). A danger is to employ linear mathematics because it is less complex to program, but once decisions are beyond a narrow range of values, the linear models become unpredictable, lack economic fidelity, and destroy the advantages of experimenting with extreme scenarios (Feinstein & Cannon 2001). In fact, a model based on linear mathematics likely will lead to players “gaming” the game (that is, making decisions on the basis of an incorrect mathematical relationship rather than on the basis of sound economic theory), therefore, missing the intended lessons entirely (Chin, Dukes, & Gamson, 2009).

For the SimWrite! engine, first the system of functions is discussed conceptually and linked to economic theory. Then each function is offered in a functional format.

The demand curve drives the simulation and is a standard nonlinear negatively sloped convex function of price and quantity demanded. The curve must respond to related input decisions such as promotion by shifting right or left with adjustments in slope or elasticity consistent with the decision. The aggregate demand curve is shaped and shifted by quality, promotion, credit policy, research and development, and training and development decisions interacting with the base demand function (Goosen, 2010). The construction of a total demand function can be multiplicative or additive. SimWrite! is modeled using an additive function to ensure better control of changing elasticities (Gold & Pray, 1982). Each of the mediating variables increment the total demand curve exponentially as directed by the nature of the function.

The mediating effect of promotion dollars and training and development dollars will follow a logistic pattern – an increasing function with two inflection points. That is, as the independent variable increases, the dependent variable (demand) will increase first at an accelerating rate and then at a decelerating rate. To explain further, initial promotion or training efforts have an increasing return as due to learning curve effects but must eventually succumb to the law of diminishing returns.

The function used to model credit policy will be an exponentially dampened function. As credit days granted increase, the impact on sales will also increase, but at a diminishing rate. The impact of research and development will be modeled using a continuous univariate Gaussian distribution that is most commonly known as the standard normal distribution (Stock & Watson, 2011). The expected or mean R & D spending is calibrated to a z score of 0. In this model, based on information from the AT Cross 10K report, new sales are expected to average 11% of total sales. A z score for actual R & D spending will be computed and incremental sales will be determined by the cumulative probability density function as defined by the normal curve. If R & D spending is greater than or less than expectations, new incremental sales will increase or decrease in correspondence to the function. Because the normal curve approaches 0 and 100% at approximately 3 standard deviations or +/- 3z, the impact of R & D will be bounded. This is an important distinction as compared to a linear R & D function that could produce infinite results.

When modeling the impact of a discrete variable such as in this case, quality, it is standard practice to use a step function or a series of linear functions – one for each discrete variable splined together. That is the approach taken here. As the quality of input materials increase, the demand curve will be shifted to the right. Greater increases will occur as quality moves from $6 to $8 than from $8 to $10.

Once the total demand is derived, the creation of the financial reports is a mechanical exercise based on accepted accounting principles. SimWrite! is based on *Financial and Managerial Accounting; the basis for business decisions* by Williams, Haka & Bettner and published by McGraw Hill (2005). Calculations used to generate the income statement, balance sheet, and selected financial performance measures presented later in this section detail each computation based on simulated operations and. in some instances, incorporate model assumptions that are identified. Because the balance sheet needs to balance, either the cash account or credit line is the adjusting entry. The formulas presented are a simple algebraic expression. Beginning measures for sales per employee, cost of equity capital, and fixed and variable cost of manufacturing and operations measures are derived from industry reports published by *BizStats (*2012*)*, *BP Plans Industry Reports (*2012*)*, *Comparisons* published by *BI Essentials (*2012*)*, and *ATX Key Statistics* (*2012*).

A data set was created using benchmark industry data to ensure external validity and that data was fitted to an appropriate function as represented in economic theory (Samuelson & Nordhaus, 2001), using standard econometric methods (Stock & Watson, 2011).

All calculations are executed in Excel™ and all Excel™ function calls are denoted by capital letters. Select screen shots are exhibited in Appendix 2. Variables are identified by name; for instance, sales price, base demand, credit days and so on. The value of function parameters are expressed as values. Order of operations are indicated by parenthesis and exponentiation is signified by the ^ symbol. This is standard mathematical notation. In those cases where a nested expression is used, the nested formulas are indented. Any assumed values are listed following the presentation of formulas.

Formulas used to create SimWrite!:

Demand = f (base demand) + f (quality) + f (promo dollars) + f (credit terms) + f(R & D spending) + f (t & d spending)

Base demand = ROUND (+ (21*sales price^2.325)-(15428*sales price) +600000, 0)

+ Quality function =ROUND (IF (material $=6, base demand * -0.25, IF (material=8, 0.05*base demand, 0.08*base demand)), 0)

+ Promo function = ROUND ((4*125)/ (4+ ((125-0)*10^ (-125*0.00125*(+promo dollars/ (sales price*base demand)*100))))/200)*base demand, 0)

+ Credit function =IF (credit days=0,-0.5*base demand, (-0.0002*credit days^2+0.0208*credit days-0.0358)*base demand)-79000

+ R & D function ==ROUND (+ (((NORMDIST (r & d spending, base r & d spending, base r & d spending *0.4, TRUE)) *0.11*beginning quantity*2) - 0.11*beginning quantity), 0)

+ T & D function =ROUND (+ (((0.05*1.2)/ (0.05+ (1.2--3)*2.71^ (-1.2*1.2*(training $ % *100))))/10)*base demand, 0)

Sales Revenue = quantity sold * sales price

Less Cost of Goods Sold = unit manufacturing cost * units sold

Unit manufacturing cost =+raw materials cost + overhead charge+1.75*(1-productivity effect). Productivity Effect = ((beginning sales / employee) – (ending sales / employee))/ (ending sales / employee)

Less Promotion Dollars

Less Research and Development Dollars

Less Other Operation Expense = ((base fixed+ (base variable*(1-productivity effect)))*sales revenue) + (average pay per employee*number of employees*training and development %) +average inventory * inventory carrying cost %

Less Interest Expense = interest rate on long-term debt *(beginning debt+ net long term borrowing)

Less Tax Expense = If (before tax income >0, before tax income * effective tax rate, 0)

Equals Net Income

Cash = IF (equity + Long-term debt + accounts payable >total fixed assets +inventory +accounts receivable, (equity +long-term debt + accounts payable - total fixed assets – inventory - accounts receivable), 0)

Accounts Receivable = IF (credit days=0, 0, ROUND (+sales revenue/ (360/credit days), 0))

Inventory = ROUND (+MAX (0, (units produced – units sold)*units manufacturing cost), 0)

Total Fixed Assets = =ROUND (+fixed assets/cost of goods sold turnover rate * unit manufacturing cost * units produced, 0)

Total Assets = cash + accounts receivable + inventory + total fixed assets

Credit Line = =MAX (+total assets-accounts payable-long-term debt-equity,0)

Accounts Payable = 0.5*cost of goods sold

Long-term debt =base long-term debt + net long-term borrowing

Total Equity = beginning equity +net income

Number of Employees = ROUND (+sales revenue/sales per employee, 0)

Sales per Employee = ((base sales + quality sales + credit period sales + r & d sales) * sales price) / base number of employees

Profit Margin = net income / sales revenue

Return on Assets = net income / total assets

Economic Profit = net income – ((total assets – current liabilities) * cost of equity capital)

Market Value = ((+equity/ equity + total liabilities)*cost of equity capital) + ((((equity + total liabilities + equity)/ equity + total liabilities))*after tax cost of long-term debt)

Model Assumptions

Base Cost of Goods Sold = 45%

Unit Cost = material cost + applied overhead + direct labor

Material Cost = decision variable

Applied Overhead = $1.50 per unit

Direct Labor Cost = $1.75 per unit

Fixed Operating Expense = 20% of base revenue

Variable Operating Expense = 15% of total revenue

Interest Rate on Long-term Debt = 4%

Interest Rate on Short-term Debt = 6%

Effective Tax Rate = 25%

Fixed Asset to Cost of Goods Sold Turnover Rate = 1.33

Cost of Equity Capital = 8%

Average Pay per Employee = $50,000

Finally, it is worth noting that the engine has been created with the intention that students are interacting with the computer in what has been labeled a stand-alone or solo play simulation (Gosenpud, Bush, & Scott, 1995). This form of play is consistent with the the General Framework for Effective Simulation Development; that is, students should play against a programmed smart competitor rather allow other novices (learners) to drive the simulation engine.

The simulation engine is also deterministic; that is, no randomness is built into the model. Chapter Two discussed the advantages of a deterministic simulation as opposed to a stochastic model and is an important element in the General Framework for Effective Simulation Development.

7. Development of an embedded Decision Support System

It is assumed that users of a business simulation are not necessarily familiar with concepts and terminology prior to playing, but it is expected they will acquire this knowledge during the course of play. Good interface design anticipates when supporting information will be called for. SimWrite! incorporates this principle by creating a glossary of terms and access to graphical economic concept/theory embedded in the design. The glossary of terms below was written by this author and published in earlier proprietary and public simulations (The Sim Series, 2003-2005). Similar definitions and explanations can be found in standard economics, accounting, and finance texts.

Glossary

Accounts Payable	Accounts Payable - The value of interest-free trade credit extended by your vendors.
Accounts Receivable	Accounts Receivable - Dollars owed to a firm by customers as a result of credit sales. Accounts Receivable is valued on the basis of net realizable value–the amount that likely will be collected. This total is impacted by the credit policy indicated on your decision page.
Balance Sheet	Balance Sheet - A financial statement that summarizes a firm's assets, liabilities, and owner's equity at a given point in time.
Cash	Cash - Coin and currency held by a firm plus checking account balances. Some short-term highly liquid investments such as Treasury Bills are considered to be cash equivalents.
Cost of Goods Sold	Cost of Goods Sold (COGS) – The cost to manufacture goods that are sold during an accounting period. COGS for a manufacturer are the direct labor, direct materials, and manufacturing overhead.
Credit Line	Credit Line - If there is a cash deficit, the amount borrowed at a 4% interest rate.
Economic Profit	Economic Profit - The after tax operating profits minus the cost of capital. Essentially, this measure is the difference between what a business earned and what it should earn. If the return on capital exceeds the cost of capital, the business is using capital wisely and creating shareholder value, thus it is a measure closely linked with stock price. Economic Profit is also known as Economic Value Added (EVA).
Equity	Equity - The owner's stake in the business. Owner's equity is comprised of their direct investment in the business (capital stock) plus undistributed profits (retained earnings).
Income Statement	Income Statement - A financial statement that reports revenues and expenses and shows the profitability of a business for a stated time period. The Income Statement is sometimes referred to as the P & L (profit and loss statement).
Interest Expense	Interest Expense - The charges incurred during the income statement period on interest bearing loans and notes. These costs are reported separately from normal operating expenses.
Inventory	Inventory - Goods held for resale by a retailer or distributor. A manufacturer will list raw materials, the value of work in

	process, plus finished goods. Inventory is valued at historical cost or market value – whichever is lower.
Long-term Debt	Long-term Liabilities - Debts that the principal amount need to be paid back over periods greater than 1 year. Long-term liabilities are valued at present value and not the sum of future payments. Long-term debt is generally incurred as initial capitalization of the firm or to finance growth opportunities.
Market Value	Market Value - derived by discounting Net Income by the Cost of Capital in perpetuity less the present value of expected risk related losses due to excessive leverage.
Net Income	Net Income - The remaining profit after all expenses (cost of goods sold, operating expenses, interest, special charges, and taxes) are subtracted. Net Income and Profit are the same thing. When net income is expressed as a percentage of revenue it is known as net profit margin or return on sales.
Other Operating Expense	Operating Expenses –Expenses other than cost of goods sold incurred in the operation of the business. Included are general expenses (rents, insurance payments, office supplies), and administrative expenses (salaries for executives, accountants, office support, etc.). Sometimes these expenses are classified as sales, general and administrative expenses (S,G & A).
Profit Margin	Profit Margin - The ratio of Net Income to Sales Revenue.
Research and Development	Research and Development - dollars spent on new product development.
Return on Assets	Return on assets (ROA) is the net income or profit derived from each dollar invested in assets and is sometimes referred to as return on investment (ROI). Return on assets is calculated by dividing net income into total assets.
Sales and Promotion	Sales and Promotion Expense - the dollars spent on advertising.
Sales Revenue	Sales Revenue - Inflow of assets (usually cash or accounts receivable) generated by the sale of goods and services (note: not the sale of fixed assets). Revenue is recognized on the financial statements at the time ownership of the goods is transferred (usually when shipped) or when the service is rendered. “Net sales” or just “sales” is often substituted on the income statement for revenue.
Tax Expense	Tax Expense - The total federal, state, and local income taxes owed on the business profits. For this simulation it is assumed to be 25% of before tax income.
Total Assets	Assets - Things of value a firm owns. Assets are grouped in 3 ways. Current assets, long-term or fixed assets, and intangible assets. Assets are valued on the basis of historical cost or market – whichever is lower.
Total Current Assets	Total Current Assets - Cash + Accounts Receivable + Inventories. It is expected these assets will be exist for less than one year.

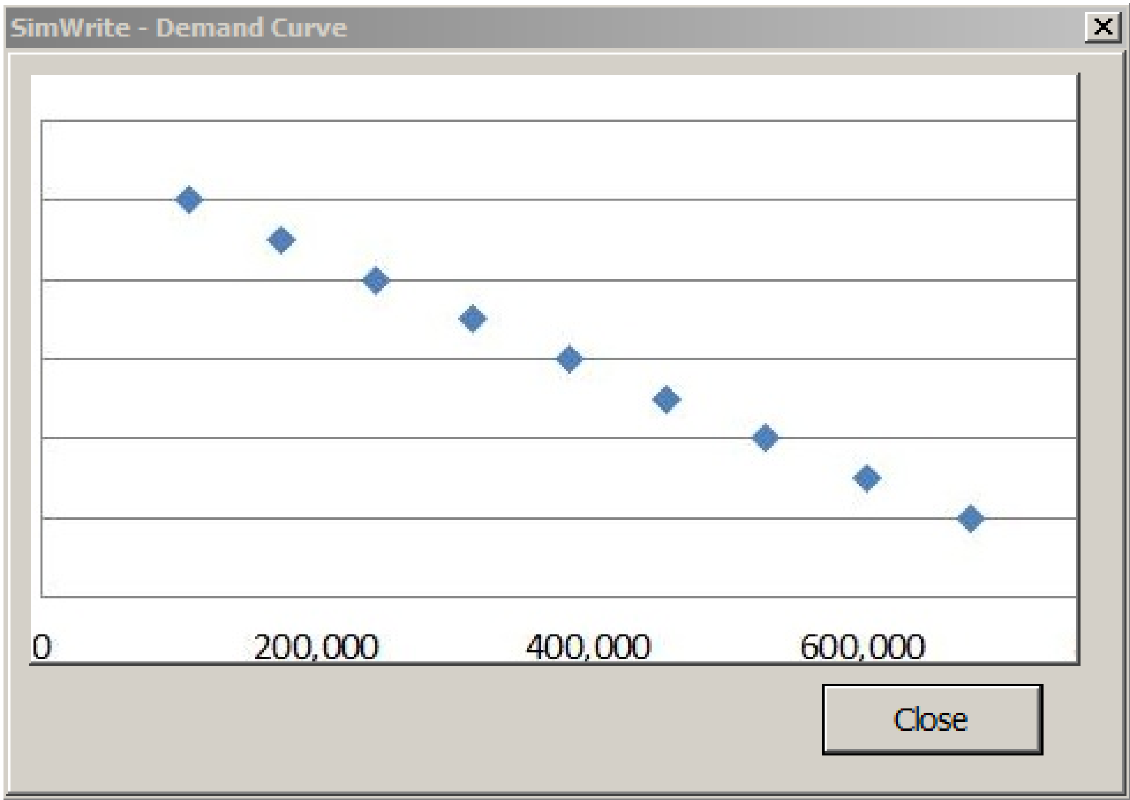
Total Current Liabilities	Current Liabilities - Short-term (less than 1 year) debts or payments a firm is obligated to pay. The bulk or current assets are likely to include accounts payable (generally dollars owed suppliers), taxes owed, and wages payable.
Total Fixed Assets	Fixed Assets - Assets that are not consumed during a one year period and are valuable in the production, sale and distribution of products and services, and are needed for the operation of the firm. Most fixed assets will be categorized as property, plant, and equipment.

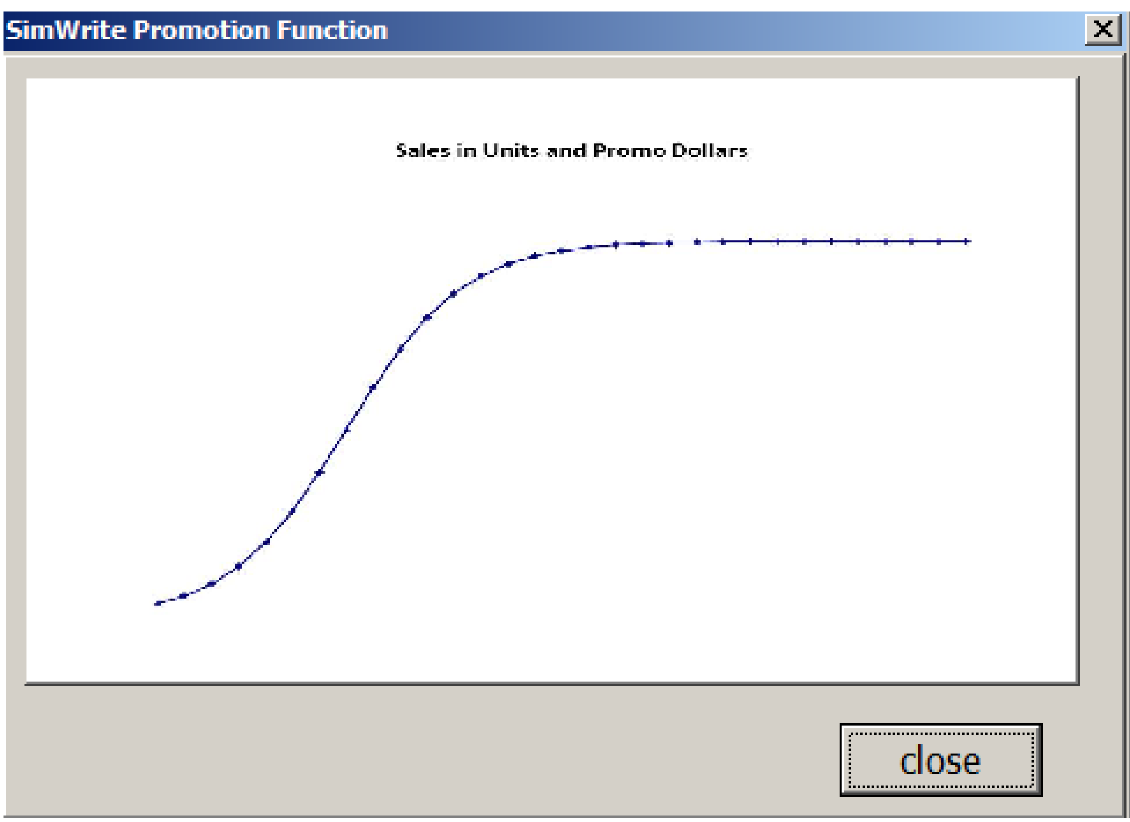
The entire glossary can be accessed at any time via a command button on the main menu. A combo box control is also available within the simulation to view a single term.

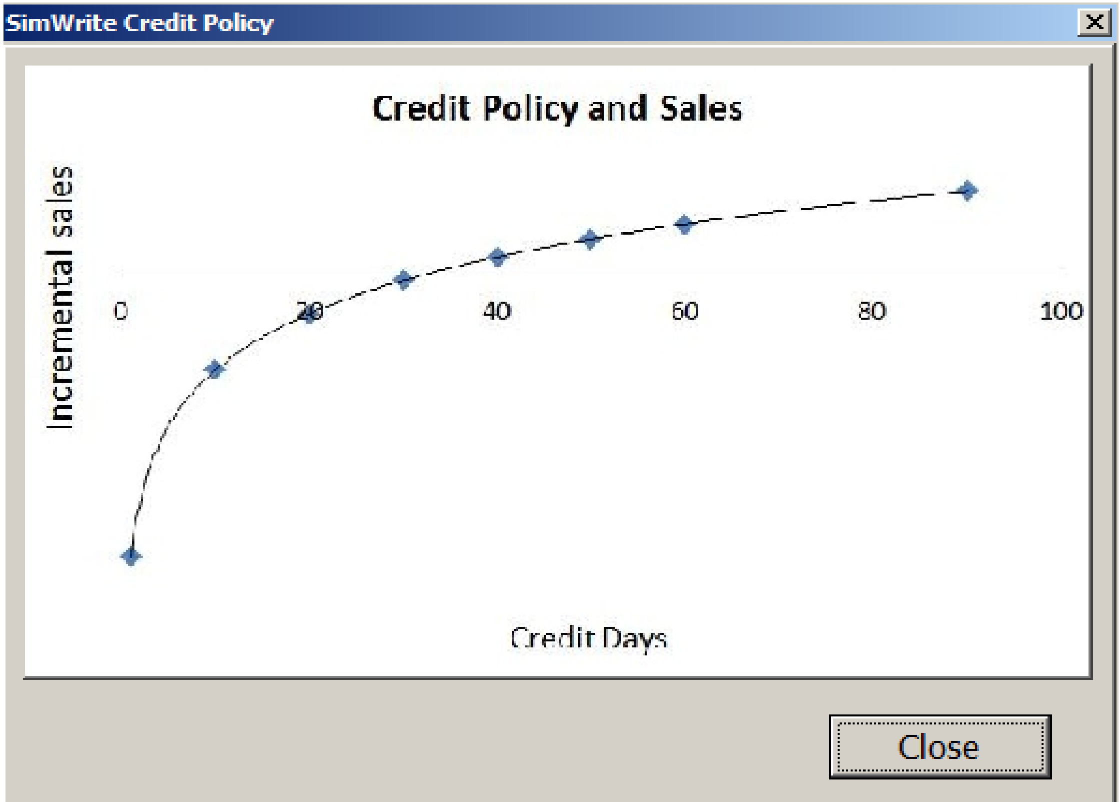
In addition to descriptive terms, a submenu is available with SimWrite! that includes a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, and a view of key variable associations to aid decision making. Below are screen shots of the submenu and the corresponding visuals.

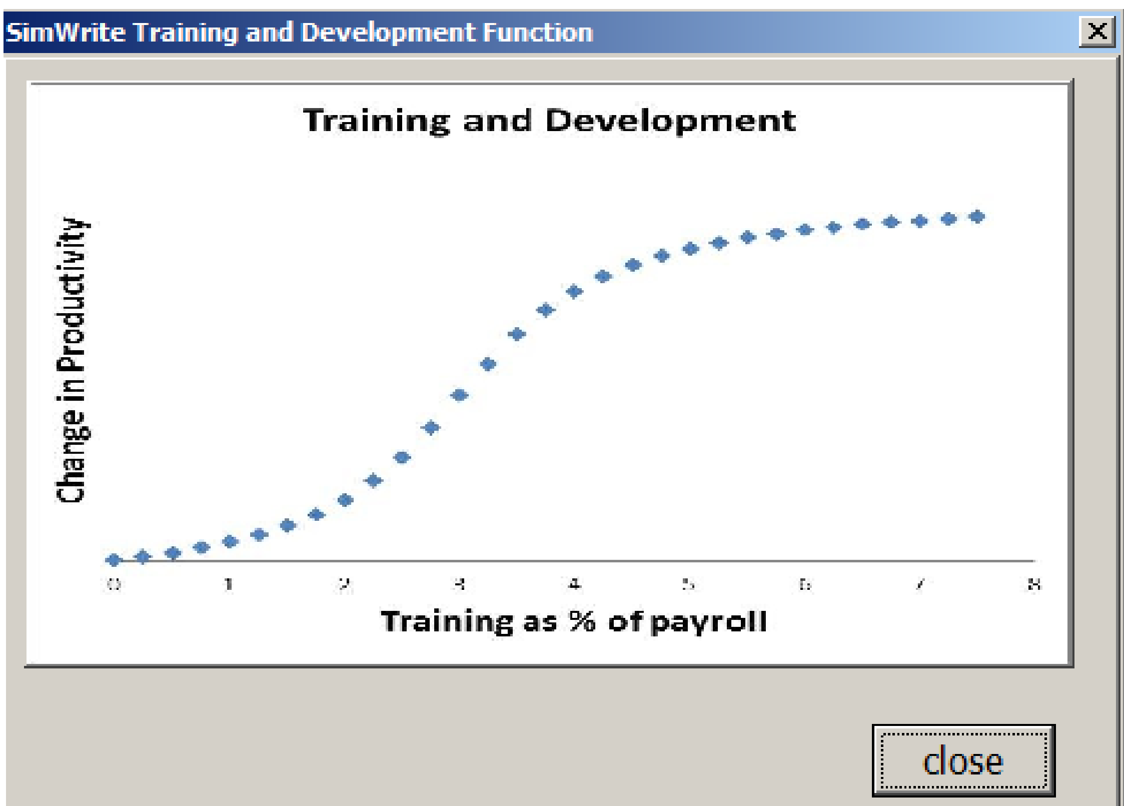

SimWrite! - help with decisions
SWOT
Demand
Promotions
Credit Days
Training
R & D
Market Value
Close

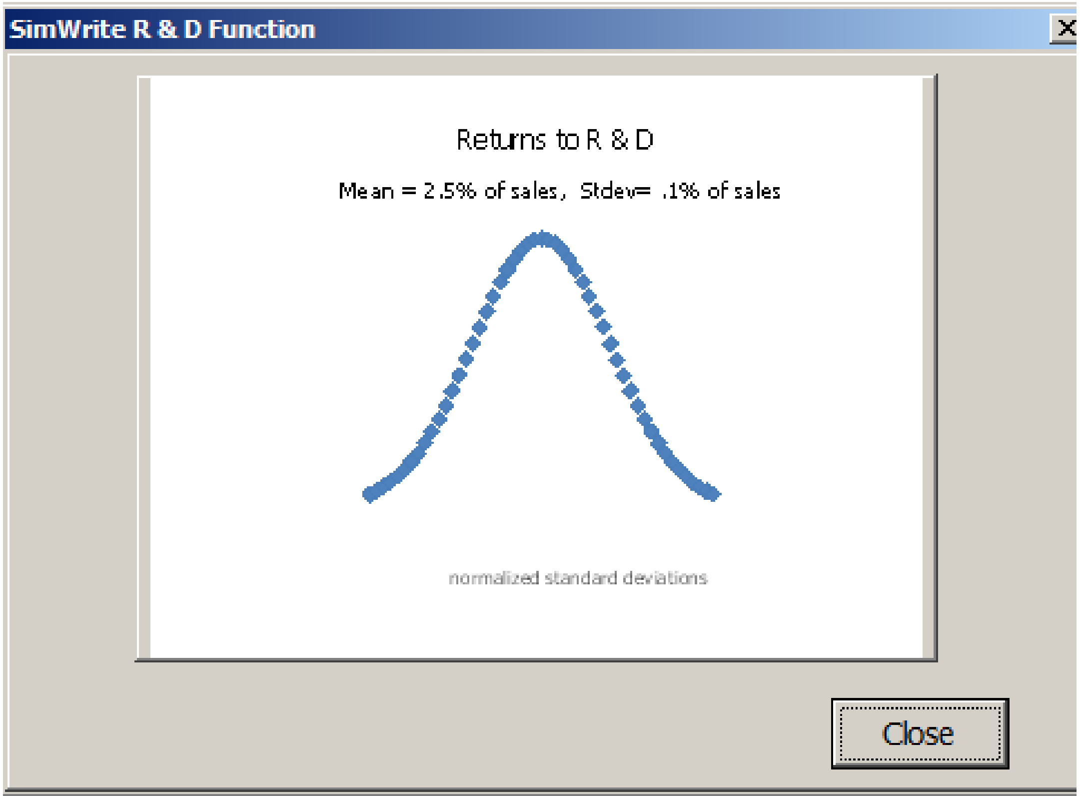

Penn's Pens Inc. SWOT Analysis
Strengths
Weaknesses
Quality products
Low Return on Assets
Loyal customers
Low productivity
Strong liquidity
Opportunities
Threats
Grow market share
Possible decrease in pen useage due to tablet computing
Improve productivity with training
Large competitors
New product development
Borrowing capacity
Close

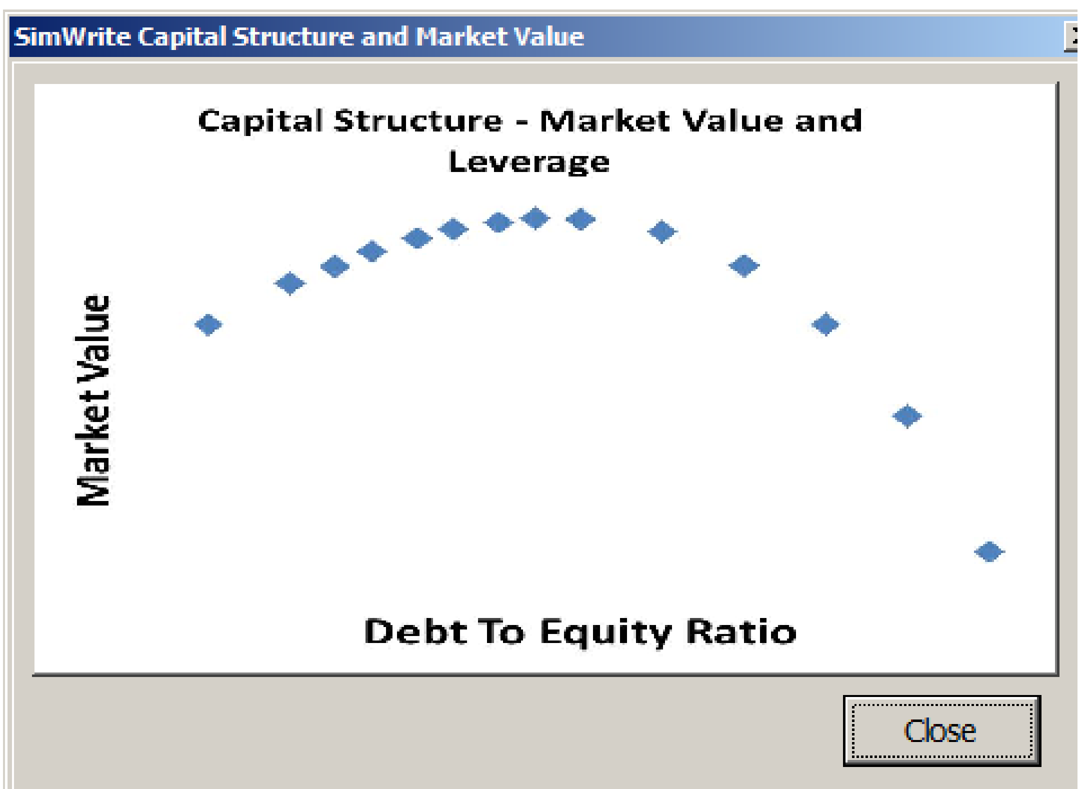

SimWrite - Demand Curve
0
200,000
400,000
600,000
Close


SimWrite Promotion Function
Sales in Units and Promo Dollars
close


SimWrite Credit Policy
Credit Policy and Sales
Incremental sales
0
20
40
60
80
100
Credit Days
Close


SimWrite Training and Development Function
Training and Development
Change in Productivity
Training as % of payroll
close


SimWrite R & D Function
Returns to R & D
Mean = 2.5% of sales, Stdev= .1% of sales
normalized standard deviations
Close


SimWrite Capital Structure and Market Value
Capital Structure - Market Value and Leverage
Market Value
Debt To Equity Ratio
Close

8. Construction of a Report Module

An important element of the g the General Framework for Effective Simulation Development is immediate and contextual results and feedback. Upon submitting the decision set in SimWrite!, the simulation engine processes outcomes and a results screen opens. A standard balance sheet and income statement is rendered that includes the current period results next to the base period figures. The statements are both normalized with income statement accounts expressed as a percentage of sales revenue and the balance sheet accounts shown as a percentage of total assets. Industry averages are reported for select income statement and balance sheet accounts.

Other measures included for both the prior period and current period are the number of employees, sales per employee, units sold, profit margin, return on assets, economic profit, and market value. These measures have been selected due to their ubiquity in financial management, (Berman, Knight, & Case, 2006) and because they are established in the scenario as game goals.

The results page includes a panel reporting the actual goal measures (net income growth, market value growth, profit margin, return on assets, and economic profit) and targeted goal measures. For each goal measure a graphic is displayed comparing performance to goal and successful performance indicators are highlighted in yellow.

Careful consideration was given to balancing the quantity of information and comfort for a novice in digesting it. Isolating the six summary measures into a panel that includes graphics conforms to the requirements of the General Framework for Effective Simulation Development. Used parsimoniously, colors and graphics can be effective communication devices and this presentation conforms to the screen density and granularity heuristics presented in Chapter Two.

9. Creation of the Leaderboard

Simulations are often played competitively and students enjoy comparing their results to others. SimWrite! has been designed with a replay option, an element established with the the General Framework for Effective Simulation Development. Many students like to keep track of their results over time and strive for a personal best. This trait is exhibited by players of video games, arcade games, and harkens back to the days of bowling alley pinball (McGonigal, J. (2011). Thus, a leaderboard has been designed as a unique feature that is exclusive to SimWrite! only.

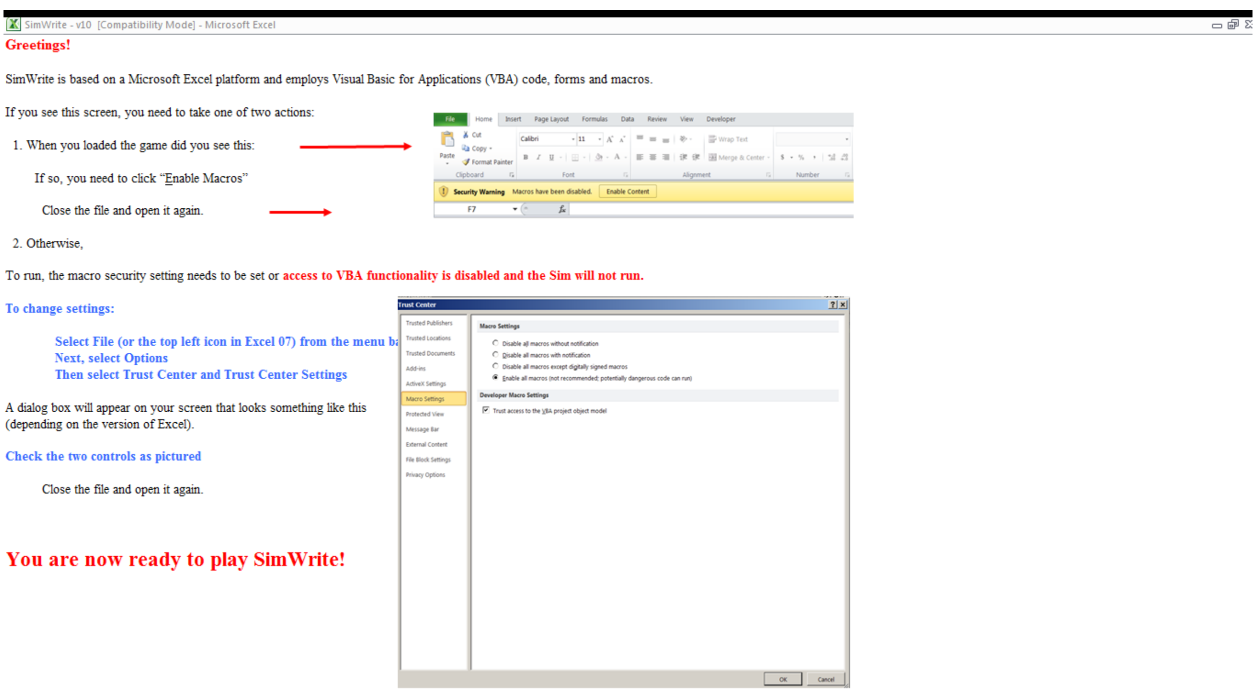
The leaderboard captures play history from an underlying database. The player may elect to add results from any play to the leaderboard by clicking an option button. The database can then be viewed at any time via the navigation interface. By default, the database is sorted chronologically, from most recent to most distant. Players can also sort by decision variable (units produced, quality, price, credit terms, R & D spending, training and development spending, and capital structure decisions) or outcome variable (units sold, net income, revenue, market value, profit dollars, and economic profit). The player also has an option to clear the database and collect new records.

In addition, the data collected from a history of game records has research value. By analyzing a time series of outcomes, learning patterns emerge that will differ by student, facilitator, and other environmental factors. While the purpose of this dissertation t is not to suggest new research projects, the database generated by this, or any simulation, can provide a useful data set.

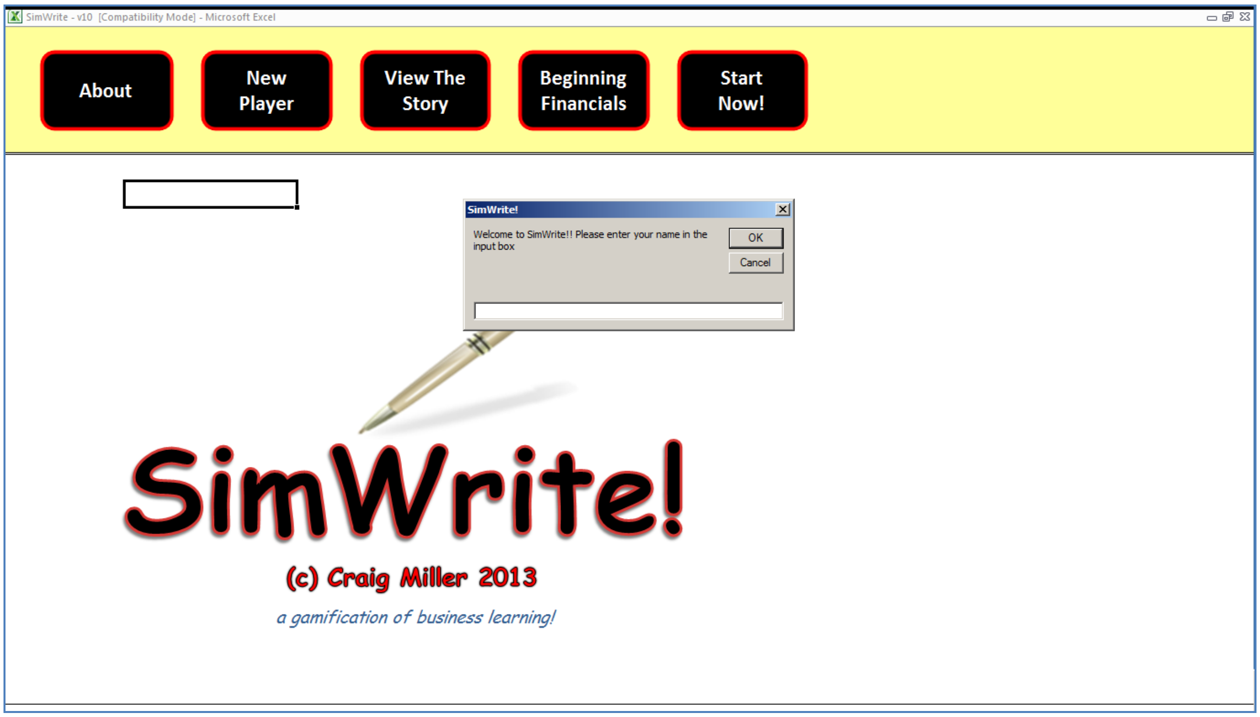
10. The Finished Interface and Navigation

In this final section, SimWrite! is presented in a series of step-by-step screen shots. SimWrite! in its entirety represents a pedagogically sound simulation that is consistent with the General Framework for Effective Simulation Development.

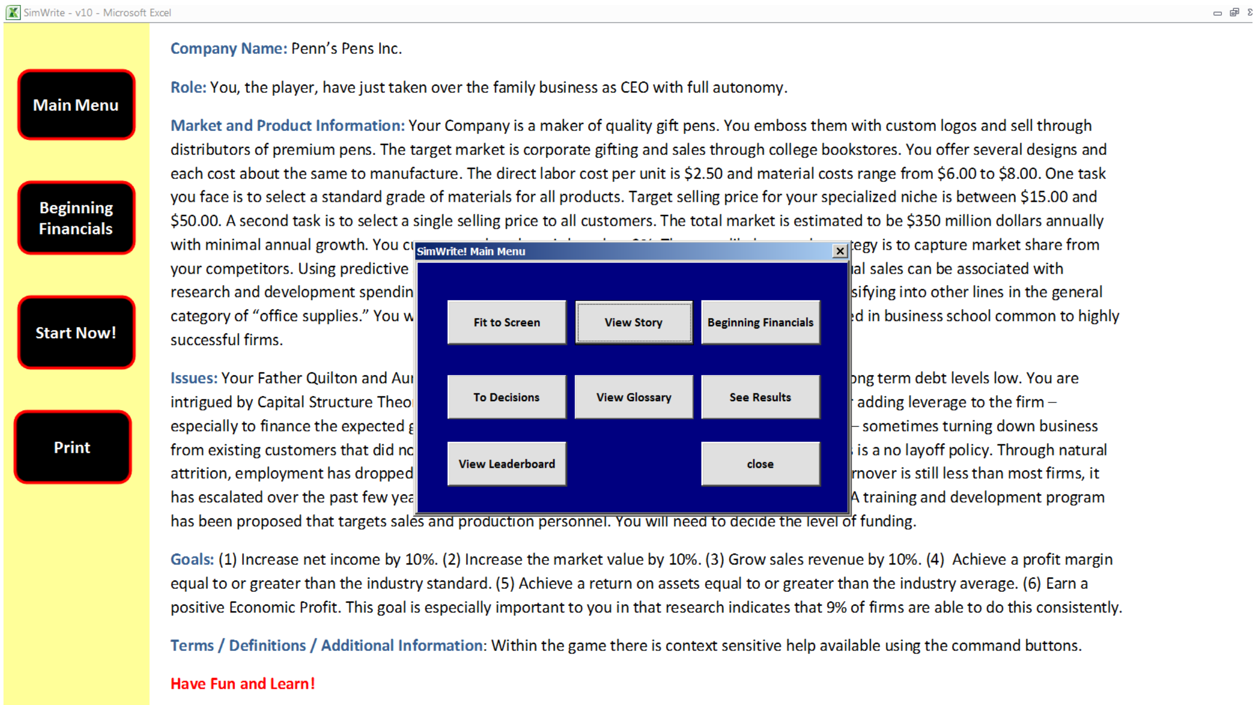
The simulation opens with the statement that SimWrite! requires Microsoft Excel version XP or higher and macro commands enabled with access to Visual Basic for Applications (VBA). Upon launching the simulation, if these conditions are not met, the screen below will appear providing the player instructions for enabling the macros and VBA component.



The game then opens with this screen and includes code that clears the Excel interface, optimizes the screen resolution for all display devices, and includes a login screen for the player to identify him or herself, or the name of their team. The opening screen also establishes the simulation "look and feel." Throughout the game, navigation will be driven by command buttons such as pictured here – consistently sized with black fill, white text, a red border, contained in a dull yellow panel. The command buttons are ordered according to expected flow from left to right or from top to bottom. Likely, a new player will want to view the story.



The nature and intention of the story has been discussed earlier. First-time players may want to print the story for reference and will likely proceed to the beginning financials. If a player "gets lost" during play, each screen includes a main menu.


SimWrite - v10 - Microsoft Excel

Main Menu

Beginning Financials

Start Now!

Print

Company Name: Penn's Pens Inc.

Role: You, the player, have just taken over the family business as CEO with full autonomy.

Market and Product Information: Your Company is a maker of quality gift pens. You emboss them with custom logos and sell through distributors of premium pens. The target market is corporate gifting and sales through college bookstores. You offer several designs and each cost about the same to manufacture. The direct labor cost per unit is $2.50 and material costs range from $6.00 to $8.00. One task you face is to select a standard grade of materials for all products. Target selling price for your specialized niche is between $15.00 and $50.00. A second task is to select a single selling price to all customers. The total market is estimated to be $350 million dollars annually with minimal annual growth. You cu ... egy is to capture market share from your competitors. Using predictive ... al sales can be associated with research and development spendin ... sifying into other lines in the general category of "office supplies." You w ... d in business school common to highly successful firms.

Issues: Your Father Quilton and Au ... ong term debt levels low. You are intrigued by Capital Structure Theo ... adding leverage to the firm – especially to finance the expected ... – sometimes turning down business from existing customers that did n ... is a no layoff policy. Through natural attrition, employment has dropped ... rnover is still less than most firms, it has escalated over the past few ye ... A training and development program has been proposed that targets sales and production personnel. You will need to decide the level of funding.

Goals: (1) Increase net income by 10%. (2) Increase the market value by 10%. (3) Grow sales revenue by 10%. (4) Achieve a profit margin equal to or greater than the industry standard. (5) Achieve a return on assets equal to or greater than the industry average. (6) Earn a positive Economic Profit. This goal is especially important to you in that research indicates that 9% of firms are able to do this consistently.

Terms / Definitions / Additional Information: Within the game there is context sensitive help available using the command buttons.

Have Fun and Learn!

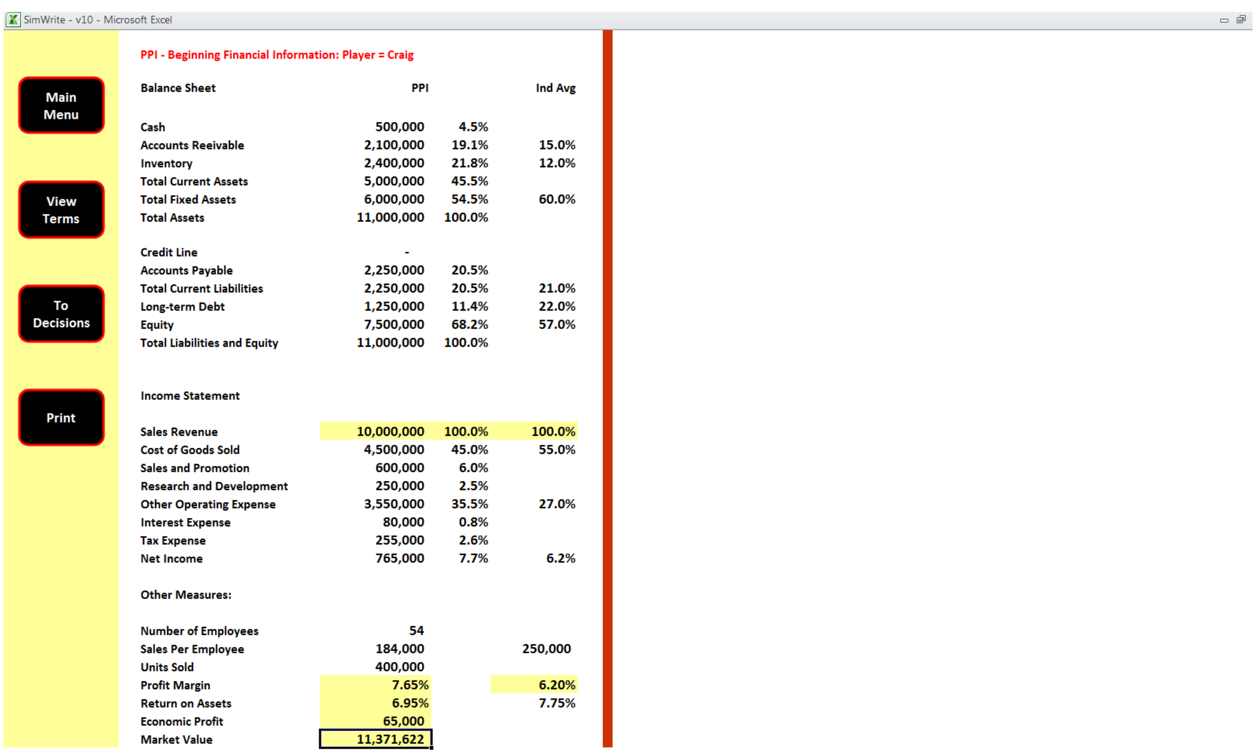
SimWrite! Main Menu

Fit to Screen | View Story | Beginning Financials

To Decisions | View Glossary | See Results

View Leaderboard | close

The beginning financials screen includes many terms that may be new to a student.


SimWrite - v10 - Microsoft Excel

Main Menu

View Terms

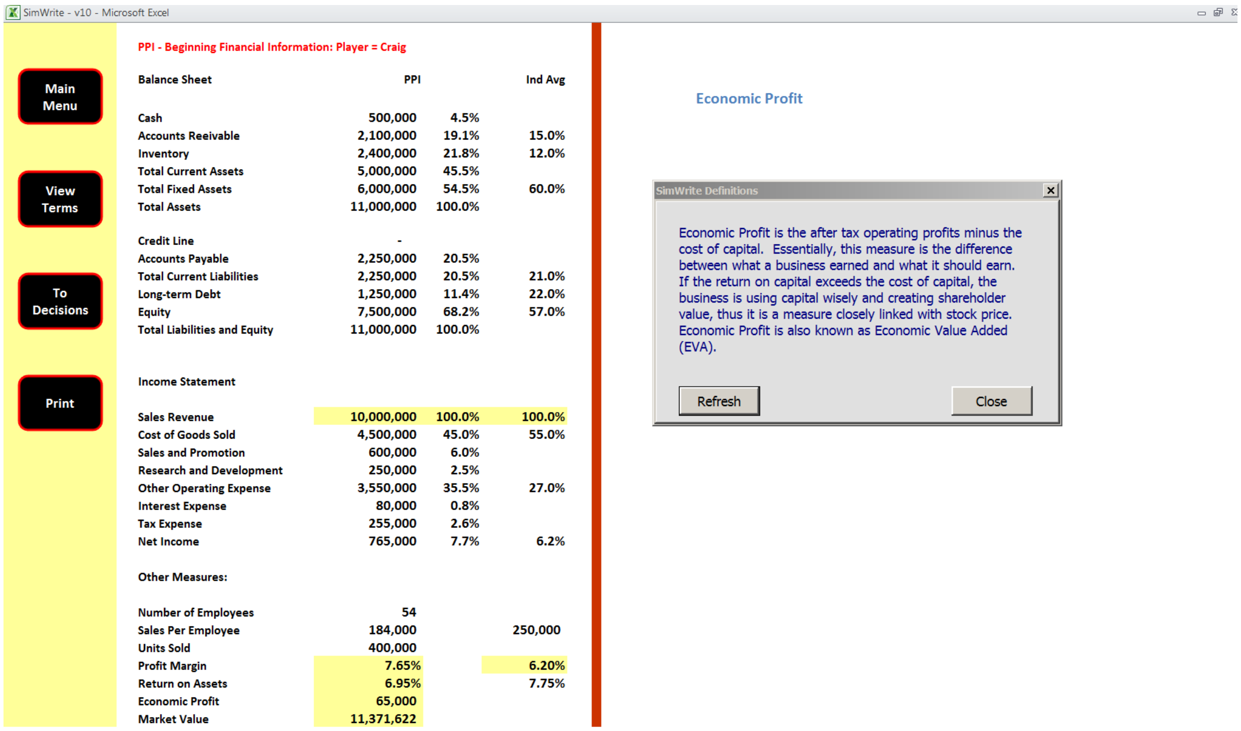
To Decisions

Print

PPI - Beginning Financial Information: Player = Craig

Balance Sheet	PPI		Ind Avg
Cash	500,000	4.5%	
Accounts Reeivable	2,100,000	19.1%	15.0%
Inventory	2,400,000	21.8%	12.0%
Total Current Assets	5,000,000	45.5%	
Total Fixed Assets	6,000,000	54.5%	60.0%
Total Assets	11,000,000	100.0%	
Credit Line	-		
Accounts Payable	2,250,000	20.5%	
Total Current Liabilities	2,250,000	20.5%	21.0%
Long-term Debt	1,250,000	11.4%	22.0%
Equity	7,500,000	68.2%	57.0%
Total Liabilities and Equity	11,000,000	100.0%	
Income Statement			
Sales Revenue	10,000,000	100.0%	100.0%
Cost of Goods Sold	4,500,000	45.0%	55.0%
Sales and Promotion	600,000	6.0%	
Research and Development	250,000	2.5%	
Other Operating Expense	3,550,000	35.5%	27.0%
Interest Expense	80,000	0.8%	
Tax Expense	255,000	2.6%	
Net Income	765,000	7.7%	6.2%
Other Measures:			
Number of Employees	54		
Sales Per Employee	184,000		250,000
Units Sold	400,000		
Profit Margin	7.65%		6.20%
Return on Assets	6.95%		7.75%
Economic Profit	65,000		
Market Value	11,371,622		

By clicking the “View Terms” command button, a dialog box with a combo control will appear enabling them to scroll through glossary terms and see a definition.



Balance Sheet	PPI		Ind Avg
Cash	500,000	4.5%	
Accounts Reeivable	2,100,000	19.1%	15.0%
Inventory	2,400,000	21.8%	12.0%
Total Current Assets	5,000,000	45.5%	
Total Fixed Assets	6,000,000	54.5%	60.0%
Total Assets	11,000,000	100.0%	
Credit Line	-		
Accounts Payable	2,250,000	20.5%	
Total Current Liabilities	2,250,000	20.5%	21.0%
Long-term Debt	1,250,000	11.4%	22.0%
Equity	7,500,000	68.2%	57.0%
Total Liabilities and Equity	11,000,000	100.0%	
Income Statement			
Sales Revenue	10,000,000	100.0%	100.0%
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Sales and Promotion	600,000	6.0%	
Research and Development	250,000	2.5%	
Other Operating Expense	3,550,000	35.5%	27.0%
Interest Expense	80,000	0.8%	
Tax Expense	255,000	2.6%	
Net Income	765,000	7.7%	6.2%
Other Measures:			
Number of Employees	54		
Sales Per Employee	184,000		250,000
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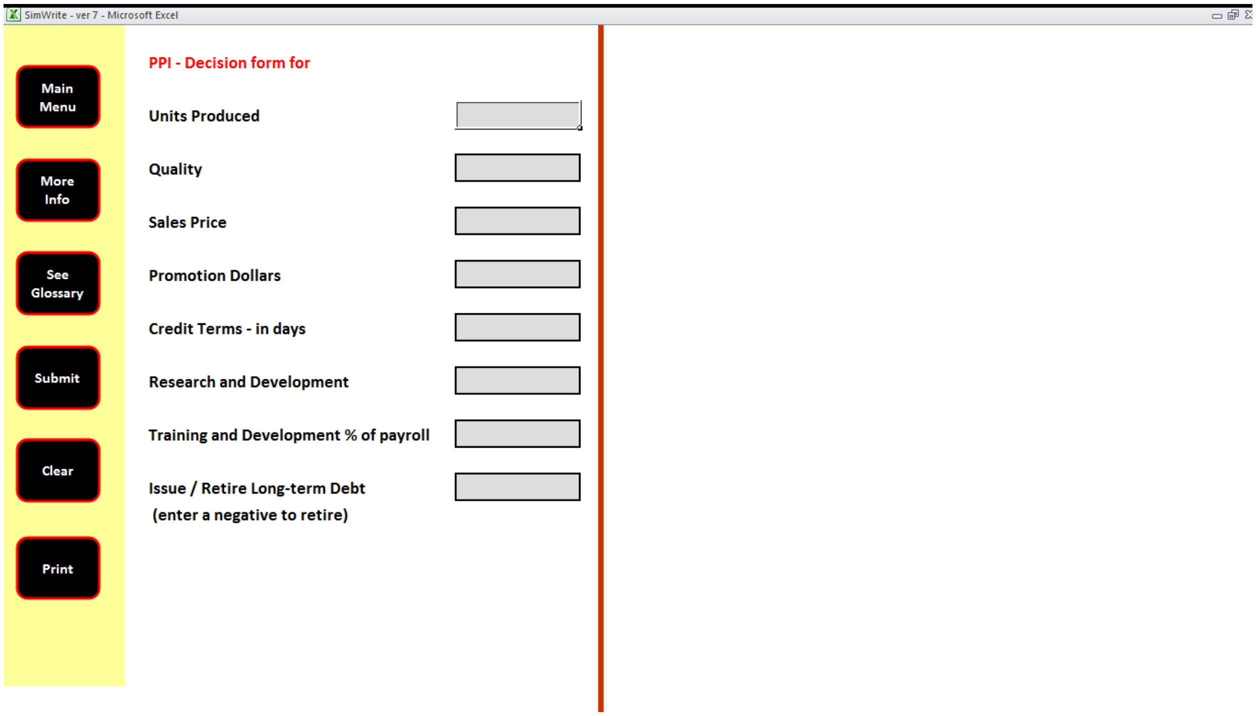
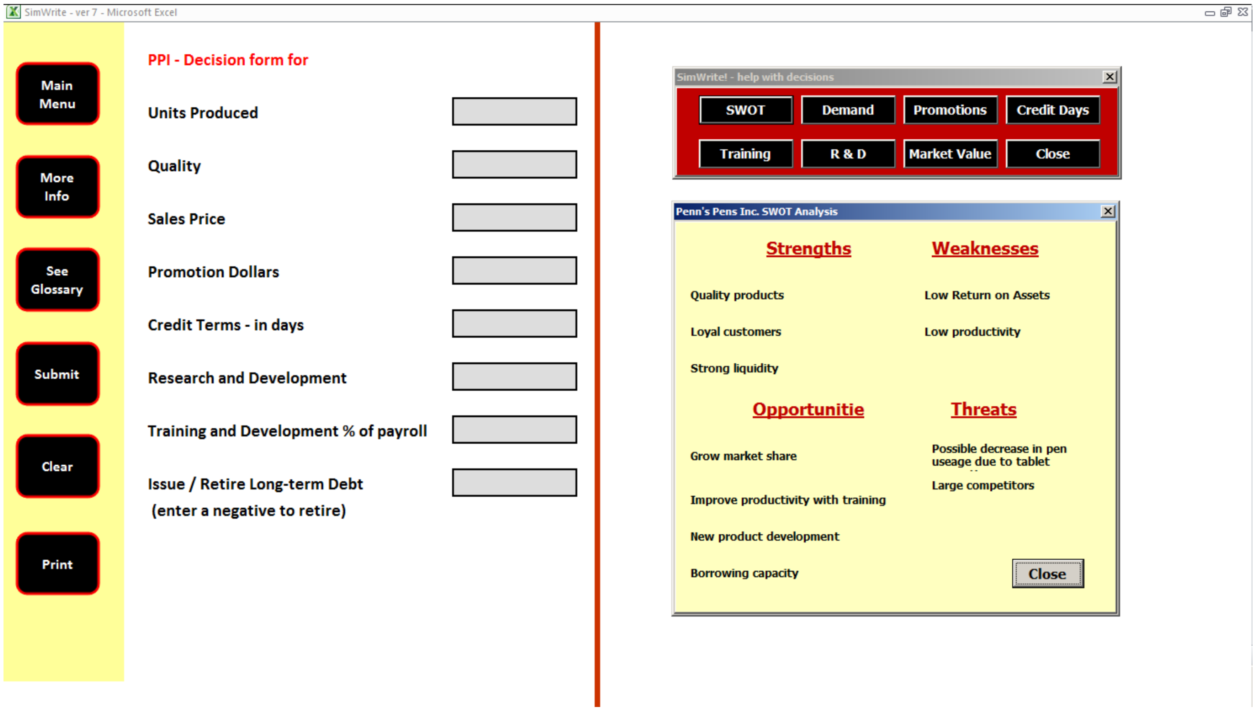
Return on Assets	6.95%		7.75%
Economic Profit	65,000		
Market Value	11,371,622		

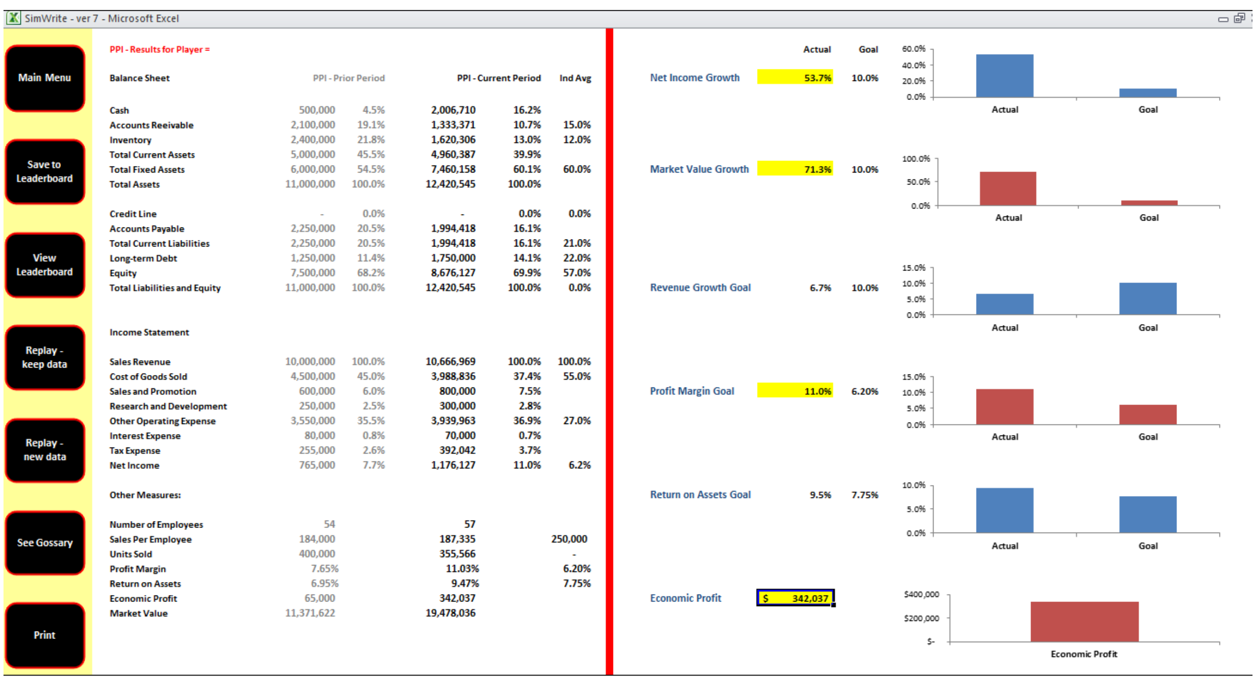
Next, a student will likely wish to navigate to the decision screen. Each input cell is validated to ensure reasonable entries. If a student enters an invalid item, such as a negative value for units produced, or an unavailable materials value in the quality cell, that entry will be rejected and a dialog box will indicate the range of values that are allowed.



Students will draw on existing knowledge when making decisions such as those above and build that knowledge through experimentation as they replay the decisions. Some will have been exposed to economic theory in prior course work but others may be learning theory as they play the game. For those players that are unfamiliar with basic economic associations, those that require some remediation, or those looking for a refresher, a command button opens a submenu that will provide helpful contextual information. For example, by clicking “more info” and “SWOT,” the following screen shot appears.

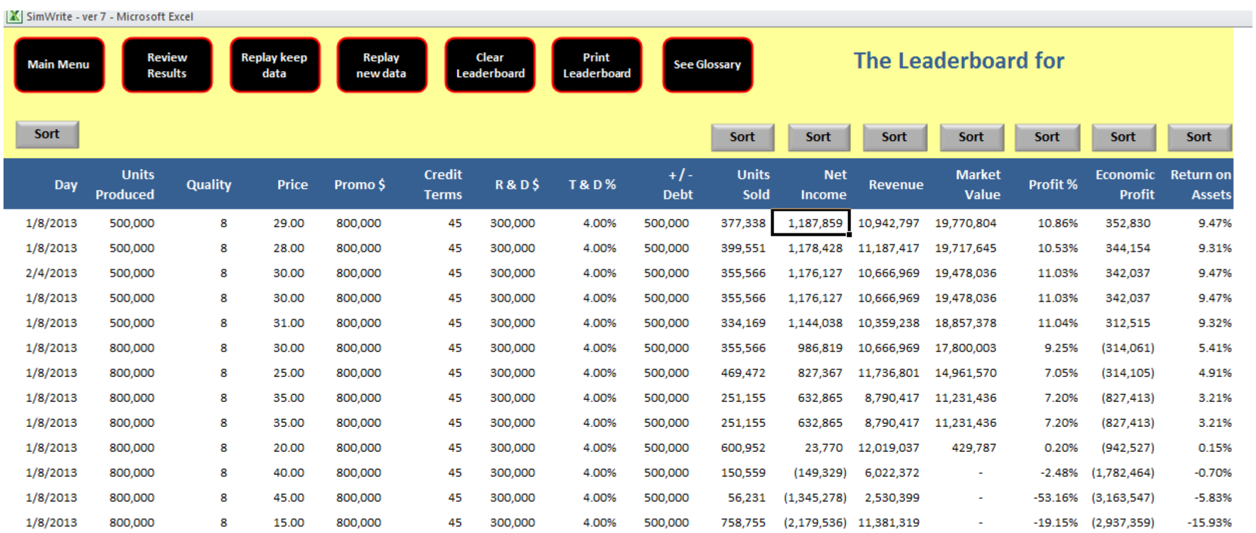


The “submit” command button will process the simulation and move to the next screen.



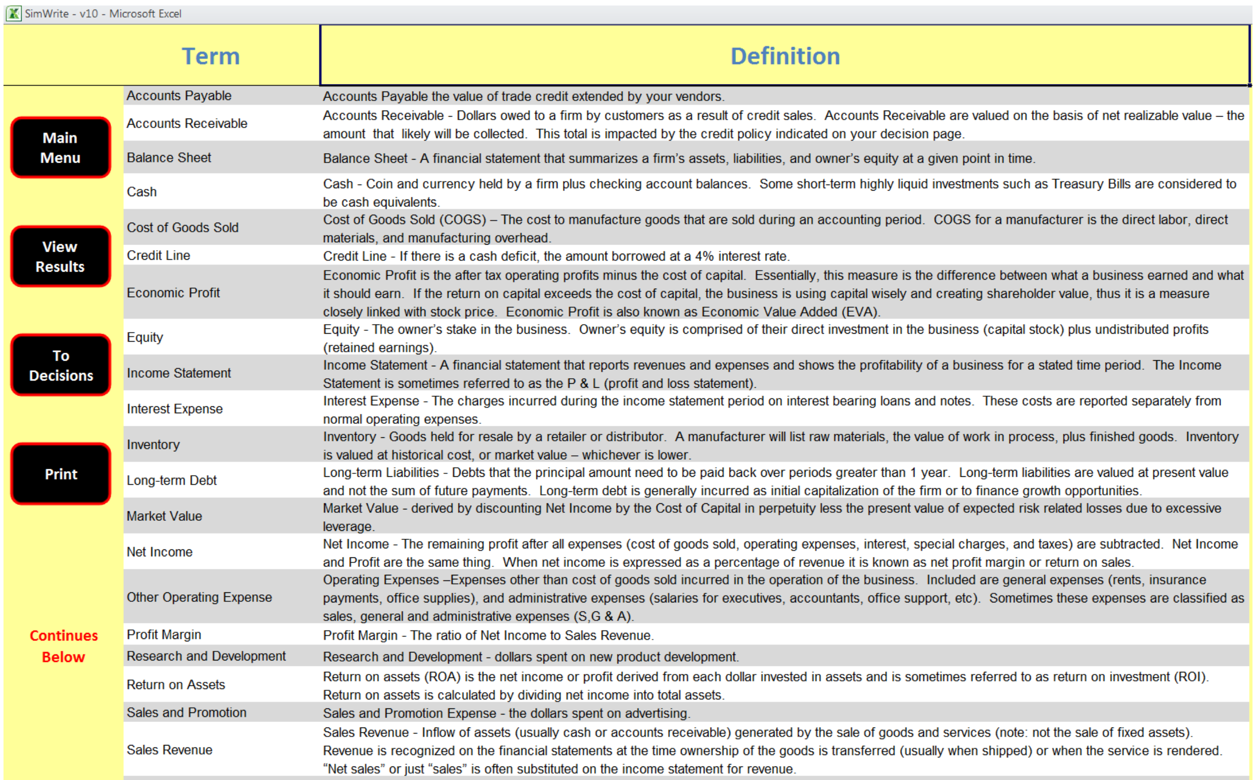
The results screen informs the player of the outcome – did they win or lose? If desired, the game can be stored in a database by clicking "save to the leaderboard." Players also have two options to replay, one by modifying current decisions and the other by starting over.

It is expected that students will periodically review their performance over time and the leaderboard will provide a means to assess and analyze performance and hopefully identify patterns of economic behavior. The leaderboard can be sorted on each performance variable as well as chronological time played. The command buttons provide options to view details of the most recent play in addition to other options.



Day	Units Produced	Quality	Price	Promo $	Credit Terms	R & D $	T & D %	+ / - Debt	Units Sold	Net Income	Revenue	Market Value	Profit %	Economic Profit	Return on Assets
1/8/2013	500,000	8	29.00	800,000	45	300,000	4.00%	500,000	377,338	1,187,859	10,942,797	19,770,804	10.86%	352,830	9.47%
1/8/2013	500,000	8	28.00	800,000	45	300,000	4.00%	500,000	399,551	1,178,428	11,187,417	19,717,645	10.53%	344,154	9.31%
2/4/2013	500,000	8	30.00	800,000	45	300,000	4.00%	500,000	355,566	1,176,127	10,666,969	19,478,036	11.03%	342,037	9.47%
1/8/2013	500,000	8	30.00	800,000	45	300,000	4.00%	500,000	355,566	1,176,127	10,666,969	19,478,036	11.03%	342,037	9.47%
1/8/2013	500,000	8	31.00	800,000	45	300,000	4.00%	500,000	334,169	1,144,038	10,359,238	18,857,378	11.04%	312,515	9.32%
1/8/2013	800,000	8	30.00	800,000	45	300,000	4.00%	500,000	355,566	986,819	10,666,969	17,800,003	9.25%	(314,061)	5.41%
1/8/2013	800,000	8	25.00	800,000	45	300,000	4.00%	500,000	469,472	827,367	11,736,801	14,961,570	7.05%	(314,105)	4.91%
1/8/2013	800,000	8	35.00	800,000	45	300,000	4.00%	500,000	251,155	632,865	8,790,417	11,231,436	7.20%	(827,413)	3.21%
1/8/2013	800,000	8	35.00	800,000	45	300,000	4.00%	500,000	251,155	632,865	8,790,417	11,231,436	7.20%	(827,413)	3.21%
1/8/2013	800,000	8	20.00	800,000	45	300,000	4.00%	500,000	600,952	23,770	12,019,037	429,787	0.20%	(942,527)	0.15%
1/8/2013	800,000	8	40.00	800,000	45	300,000	4.00%	500,000	150,559	(149,329)	6,022,372	-	-2.48%	(1,782,464)	-0.70%
1/8/2013	800,000	8	45.00	800,000	45	300,000	4.00%	500,000	56,231	(1,345,278)	2,530,399	-	-53.16%	(3,163,547)	-5.83%
1/8/2013	800,000	8	15.00	800,000	45	300,000	4.00%	500,000	758,755	(2,179,536)	11,381,319	-	-19.15%	(2,937,359)	-15.93%

The glossary view will most likely be selected from the decisions and results screens. A command button allows the player to return to those screens. A command button will print the entire glossary as a formatted document.



Term	Definition
Accounts Payable	Accounts Payable the value of trade credit extended by your vendors.
Accounts Receivable	Accounts Receivable - Dollars owed to a firm by customers as a result of credit sales. Accounts Receivable are valued on the basis of net realizable value – the amount that likely will be collected. This total is impacted by the credit policy indicated on your decision page.
Balance Sheet	Balance Sheet - A financial statement that summarizes a firm's assets, liabilities, and owner's equity at a given point in time.
Cash	Cash - Coin and currency held by a firm plus checking account balances. Some short-term highly liquid investments such as Treasury Bills are considered to be cash equivalents.
Cost of Goods Sold	Cost of Goods Sold (COGS) – The cost to manufacture goods that are sold during an accounting period. COGS for a manufacturer is the direct labor, direct materials, and manufacturing overhead.
Credit Line	Credit Line - If there is a cash deficit, the amount borrowed at a 4% interest rate.
Economic Profit	Economic Profit is the after tax operating profits minus the cost of capital. Essentially, this measure is the difference between what a business earned and what it should earn. If the return on capital exceeds the cost of capital, the business is using capital wisely and creating shareholder value, thus it is a measure closely linked with stock price. Economic Profit is also known as Economic Value Added (EVA).
Equity	Equity - The owner's stake in the business. Owner's equity is comprised of their direct investment in the business (capital stock) plus undistributed profits (retained earnings).
Income Statement	Income Statement - A financial statement that reports revenues and expenses and shows the profitability of a business for a stated time period. The Income Statement is sometimes referred to as the P & L (profit and loss statement).
Interest Expense	Interest Expense - The charges incurred during the income statement period on interest bearing loans and notes. These costs are reported separately from normal operating expenses.
Inventory	Inventory - Goods held for resale by a retailer or distributor. A manufacturer will list raw materials, the value of work in process, plus finished goods. Inventory is valued at historical cost, or market value – whichever is lower.
Long-term Debt	Long-term Liabilities - Debts that the principal amount need to be paid back over periods greater than 1 year. Long-term liabilities are valued at present value and not the sum of future payments. Long-term debt is generally incurred as initial capitalization of the firm or to finance growth opportunities.
Market Value	Market Value - derived by discounting Net Income by the Cost of Capital in perpetuity less the present value of expected risk related losses due to excessive leverage.
Net Income	Net Income - The remaining profit after all expenses (cost of goods sold, operating expenses, interest, special charges, and taxes) are subtracted. Net Income and Profit are the same thing. When net income is expressed as a percentage of revenue it is known as net profit margin or return on sales.
Other Operating Expense	Operating Expenses –Expenses other than cost of goods sold incurred in the operation of the business. Included are general expenses (rents, insurance payments, office supplies), and administrative expenses (salaries for executives, accountants, office support, etc). Sometimes these expenses are classified as sales, general and administrative expenses (S,G & A).
Profit Margin	Profit Margin - The ratio of Net Income to Sales Revenue.
Research and Development	Research and Development - dollars spent on new product development.
Return on Assets	Return on assets (ROA) is the net income or profit derived from each dollar invested in assets and is sometimes referred to as return on investment (ROI). Return on assets is calculated by dividing net income into total assets.
Sales and Promotion	Sales and Promotion Expense - the dollars spent on advertising.
Sales Revenue	Sales Revenue - Inflow of assets (usually cash or accounts receivable) generated by the sale of goods and services (note: not the sale of fixed assets). Revenue is recognized on the financial statements at the time ownership of the goods is transferred (usually when shipped) or when the service is rendered. "Net sales" or just "sales" is often substituted on the income statement for revenue.

Simulation development is a complex task requiring an understanding of the dynamic and nonlinear nature of economic systems, the ability to abstract these systems mathematically, to create a program that is pedagogically sound, and to create a scenario that is plausible and fun. This chapter provides guidance and insight for those people who may wish to pursue this challenging and rewarding task. Chapter Five will formally assess this assertion using a business simulation assessment tool created for this project and derived from the research based General Framework for Effective Simulation Development.

Chapter Five: Assessment Procedure and Analysis

This dissertation is offering two valuable contributions to the domain of business simulations as a teaching tool. The first is a research based the General Framework for Effective Simulation Development. Twelve elements of superior simulation design and development emerged from the published finding of scholars over many decades and this framework has been codified and presented earlier in the dissertation. The second contribution to the simulation and gaming domain is a structured methodology to assess the pedagogical efficacy of a specific simulation and evaluate the simulation's fidelity to established economic theory. A checklist to evaluate the pedagogical efficacy of a simulation was developed in Chapter Three. This checklist called the Business Simulation Assessment Tool is based on objective and binary data and is demonstrated and employed in this section.

A difficult task in developing a high fidelity business simulation is the creation and validation of the system of equations, or algorithms, that serve as the simulation engine. The formulas are generally not exposed to players and facilitator's of simulations, and even if they were, it is nearly impossible to identify fidelity by examining the formulas. As an alternative, this project has created a tool that can be used iteratively to assess the fidelity of each formula in isolation and as part of a dynamic system by comparing the simulated outcome patterns to expected outcome patterns as predicted by economic theory. This tool was created and presented in Chapter Three as the Economic Theory Input-Output Matrix.

A benefit of both assessment tools and this methodology is that it does not require surveys and test subjects, sampling designs, subjective judgments, or use of statistical methods. Instead, the simulation being tested is the data generating instrument.

Summary of Part One: Building a Prototype for Testing.

Chapter four described in detail the building of a prototype simulation for testing named as SimWrite!. The six steps to develop a simulation are :(1) Create an archetypical manufacturing firm with beginning financial statements. (2) Write a short scenario establishing a set of quantitative goals. (3) Identify business decisions or input variables. (4) Identify a standard output or results report. (5) Create the econometric simulation model. For each variable, a function must be consistent with established economic theory and general industry or sector benchmarks. (6) Program the simulation interface and navigation system.

Part Two: A Test of Pedagogical Efficacy

The test simulation, SimWrite!, was extensively described with words, calculations, and screen shots in Chapter Four. The following notations link each of the 12 elements of the General Framework for Effective Simulation Development to the checklist that follows.

> *An interface should be simple, uncluttered, and intuitive using standard Windows controls. (Element 8)*
>
> *The MiniSim is preferred to a MaxiSim – they are more focused, play faster, and provide greater course flexibility. (Element 3)*
>
> *Graphics and colors are effective but should be used parsimoniously. (Element 9)*
>
> *Business simulations should include a story or scenario based on the principles of effective story telling. (Element 1)*
>
> *Feedback should be immediate and contextual. (Element 5)*
>
> *Balanced complexity – limit the number of decisions to 7 +/- 2 to maximize. (Element 2)*
>
> *A replay option is preferred to single shot play – practice and reflection are critical components of learning. (Element 4)*
>
> *Essentials of game play should be incorporated – each simulation should include stated and quantitative goals with clearly identified winners. (Element 10)*

A deterministic simulation is a better learning tool that a stochastic model. Outcomes are consistent with input variables. (Element 6)

High fidelity is critical. (Element 12)

Skill and knowledge should be the primary determinants of "winning" – decisions should be based on thoughtful deliberation and application of theory and best practices. (Element 11)

Students should compete against programmed competitor and themselves. (Element 7)

Following is the Business Simulation Assessment Tool, with respect to the test simulation, SimWrite!. Each of the 12 essential elements is represented on this checklist and is checked off accordingly.

A Business Simulation Assessment Tool

#	Item	Yes	No	Can't Answer
1	The story or scenario used with this simulation clearly identifies the business goal or goals our team is to achieve.	X		
2	The number of decisions per round is no more than 10.	X		
3	I learn more when I can replay a decision multiple times.	X		
4	A decision can be replayed.	X		
5	Results are available immediately after decisions are submitted.	X		
6	Results are determined only by decisions - not by randomness.	X		
7	Results are determined by the simulation algorithms rather than other player actions.	X		
8	Navigation through the simulation uses command buttons.	X		
9	No screen has more than 4 colors or fonts.	X		
10	The goals of the game are explicit, quantitative, and based on business measures.	X		
11	Successful outcomes are associated with more skill and knowledge of the simulation subject matter.	X		
12	The simulation model will return results that seem realistic and consistent with non-linear economic theory.	X		

Part Three: A Test of Economic Fidelity

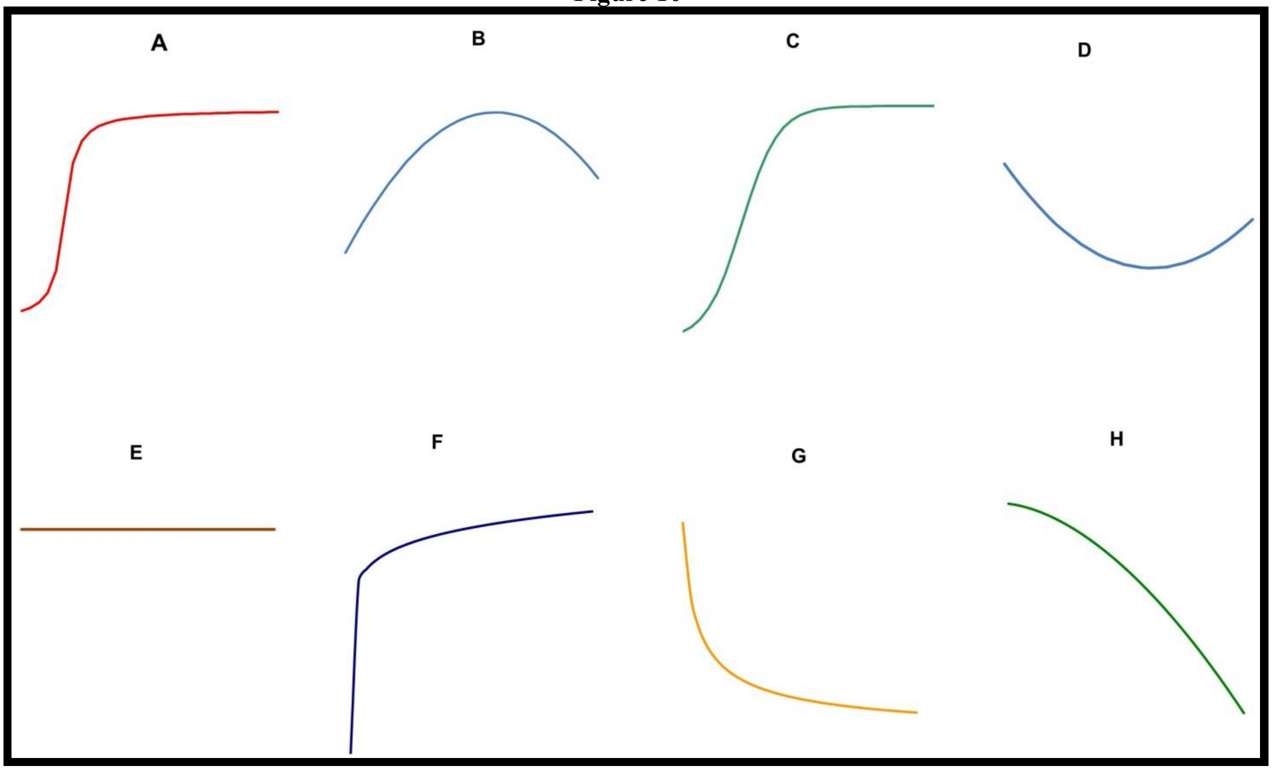
A unique advantage of a simulation as compared to other "experiential" teaching methods used in business school such as case studies, internships, and service learning, is the simulation can be used as an experimental device. That is, one variable can be changed with others held constant and hypotheses can be formed and tested. Because SimWrite! is designed to allow for replays and capture results in a database, the experimental design used to test for economic fidelity is obvious.

For each decision variable (units produced, quality, sales price, promotion dollars, credit terms, research and development dollars, training and development dollars, and long term debt acquisition/disposition), the input for one will be varied over a range of credible values arranged in an ascending order with the other inputs held constant. The output measures (units sold, sales revenue, market value, net income, economic profit, and return on assets will be captured, graphed, and labeled using one of the functional relationships presented in Chapter Three and reproduced below. The expected Economic Theory Input-Output Matrix will be compared to the actual Economic Theory Input-Output Matrix generated through experimentation in a series of eight tests, each focusing on a single input variable. For each test, a spreadsheet of inputs and outcomes will be presented along with graphical associations. These actual outcomes will be compared to the expected patterns and the ratio of matches between the expected and actual table (the table has fifty-six cells) will be deemed the economic fidelity ratio.

The Economic Theory Input-Output Matrix introduced in Chapter Three is reproduced in this chapter and was derived using accepted economic theory as it has evolved over time. The appendix to this dissertation describes the expected relationship between each of the eight independent variables and the seven tested performance measures. The Economic Theory Input-

Output Matrix is coded to correspond with one of the patterns displayed below. The technical note in Chapter Three has been included here to further explain each pattern.

Figure 10



A brief technical note related to each function:

1. A is a logistic function. It is characterized by an increase in the dependent variable as the independent variable increases with two inflection points. It is a function that increases slowly, then speeds up, and then slows down. The relationship between training and productivity is an example of this relationship in that first there is a learning curve effect followed by diminishing returns.
2. B is a parabola and is common to economic theory when explaining maximization behavior. One example is the relationship between price and revenue – there is a profit maximizing price.

3. C is an inhibited growth function. It describes those conditions where an increase in the independent variable is associated with an increase in the dependent variable until the constraining factor. There may be one or two inflection points. An example is advertising and sales units. Units sold are constrained by the production quantity.
4. D is also a common function found in economic theory and describes minimization behavior. The relationship between average unit cost and production quantity will look like D as fixed costs are allocated over more units. Eventually the cost for additional input variables will rise due to demand pressures.
5. E is described as a constant relationship or even as a null relationship. The change in one variable is totally independent of the other. For example, the capital structure decision is independent of the units that can be sold.
6. F is an exponentially dampened positive relationship and represents the classic economic concept known as diminishing marginal returns. An example is the relationship between product quality and units sold. The incremental value of quality will elicit more sales, but from fewer customers.
7. G is an exponentially decreasing function and describes the classic demand curve where demand will increase as price goes down. The demand curve, as graph G indicates is expected to have a concave shape. As the price of a good continues to drop, aggregate demand will increase incrementally for that good as it becomes a preferred substitute.
8. H is a convex exponentially decreasing function. The rate of change in the independent variable increases more than proportionally to the changes of the independent variable. An example is as debt increases, all else held constant; the profit margin will decrease at

an increasing rate. This is related to the interest rate charged to additional borrowing will increase due to the increased risk.

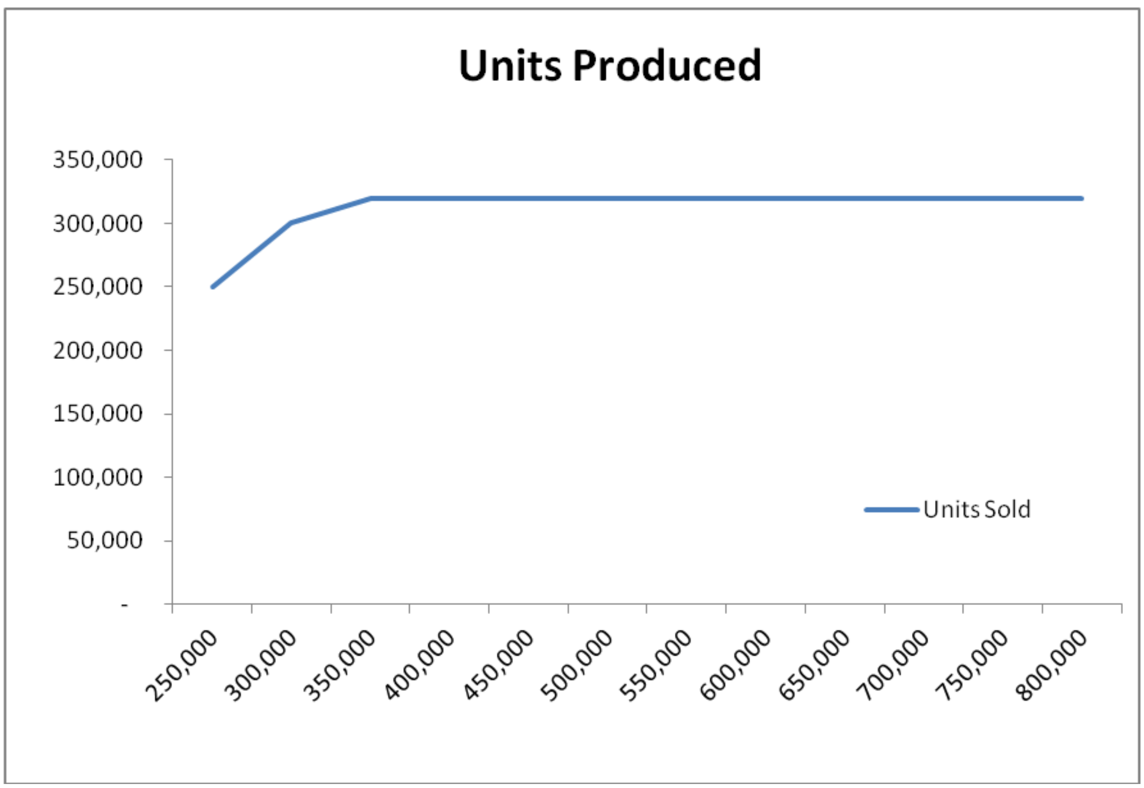
Below is a reproduction of the Economic Theory Input-Output Matrix developed and presented in Chapter One. Following is a series of eight tests, each using the decision variable as an independent variable that will be varied over the range probable values, and plotted against the seven performance measures. The results will be reported numerically and graphically and will be the basis of the fidelity index. The relevant cells of the Economic Theory Input-Output Matrix will also be displayed.

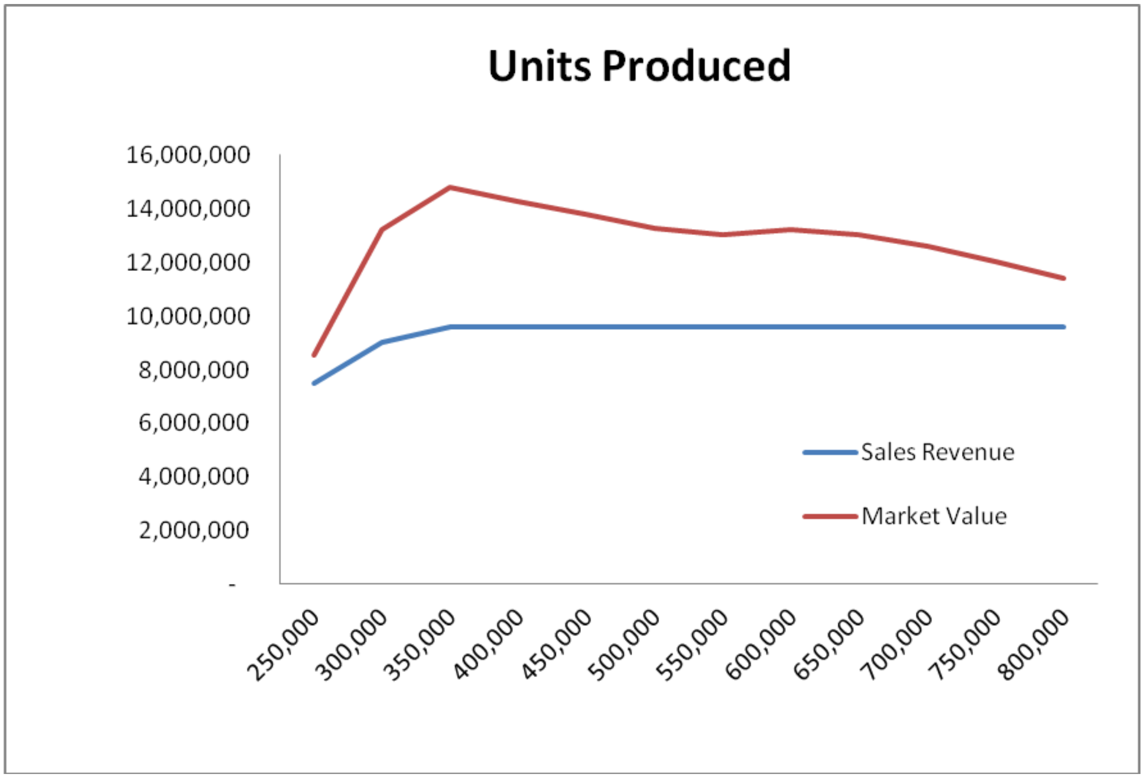
Expected Economic Theory Input Output Matrix

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Units Produced	C	B	C	B	B	B	B
Quality	F	B	F	B	B	B	B
Price	G	B	B	B	B	B	B
Promo Dollars	A	B	A	B	B	B	B
Credit Terms	F	B	F	B	B	B	B
R & D Dollars	A	B	A	B	B	B	B
Training Budget	A	B	A	B	H	B	B
Change in LTD	E	H	E	B	H	H	E

Test 1 – Independent Variable = Production in Units

Units Produced	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
250,000	250,000	540,674	7,500,000	8,523,075	7.2%	(202,580)	5.0%
300,000	300,000	828,433	9,000,000	13,227,770	9.2%	62,159	7.3%
350,000	319,598	922,313	9,587,947	14,799,816	9.6%	148,528	8.0%
400,000	319,598	890,395	9,587,947	14,298,028	9.3%	119,164	7.8%
450,000	319,598	858,478	9,587,947	13,795,528	9.0%	89,800	7.5%
500,000	319,598	826,561	9,587,947	13,292,314	8.6%	60,436	7.3%
550,000	319,598	794,643	9,587,947	13,053,267	8.3%	2,517	6.8%
600,000	319,598	762,726	9,587,947	13,228,912	8.0%	(135,167)	5.9%
650,000	319,598	730,809	9,587,947	13,038,581	7.6%	(272,851)	5.1%
700,000	319,598	698,891	9,587,947	12,617,796	7.3%	(410,536)	4.5%
750,000	319,598	666,974	9,587,947	12,053,356	7.0%	(548,220)	3.9%
800,000	319,598	635,056	9,587,947	11,402,135	6.6%	(685,905)	3.5%




Units Produced
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
250,000
300,000
350,000
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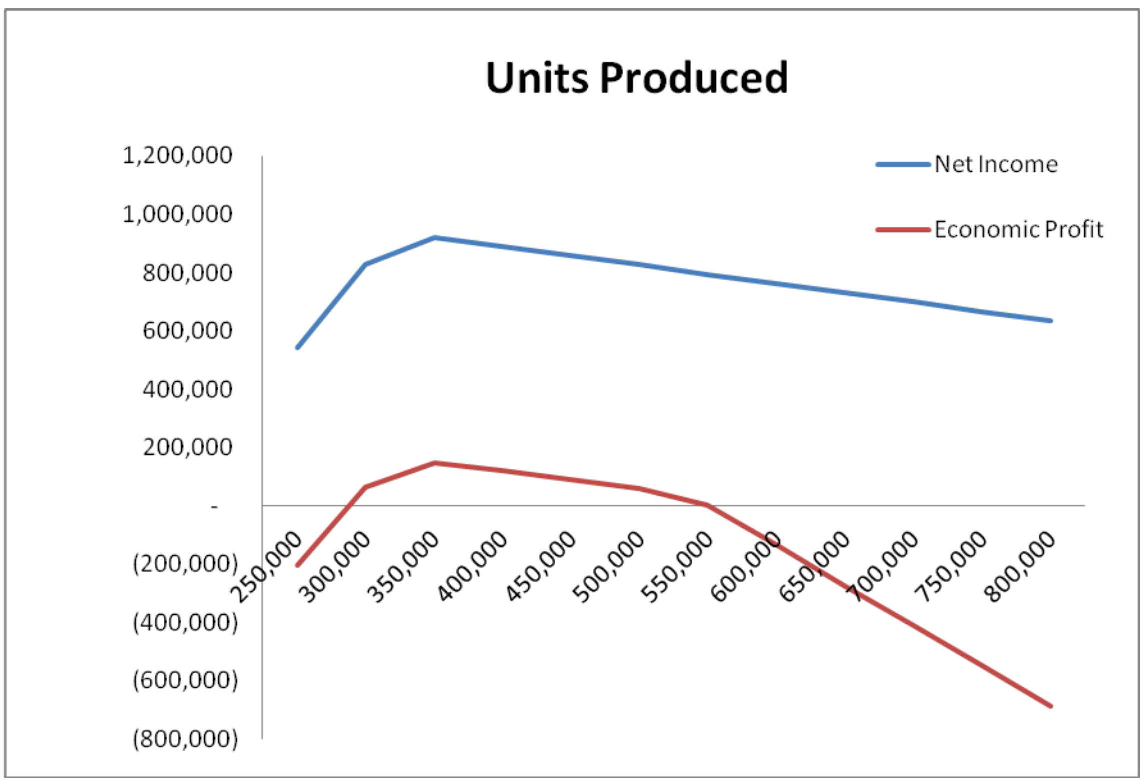
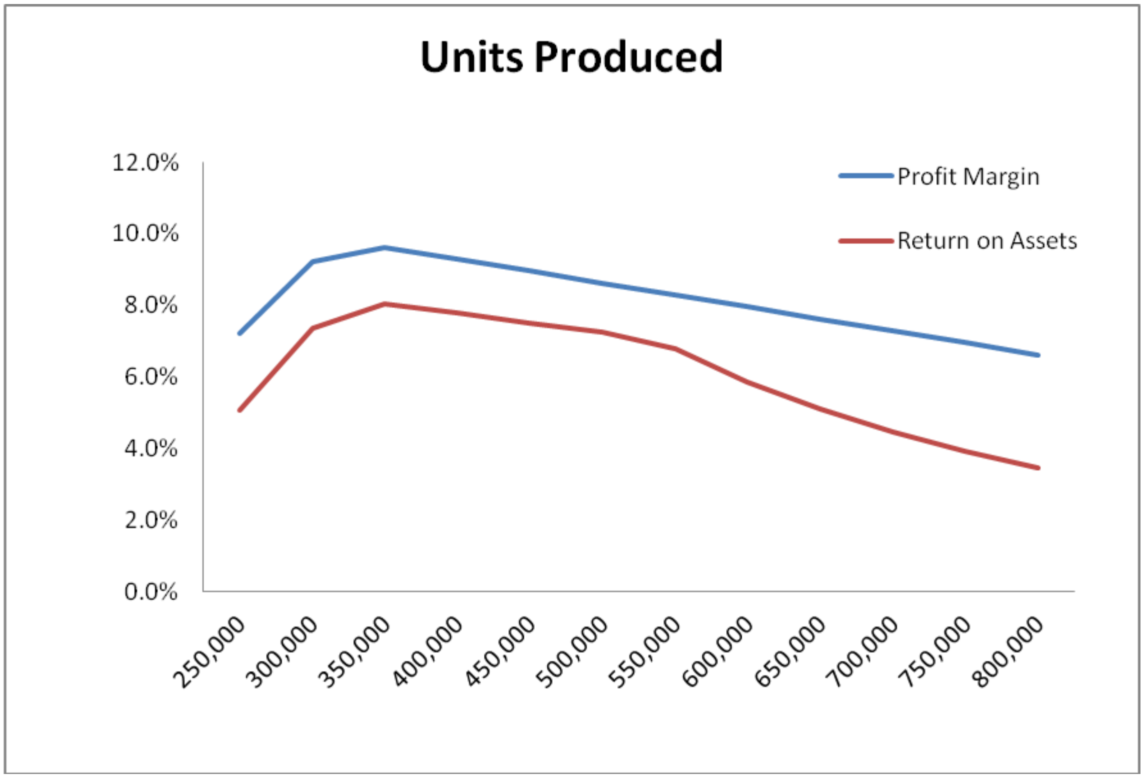
450,000
500,000
550,000
600,000
650,000
700,000
750,000
800,000
Sales Revenue
Market Value


Units Produced
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
(200,000)
(400,000)
(600,000)
(800,000)
250,000
300,000
350,000
400,000
450,000
500,000
550,000
600,000
650,000
700,000
750,000
800,000
Net Income
Economic Profit



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Units Produced	C	B	C	B	B	B	B

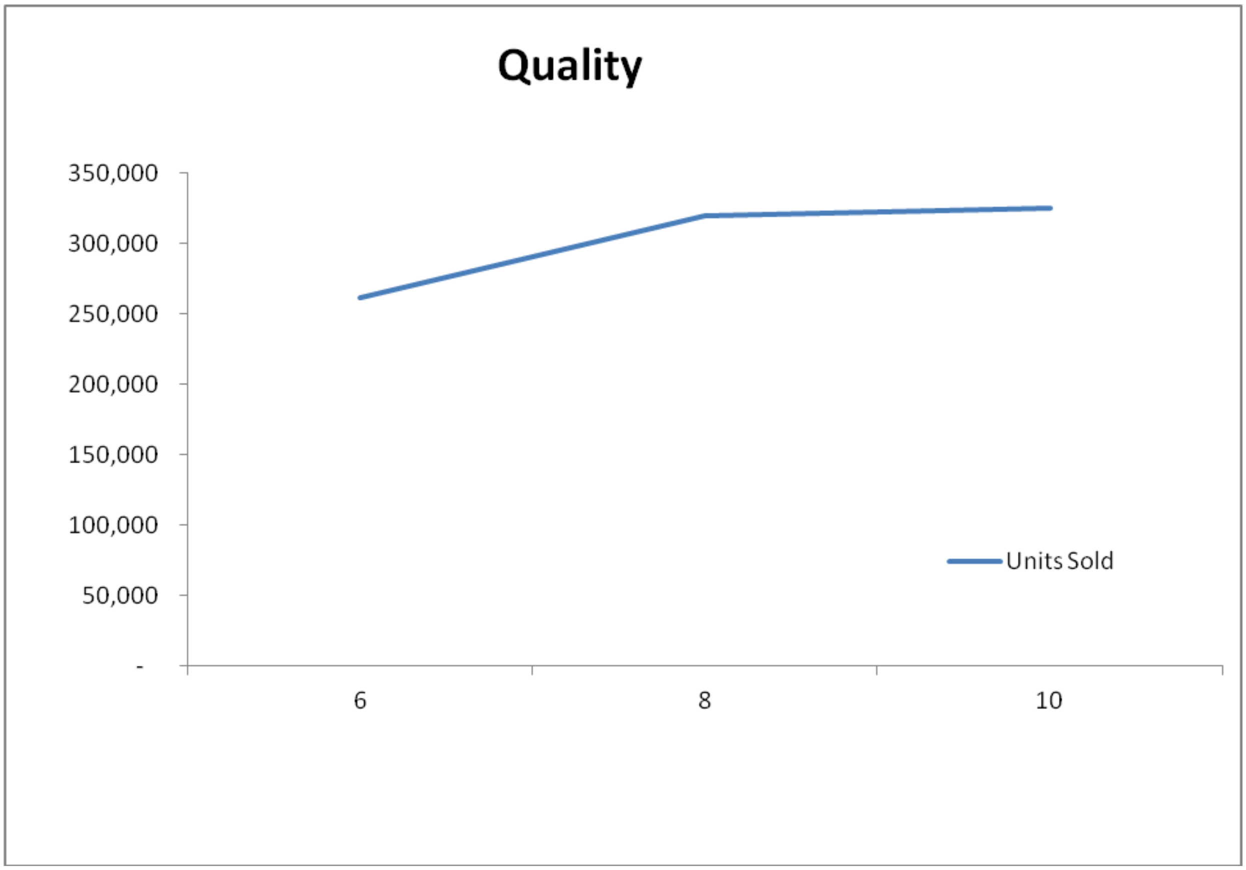
Actual

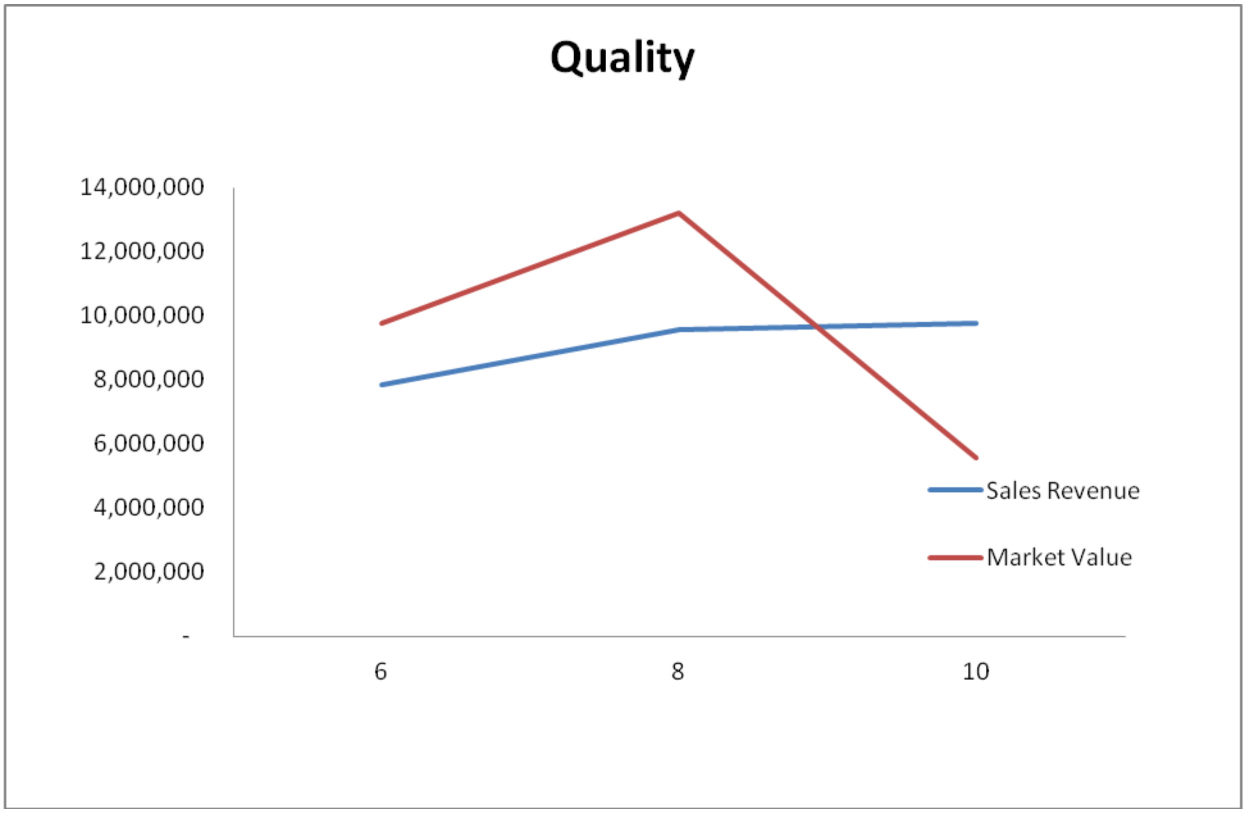
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Units Produced	C	B	C	B	B	B	B

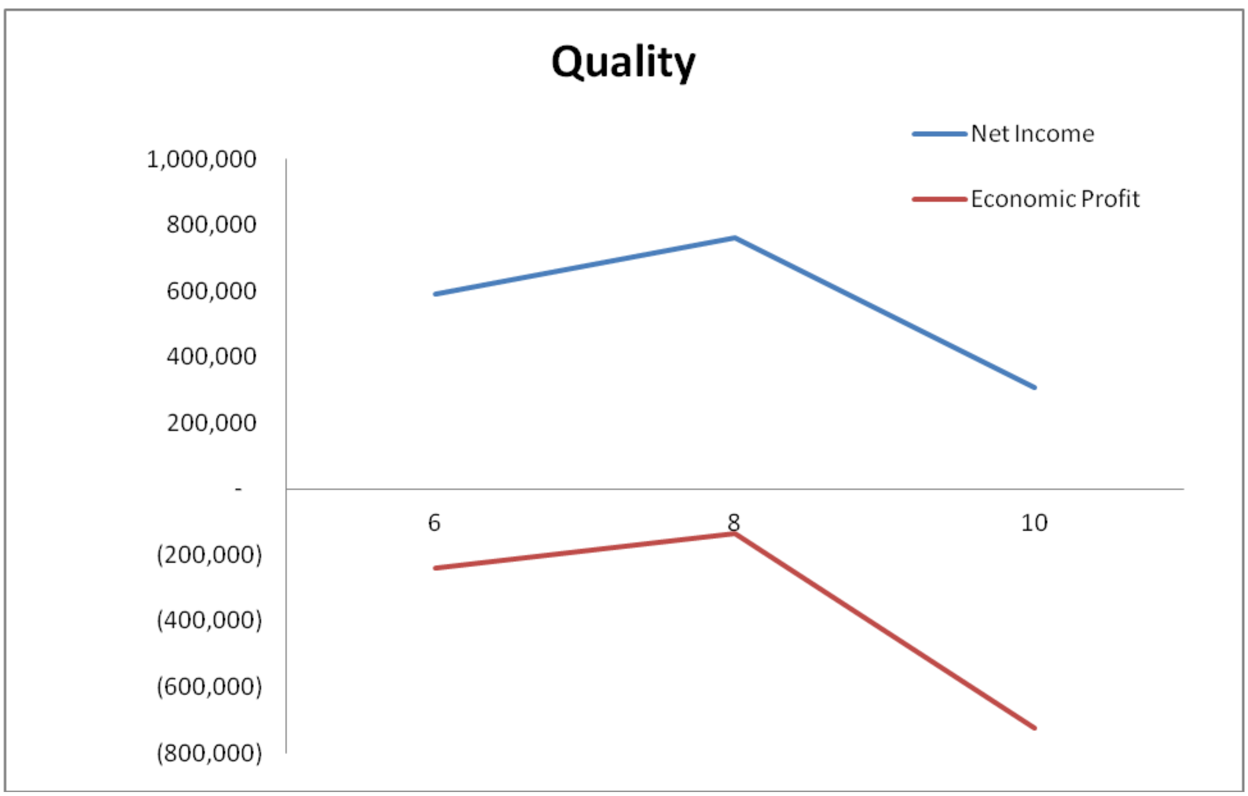
Fidelity Ratio = 7 / 7 = 1.00

Test 2 – Independent Variable = Quality of Inputs

Quality	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
6	261,324	589,008	7,839,727	9,778,804	7.5%	(240,407)	5.1%
8	319,598	762,726	9,587,947	13,228,912	8.0%	(135,167)	5.9%
10	325,426	309,260	9,762,787	5,586,860	3.2%	(725,198)	2.0%




Quality
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
6
8
10
Sales Revenue
Market Value


Quality
Net Income
Economic Profit
1,000,000
800,000
600,000
400,000
200,000
-
(200,000)
(400,000)
(600,000)
(800,000)
6
8
10

Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Quality	F	B	F	B	B	B	B

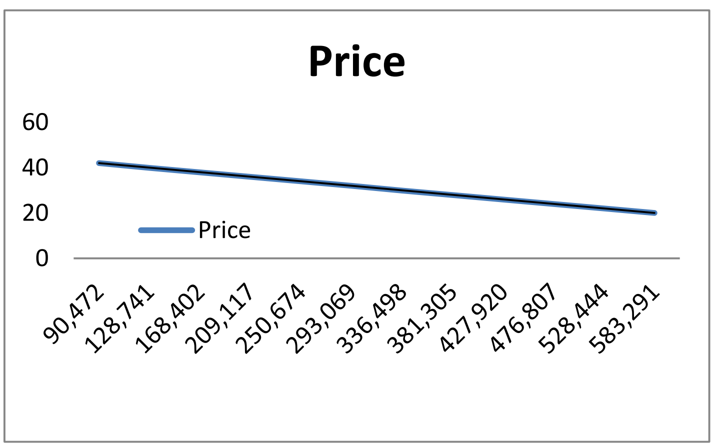
Actual

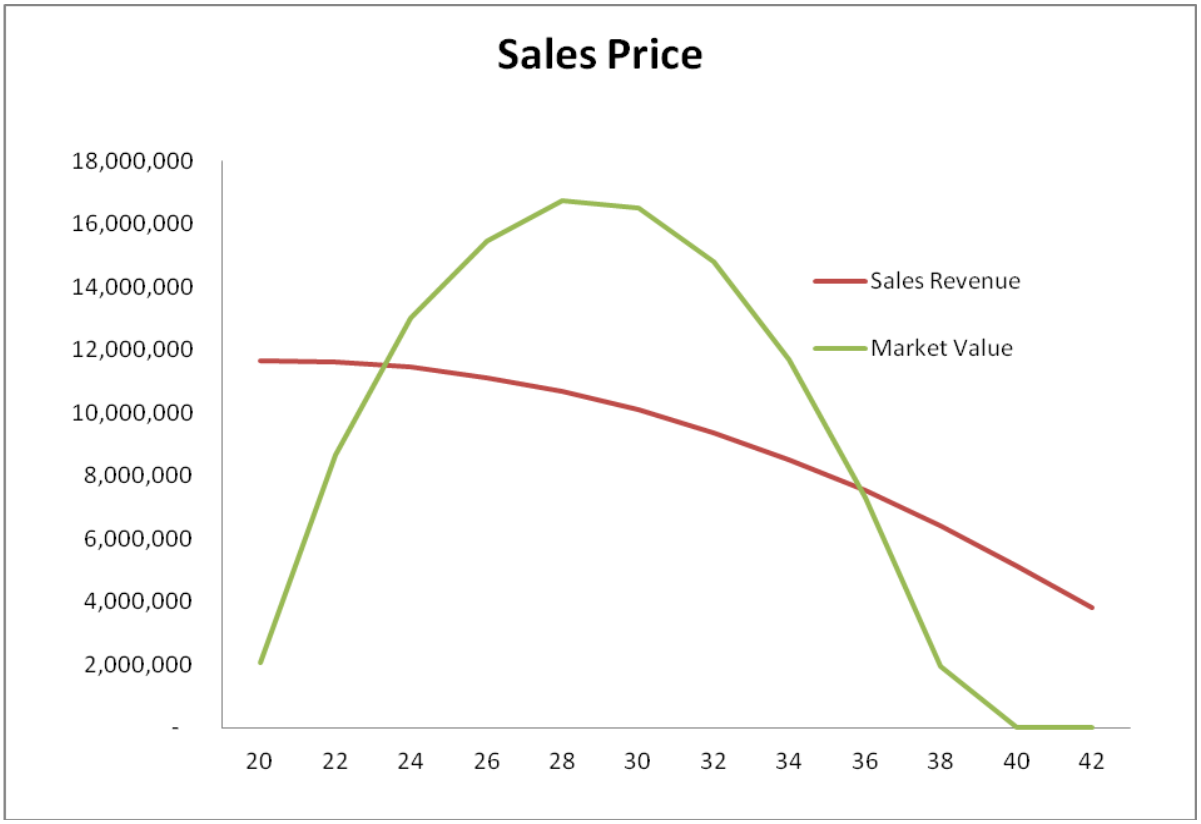
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Quality	F	B	F	B	B	B	B

Fidelity Ratio = 7/7 = 1.00

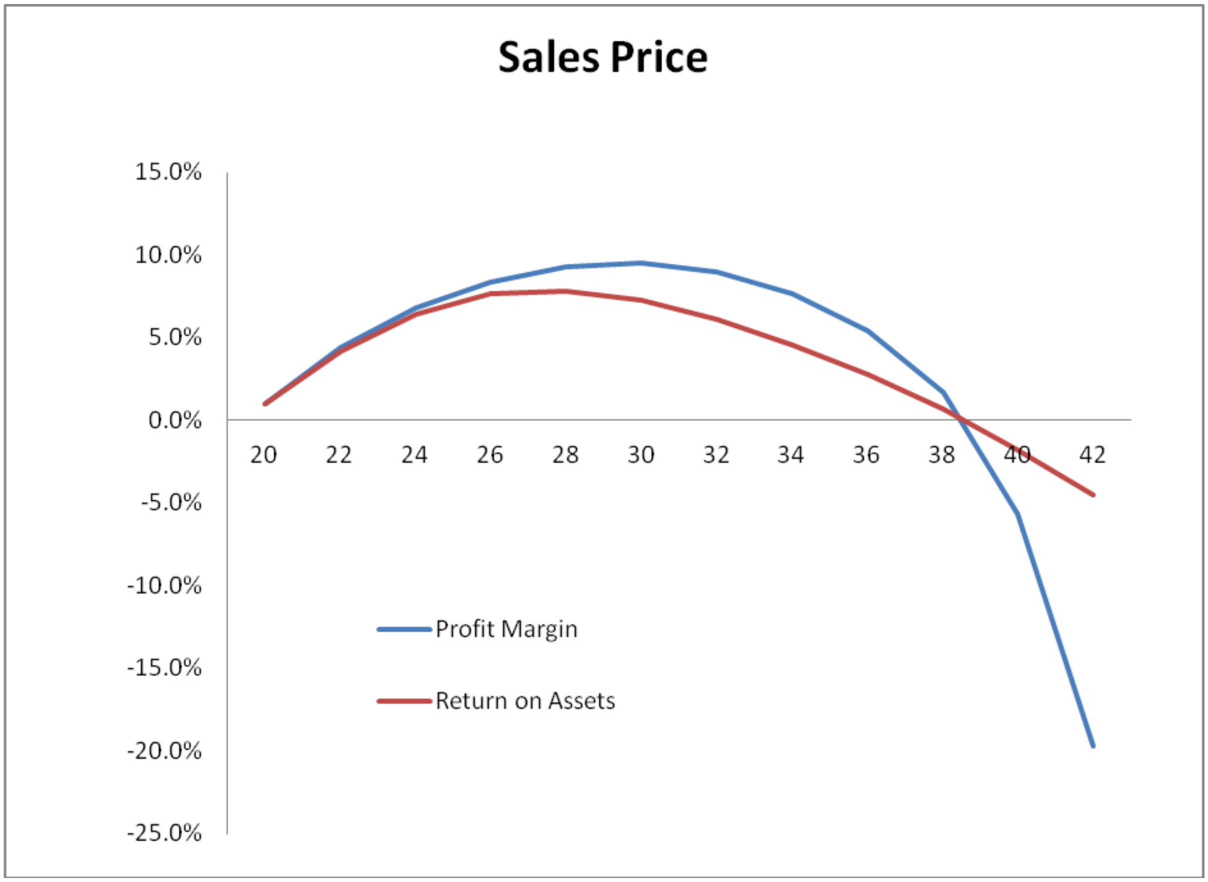
Test 3 – Independent Variable = Price

Sales Price	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
20	583,291	118,033	11,665,817	2,050,447	1.0%	(591,409)	1.0%
22	528,444	507,212	11,625,767	8,660,736	4.4%	(233,365)	4.2%
24	476,807	773,825	11,443,361	12,999,212	6.8%	11,919	6.4%
26	427,920	930,543	11,125,932	15,462,861	8.4%	149,053	7.7%
28	381,305	988,001	10,676,529	16,739,328	9.3%	143,865	7.8%
30	336,498	955,431	10,094,929	16,510,510	9.5%	49,903	7.2%
32	293,069	841,258	9,378,204	14,803,942	9.0%	(125,309)	6.1%
34	250,674	654,370	8,522,909	11,685,909	7.7%	(373,684)	4.6%
36	209,117	405,567	7,528,205	7,312,249	5.4%	(685,014)	2.7%
38	168,402	108,705	6,399,269	1,965,731	1.7%	(1,045,720)	0.7%
40	128,741	(292,405)	5,149,652	-	-5.7%	(1,511,873)	-1.8%
42	90,472	(748,254)	3,799,810	-	-19.7%	(2,033,528)	-4.5%




Sales Price
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
20 22 24 26 28 30 32 34 36 38 40 42
Sales Revenue
Market Value


Sales Price
1,500,000
1,000,000
500,000
-
(500,000)
(1,000,000)
(1,500,000)
(2,000,000)
(2,500,000)
20 22 24 26 28 30 32 34 36 38 40 42
Net Income
Economic Profit



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Price	G	B	B	B	B	B	B

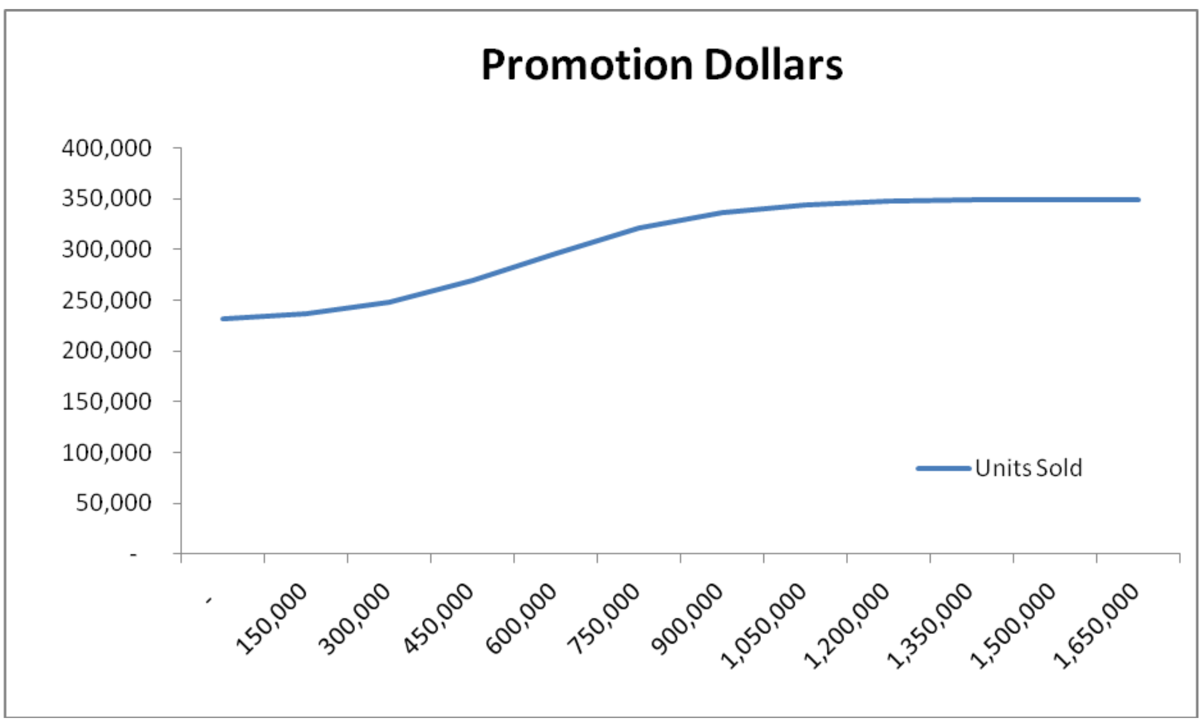
Actual

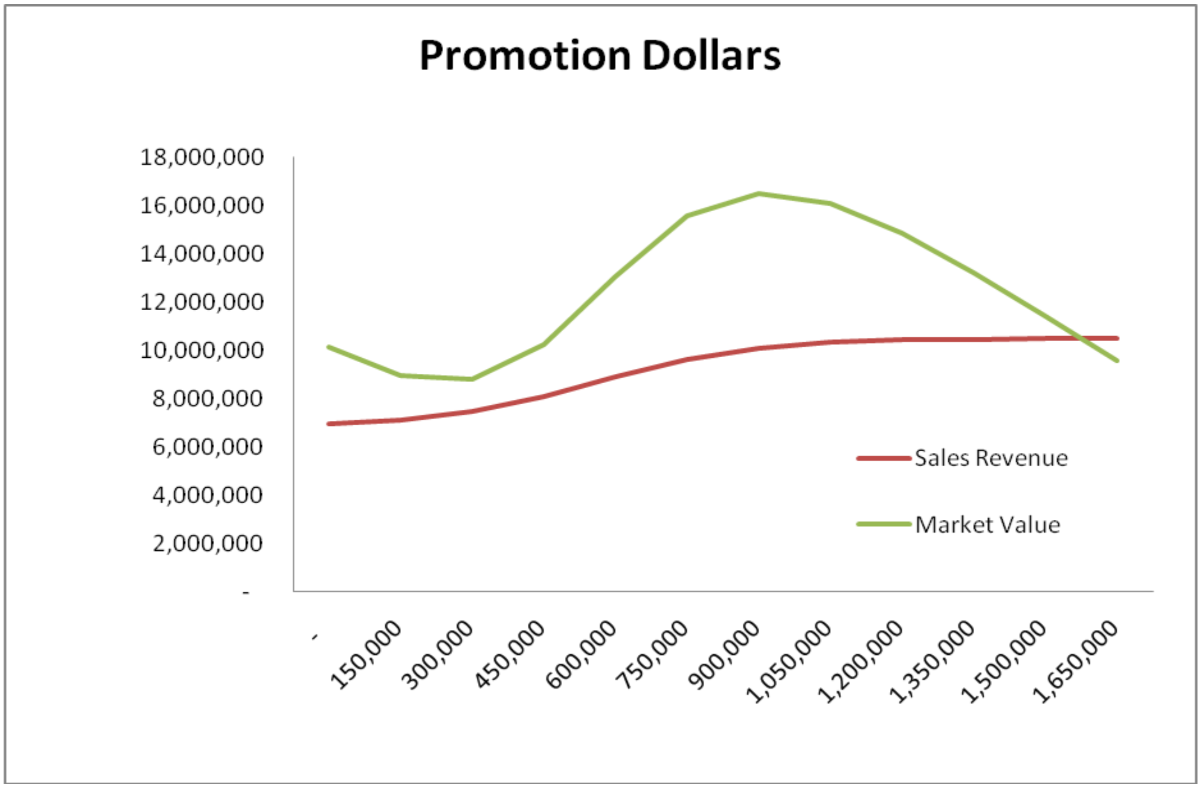
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Price	G	B	B	B	B	B	B

Fidelity Ratio = 7/7 = 1.00

Test 4 – Independent Variable = Promotion Dollars

Promo Dollars	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
-	231,933	564,143	6,957,979	10,132,242	8.1%	(497,707)	3.9%
150,000	237,244	498,450	7,117,309	8,955,993	7.0%	(555,126)	3.4%
300,000	248,736	489,906	7,462,069	8,790,064	6.6%	(545,889)	3.4%
450,000	269,434	574,809	8,083,009	10,259,586	7.1%	(429,383)	4.1%
600,000	296,788	740,165	8,903,629	13,067,640	8.3%	(223,095)	5.4%
750,000	321,220	893,372	9,636,589	15,566,877	9.3%	(34,132)	6.7%
900,000	336,498	955,431	10,094,929	16,510,510	9.5%	49,903	7.2%
1,050,000	344,034	931,416	10,321,009	16,065,972	9.0%	36,619	7.1%
1,200,000	347,317	857,956	10,419,499	14,830,959	8.2%	(32,189)	6.6%
1,350,000	348,669	761,621	10,460,059	13,216,941	7.3%	(126,613)	5.8%
1,500,000	349,213	655,639	10,476,379	11,428,174	6.3%	(231,826)	5.0%
1,650,000	349,430	545,741	10,482,889	9,554,994	5.2%	(341,417)	4.2%




Promotion Dollars
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
Sales Revenue
Market Value
-
150,000
300,000
450,000
600,000
750,000
900,000
1,050,000
1,200,000
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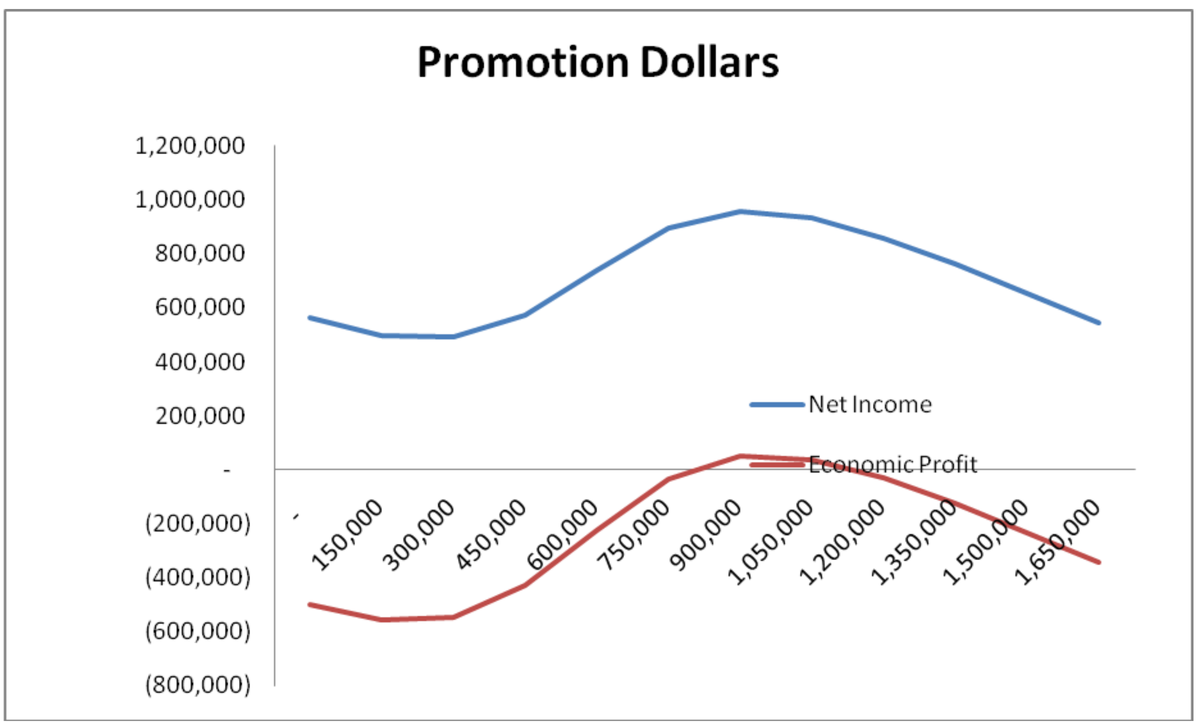
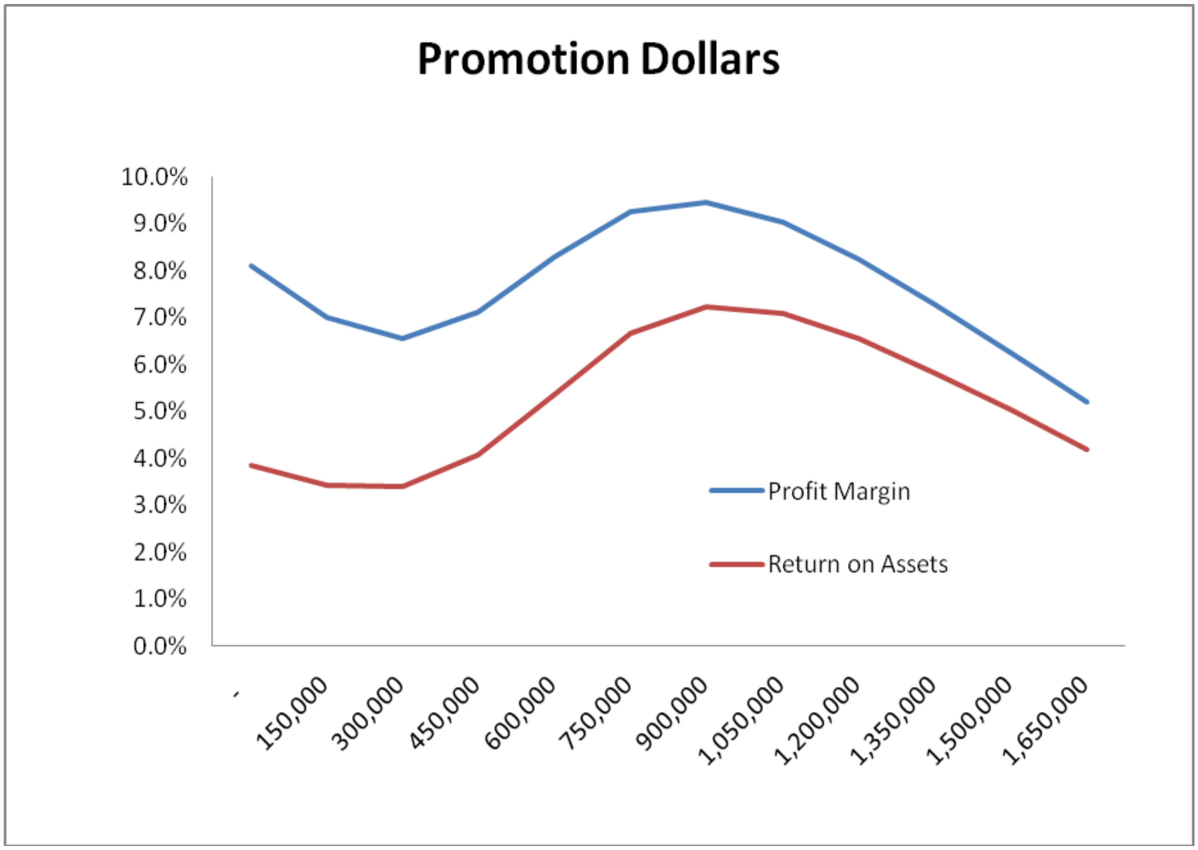
1,650,000


Promotion Dollars
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
(200,000)
(400,000)
(600,000)
(800,000)
Net Income
Economic Profit
-
150,000
300,000
450,000
600,000
750,000
900,000
1,050,000
1,200,000
1,350,000
1,500,000
1,650,000



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Promo Dollars	A	B	A	B	B	B	B

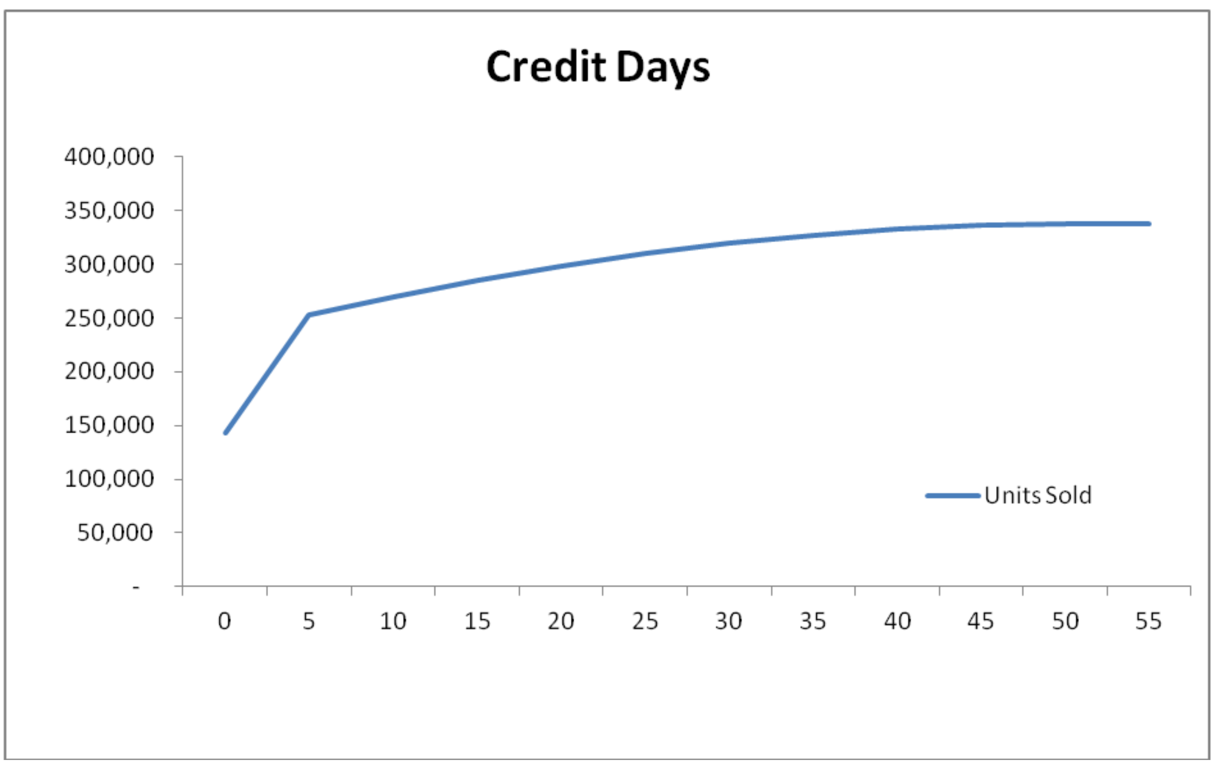
Actual

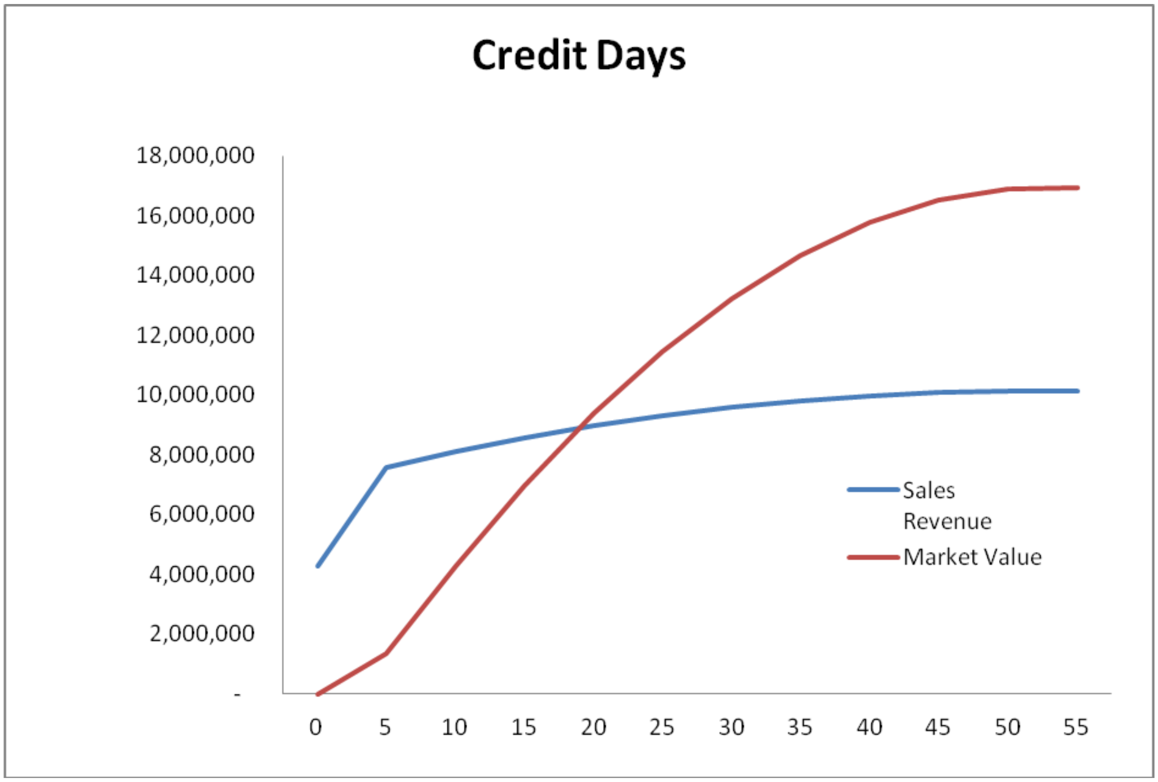
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Promo Dollars	A	B	A	B	B	B	B

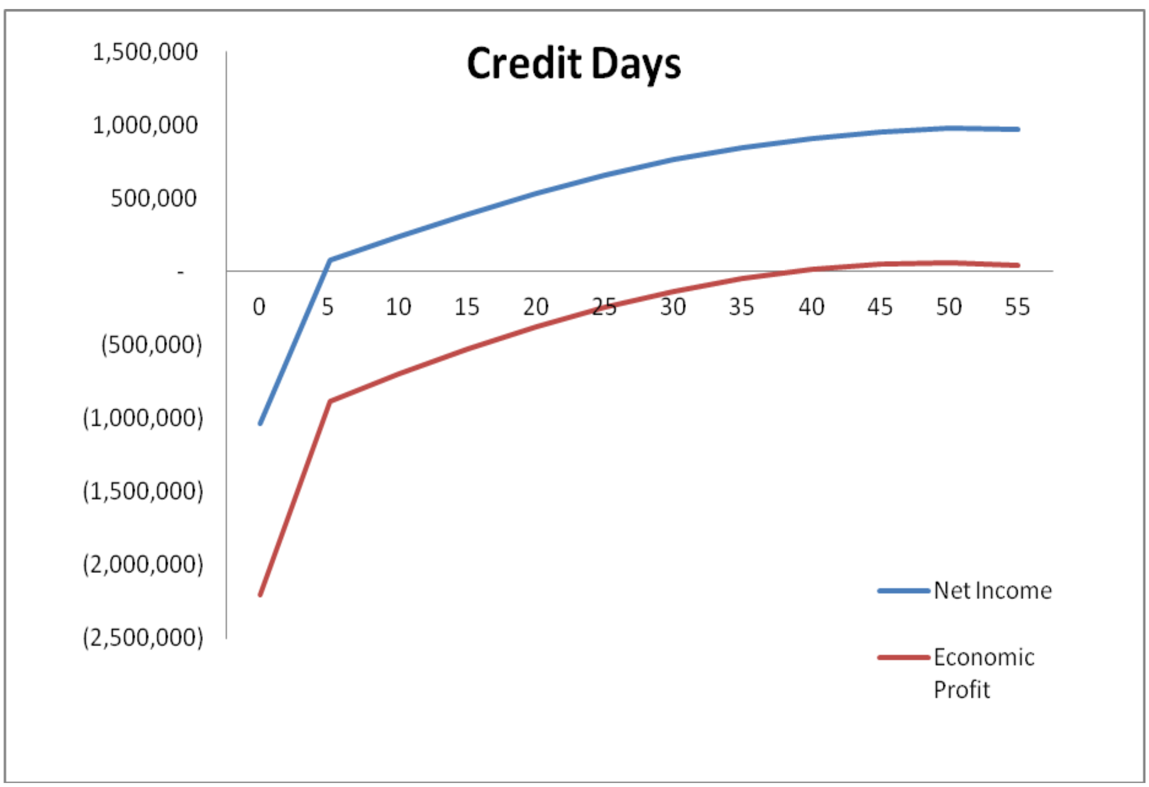
Fidelity Ratio = 7/7 = 1.00

Test 5 = Independent Variable = Credit Terms

Credit Terms	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
0	143,184	(1,037,714)	4,295,520	-	-24.2%	(2,200,164)	-6.7%
5	252,583	75,531	7,577,500	1,352,897	1.0%	(886,993)	0.6%
10	269,871	241,591	8,096,137	4,298,187	3.0%	(698,969)	1.8%
15	285,217	395,100	8,556,500	6,978,319	4.6%	(528,316)	3.0%
20	298,620	534,516	8,958,589	9,374,154	6.0%	(376,267)	4.1%
25	310,080	657,675	9,302,405	11,462,478	7.1%	(244,694)	5.0%
30	319,598	762,726	9,587,947	13,228,912	8.0%	(135,167)	5.9%
35	327,174	848,132	9,815,214	14,664,103	8.6%	(48,960)	6.5%
40	332,807	912,671	9,984,208	15,760,562	9.1%	12,955	7.0%
45	336,498	955,431	10,094,929	16,510,510	9.5%	49,903	7.2%
50	338,246	975,818	10,147,375	16,904,920	9.6%	61,511	7.3%
55	338,052	973,549	10,141,548	16,933,699	9.6%	47,703	7.2%




Credit Days
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
0
5
10
15
20
25
30
35
40
45
50
55
Sales Revenue
Market Value


Credit Days
1,500,000
1,000,000
500,000
-
(500,000)
(1,000,000)
(1,500,000)
(2,000,000)
(2,500,000)
0
5
10
15
20
25
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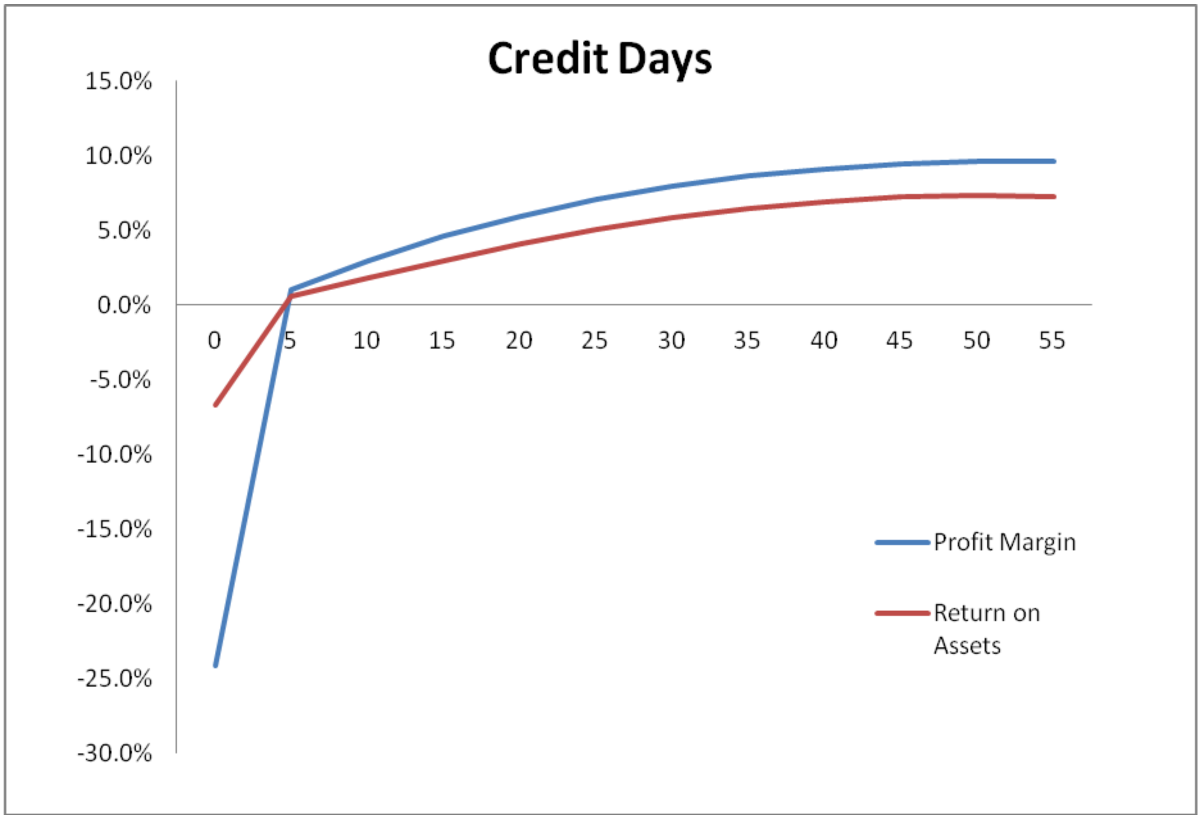
40
45
50
55
Net Income
Economic Profit



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Credit Terms	F	B	F	B	B	B	B

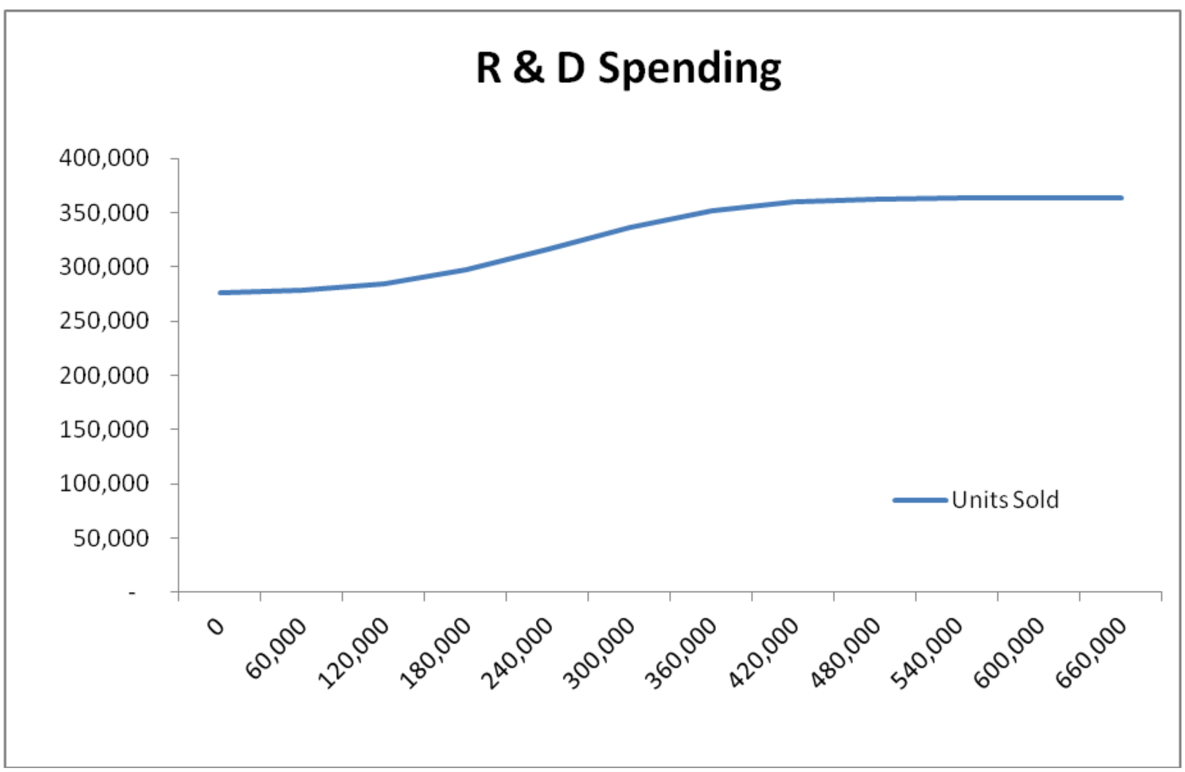
Actual

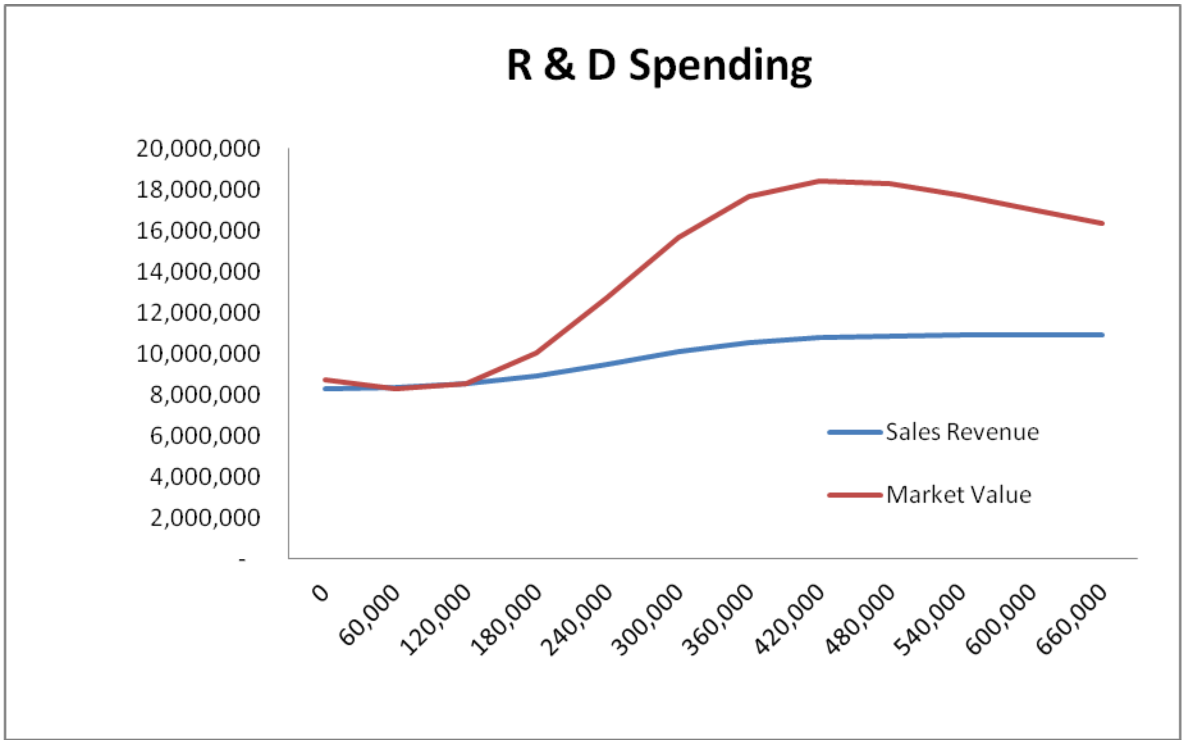
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Credit Terms	F	B	F	B	B	B	B

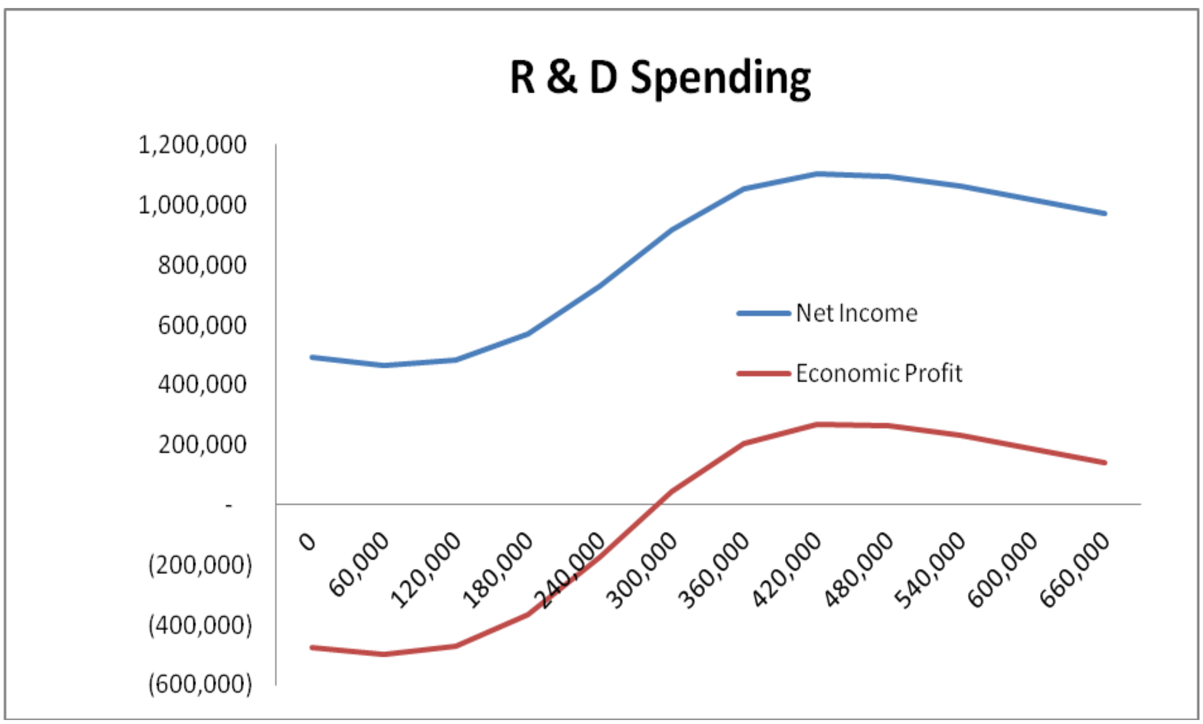
Fidelity Ratio = 7/7 = 1.00

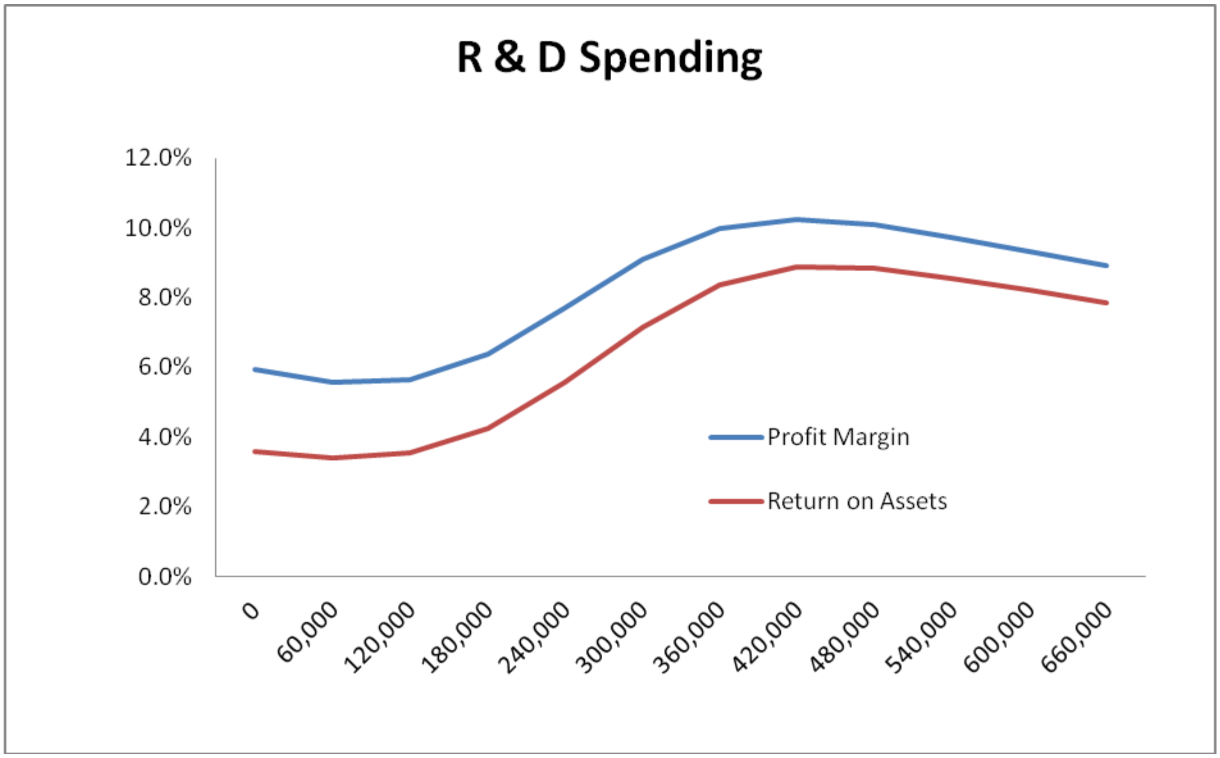
Test 6 = Independent Variable = Research and Development Spending

Research and Development	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
0	276,144	491,055	8,284,327	8,725,957	5.9%	(475,394)	3.6%
60,000	278,125	465,849	8,343,757	8,279,905	5.6%	(497,422)	3.4%
120,000	284,116	481,374	8,523,487	8,538,895	5.6%	(472,318)	3.5%
180,000	296,891	568,757	8,906,737	10,023,520	6.4%	(364,661)	4.3%
240,000	316,093	731,249	9,482,797	12,718,746	7.7%	(172,085)	5.6%
300,000	336,447	917,345	10,093,417	15,668,710	9.1%	45,389	7.2%
360,000	351,659	1,052,556	10,549,777	17,692,272	10.0%	203,709	8.4%
420,000	359,676	1,105,110	10,790,287	18,423,837	10.2%	268,324	8.9%
480,000	362,654	1,096,802	10,879,627	18,260,603	10.1%	264,475	8.8%
540,000	363,434	1,061,452	10,903,027	17,704,130	9.7%	230,292	8.6%
600,000	363,578	1,018,236	10,907,347	17,029,144	9.3%	187,290	8.2%
660,000	363,596	973,459	10,907,887	16,326,352	8.9%	142,540	7.8%




R & D Spending
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
0
60,000
120,000
180,000
240,000
300,000
360,000
420,000
480,000
540,000
600,000
660,000
Sales Revenue
Market Value


R & D Spending
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
(200,000)
(400,000)
(600,000)
0
60,000
120,000
180,000
240,000
300,000
360,000
420,000
480,000
540,000
600,000
660,000
Net Income
Economic Profit



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
R & D Dollars	A	B	A	B	B	B	B

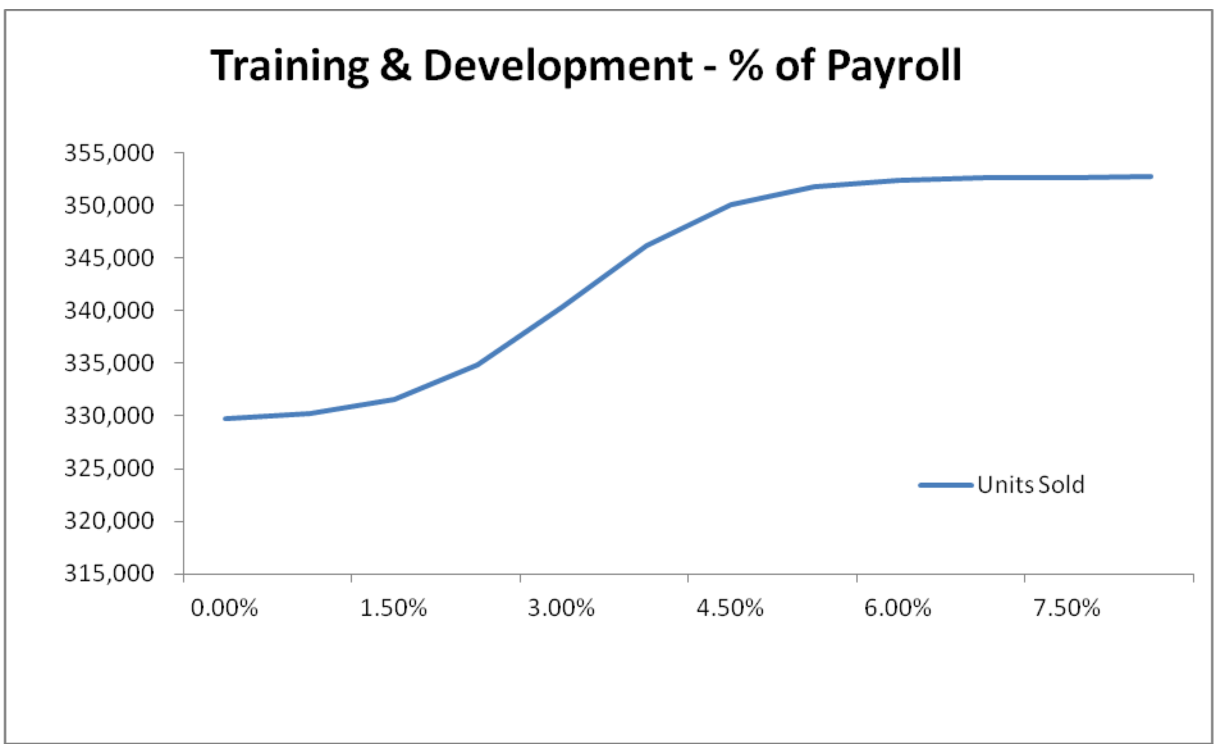
Actual

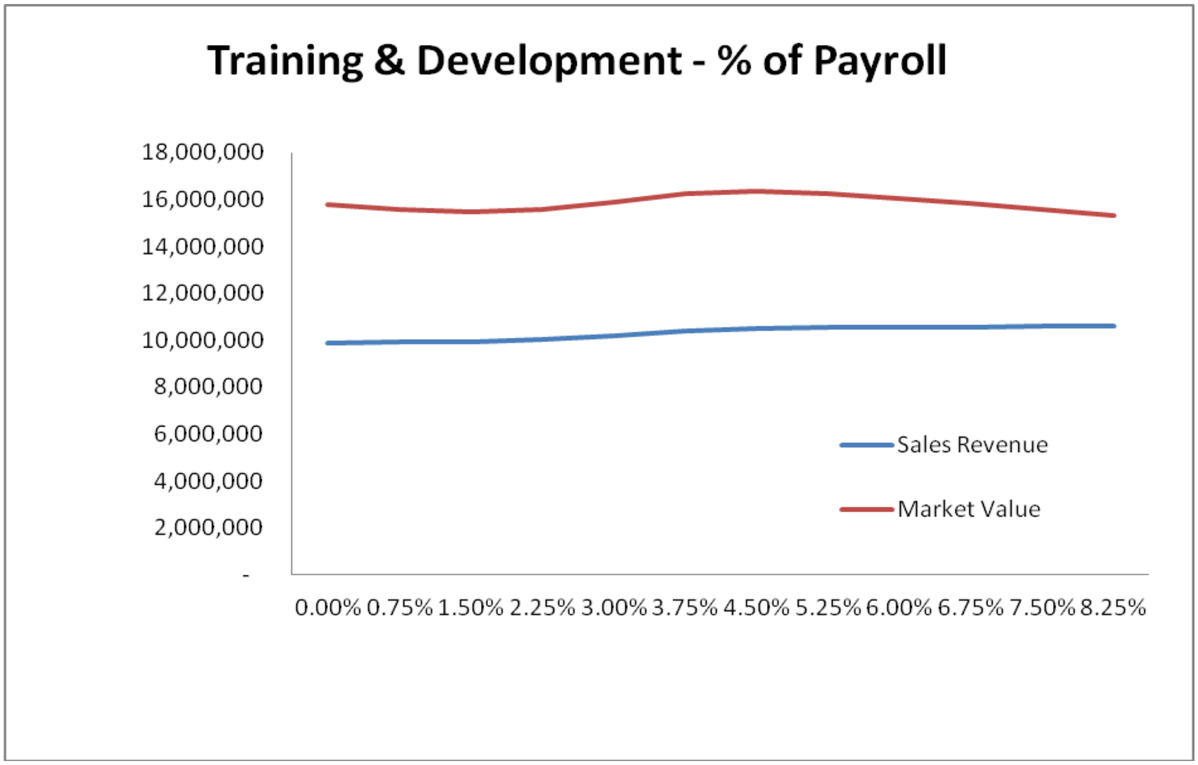
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
R & D Dollars	A	B	A	B	B	B	B

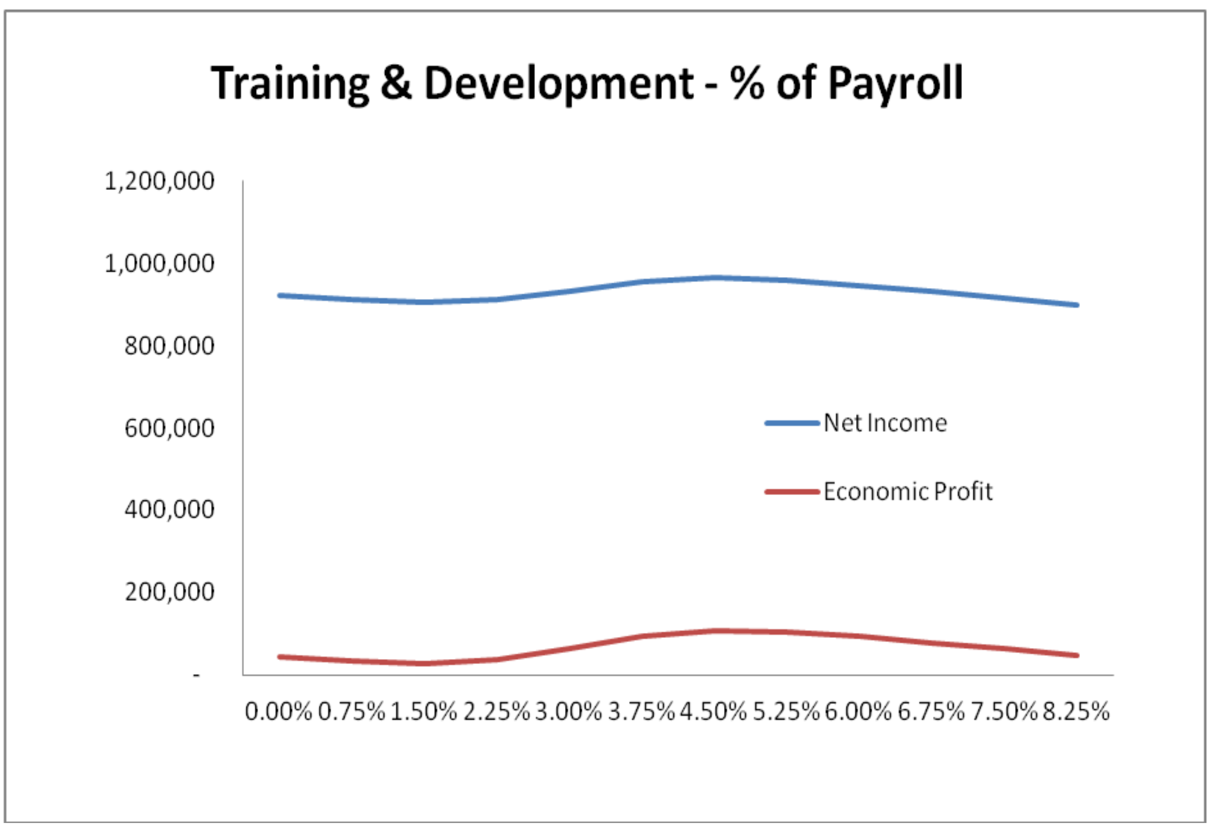
Fidelity Ratio = 7/7 = 1/00

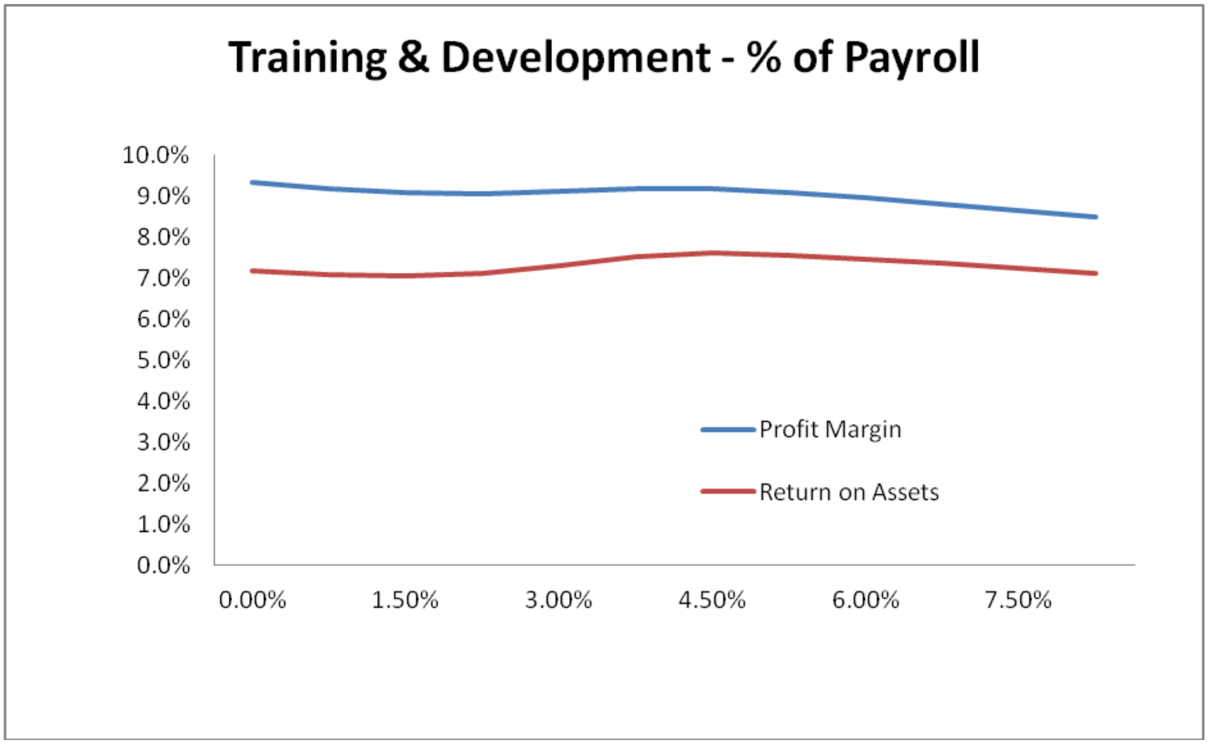
Test 7 – Independent Variable = Training and Development

Training and Development (% of payroll)	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
0.00%	329,701	923,063	9,891,037	15,793,927	9.3%	43,343	7.2%
0.75%	330,214	911,362	9,906,427	15,600,838	9.2%	32,232	7.1%
1.50%	331,595	905,559	9,947,857	15,499,798	9.1%	28,019	7.1%
2.25%	334,820	911,444	10,044,607	15,580,546	9.1%	37,616	7.1%
3.00%	340,360	932,499	10,210,807	15,895,235	9.1%	65,048	7.3%
3.75%	346,249	955,363	10,387,477	16,233,826	9.2%	94,691	7.5%
4.50%	350,029	965,020	10,500,877	16,368,613	9.2%	108,699	7.6%
5.25%	351,738	958,633	10,552,147	16,256,949	9.1%	104,280	7.6%
6.00%	352,386	946,725	10,571,587	16,062,411	9.0%	93,117	7.5%
6.75%	352,616	931,975	10,578,487	15,824,180	8.8%	78,633	7.4%
7.50%	352,695	916,200	10,580,857	15,569,744	8.7%	62,948	7.2%
8.25%	352,722	900,071	10,581,667	15,309,320	8.5%	46,850	7.1%




Training & Development - % of Payroll
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
Sales Revenue
Market Value
0.00% 0.75% 1.50% 2.25% 3.00% 3.75% 4.50% 5.25% 6.00% 6.75% 7.50% 8.25%


Training & Development - % of Payroll
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Net Income
Economic Profit
0.00% 0.75% 1.50% 2.25% 3.00% 3.75% 4.50% 5.25% 6.00% 6.75% 7.50% 8.25%



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Training Budget	A	B	A	B	H	B	B

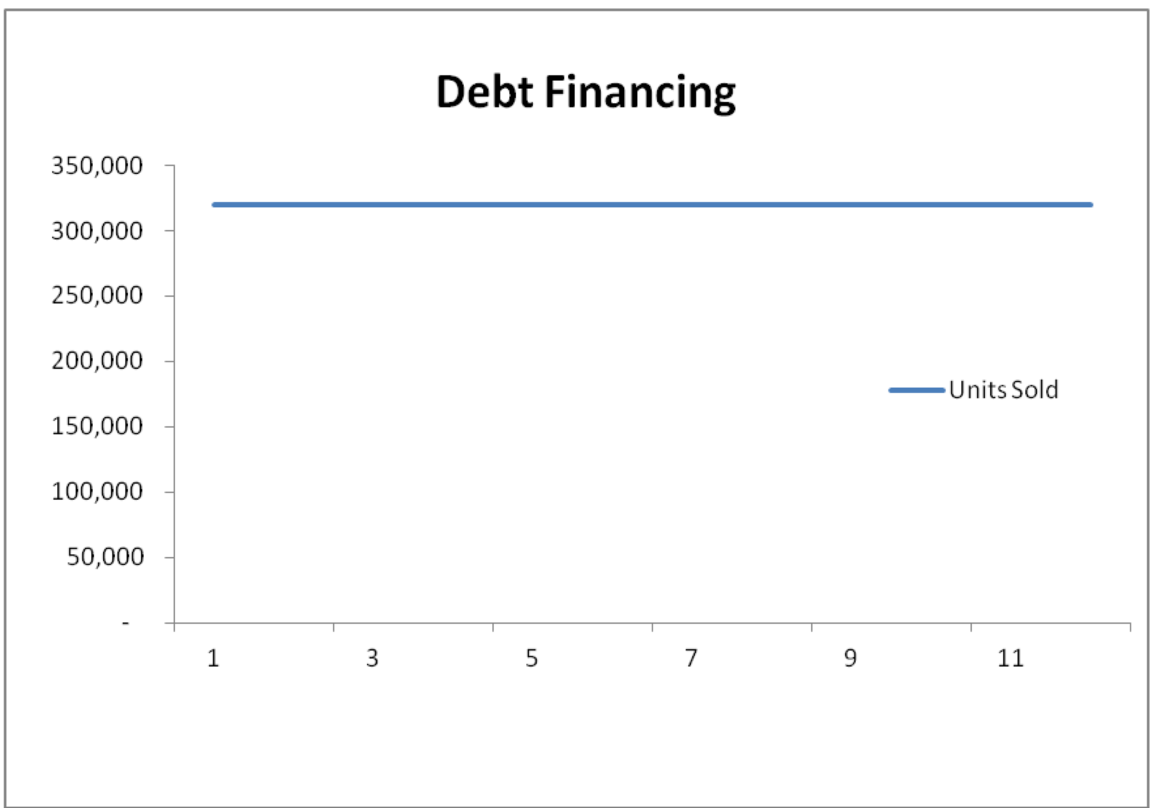
Actual

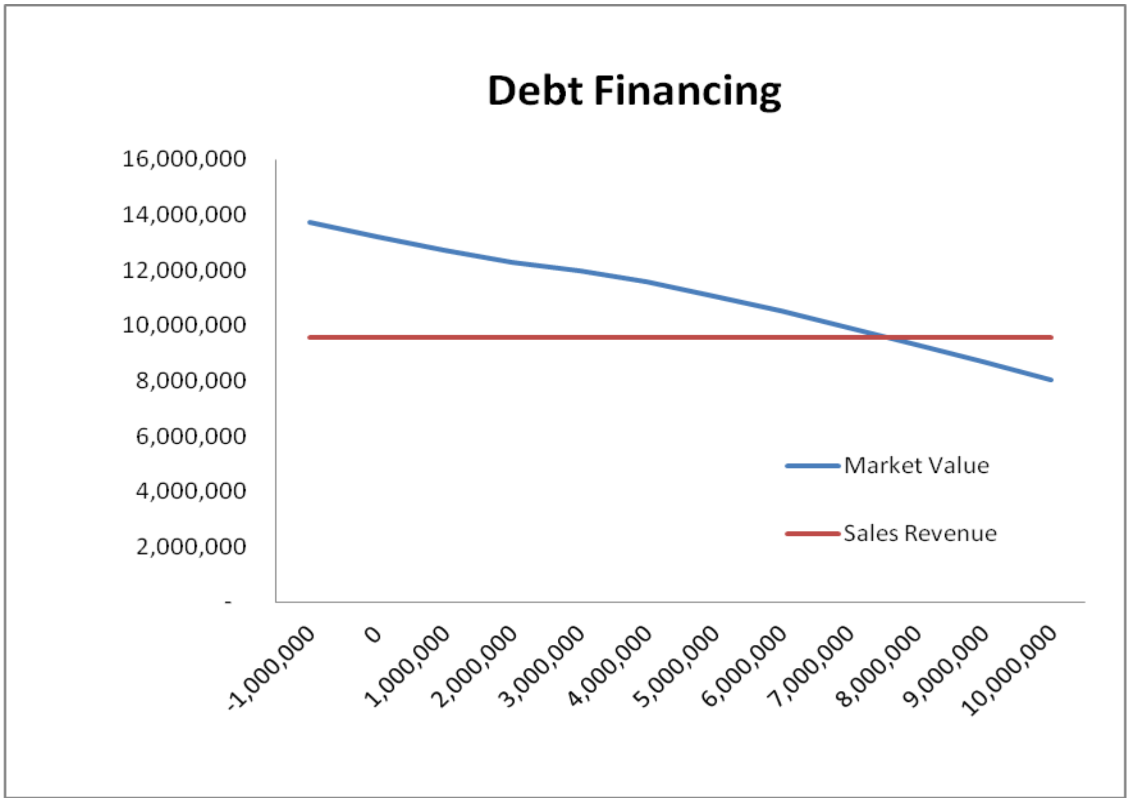
Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Training Budget	A	B	A	B	H	B	B

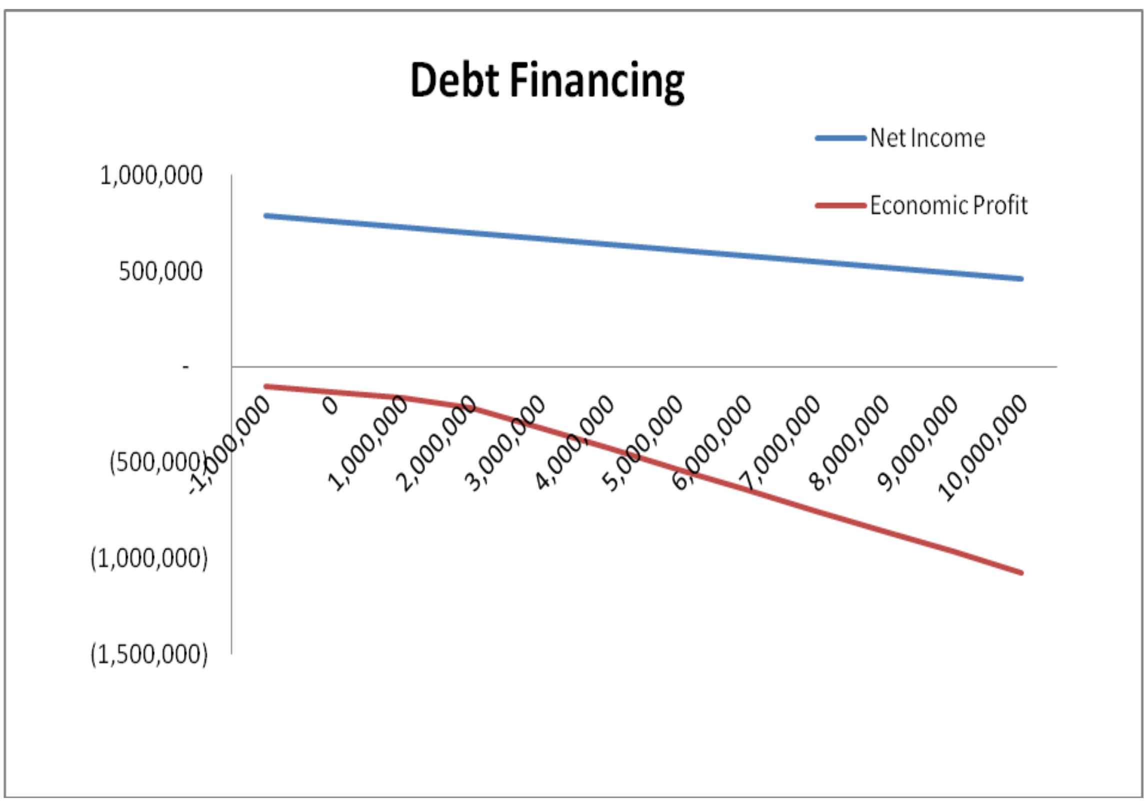
Fidelity Ratio = 7/7 = 1.00

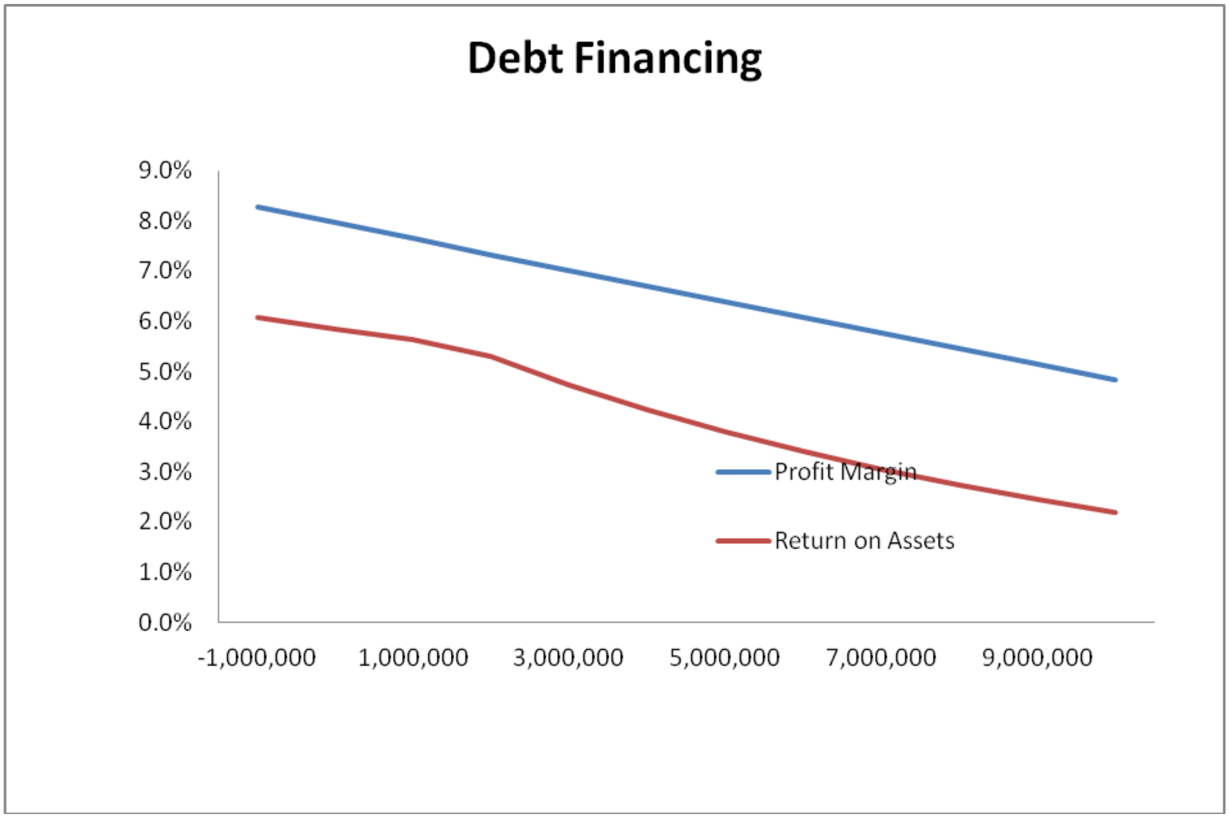
Test 8 – Independent Variable =

Issue / Retire Long-term Debt	Units Sold	Net Income	Sales Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets	WACC	leverage
-1,000,000	319,598	792,726	9,587,947	13,730,532	8.3%	(105,167)	6.1%	0.062	0.364
0	319,598	762,726	9,587,947	13,228,912	8.0%	(135,167)	5.9%	0.062	0.366
1,000,000	319,598	732,726	9,587,947	12,725,634	7.6%	(165,167)	5.6%	0.062	0.369
2,000,000	319,598	702,726	9,587,947	12,293,655	7.3%	(213,492)	5.3%	0.061	0.382
3,000,000	319,598	672,726	9,587,947	11,998,694	7.0%	(321,092)	4.7%	0.059	0.426
4,000,000	319,598	642,726	9,587,947	11,581,420	6.7%	(428,692)	4.2%	0.057	0.465
5,000,000	319,598	612,726	9,587,947	11,079,696	6.4%	(536,292)	3.8%	0.055	0.498
6,000,000	319,598	582,726	9,587,947	10,521,018	6.1%	(643,892)	3.4%	0.054	0.529
7,000,000	319,598	552,726	9,587,947	9,925,541	5.8%	(751,492)	3.1%	0.052	0.555
8,000,000	319,598	522,726	9,587,947	9,308,135	5.5%	(859,092)	2.7%	0.051	0.580
9,000,000	319,598	492,726	9,587,947	8,679,826	5.1%	(966,692)	2.5%	0.050	0.601
10,000,000	319,598	462,726	9,587,947	8,048,799	4.8%	(1,074,292)	2.2%	0.049	0.621




Debt Financing
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
-1,000,000
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
8,000,000
9,000,000
10,000,000
Market Value
Sales Revenue


Debt Financing
Net Income
Economic Profit
1,000,000
500,000
-
(500,000)
(1,000,000)
(1,500,000)
-1,000,000
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
8,000,000
9,000,000
10,000,000



Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Change in LTD	E	H	E	B	H	H	E

Actual

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Change in LTD	E	H	E	H	H	H	E

Fidelity Ratio = 6/7 = .86

Summary – Expected

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Units Produced	C	B	C	B	B	B	B
Quality	F	B	F	B	B	B	B
Price	G	B	B	B	B	B	B
Promo Dollars	C	B	C	B	B	B	B
Credit Terms	F	B	F	B	B	B	B
R & D Dollars	A	B	A	B	B	B	B
Training Budget	A	B	A	B	H	B	B
Change in LTD	E	H	E	B	H	H	E

Summary- Actual

Decision	Units Sold	Net Income	Revenue	Market Value	Profit Margin	Economic Profit	Return on Assets
Units Produced	C	B	C	B	B	B	B
Quality	F	B	F	B	B	B	B
Price	G	B	B	B	B	B	B
Promo Dollars	C	B	C	B	B	B	B
Credit Terms	F	B	F	B	B	B	B
R & D Dollars	A	B	A	B	B	B	B
Training Budget	A	B	A	B	H	B	B
Change in LTD	E	H	E	H	H	H	E

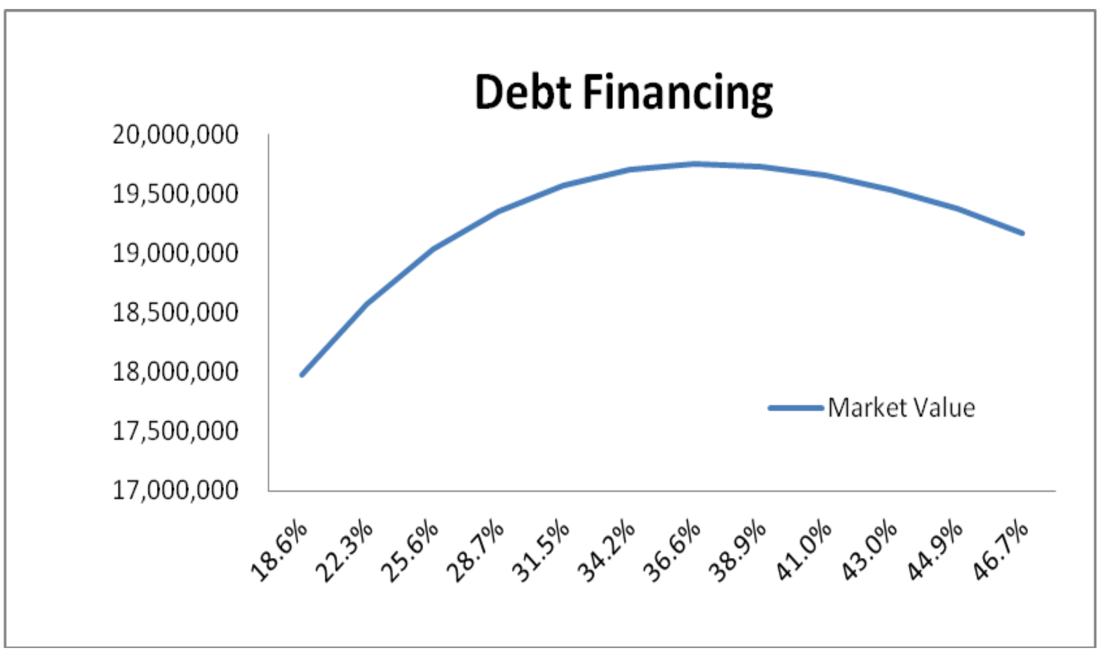
Fidelity Ratio = 55/56 = .98

Discussion of Results

The objective of this exercise is to test the assessment tools using the prototype simulation. Because the prototype simulation was guided by the General Framework for Effective Simulation Development, it is expected to pass the test for pedagogical soundness, which it did with a perfect score. More importantly, the checklist does provide a developer or user of a simulation to critically evaluate and score any business simulation. It is not recommended that a minimal threshold for acceptance be established. Rather, its effectiveness can be established by the number of “yes” checks.

In testing the economic fidelity of the test simulation, it is again expected to conform to economic theory as the algorithms were explicitly selected for that purpose. Of the 56 associations tested, 55 did conform to the expected pattern. The one that did not, market value, requires further reflection.

The test values were created using an array of "credible" values. What if the test was run again using "superior" values? The experiment was recreated with the following two changes. Research and Development funding was increased from $250,000 to $300,000 and the training budget was increased from 2.5% of payroll to 4%. Benchmarked against industry practices, both are closer to ideal than adequate. With these changes, the new relationship does show a match to expected economic theory with market value reaching a peak when the firm is leveraged at 36.6%.



Because the firm modeled first was not making adequate profits, the advantages of a lower cost of capital was offset by the increased interest charge. This is a classic example of not using leverage effectively.

The entire set of tests was recreated using the new superior numbers. The results reported earlier were not affected and in fact, the total fidelity ratio of the test simulation is 1.00, as expected. The second set of tests need not be reported as a favor to the reader's time.

A final issue to address is why was this assessment not applied to a different simulation? Recall, the intent of this dissertation is to not only create an assessment tool based on best practices, but to demonstrate that by following the guidelines presented, a simulation that is both pedagogically sound and consistent with economic theory can be developed. Hopefully, the details of Chapter Four are useful and support this assertion.

In summary, the two assessment tools developed for this dissertation have been implemented successfully. The test simulation created for this project was used as a test and was judged to be an effective business simulation for teaching based on both the General Framework for Effective Simulation Development established through research, and the test simulation has demonstrated economic fidelity as the simulation results match established economic theory.

Chapter Six: Summary and Conclusion

There are virtually hundreds and hundreds of computer simulations that are marketed to business faculty today. Although many business simulations used to teach managerial decision making are based on simple linear models, economic behavior in the marketplace is in fact a nonlinear dynamic system. Therefore, unless the outcomes of a simulation accurately represent the financial and operational realities of business, actual learning and, by inference, career preparation for business students is inhibited. The development of a framework which heretofore has not existed that reflects a set of both best practices and theoretical understanding would address this significant problem in higher education today.

The three main objectives this dissertation were to (1) to identify and codify a framework for best practices in developing a simulation; (2) to construct a prototype or test simulation based on these best practices; and (3) to create a methodology to assess pedagogical efficacy and economic fidelity. To that end, a General Framework for Effective Business Simulation, the first of its kind, was created that integrates key principles from economic theory and game theory, fundamentals of certain learning theory, and components of computer interface design based on visualization and communication theory. A methodology is presented to test the fidelity of internal modeling against simulated outcomes that reflect the veracity of economic theory.

Contributions to Knowledge

Business Simulation in some form has been used for many years as a methodology for teaching business. Since the 1950's many simulations have used computer technology and with the advent of the personal computer in the 1970's and 1980's, this methodology has become more popular and accessible as the number of simulations has increased and both faculty and students became accustomed to working with this medium. The literature review captured the many benefits to employing computer simulation. Among those benefits are; increased student engagement, more authentic assessment, the ability to experiment with alternate strategies and decisions, and the opportunity to practice and receive immediate feedback. Given these benefits, it is interesting that simulation use within business schools has lagged behind usage levels in the corporate training area.

While this study cited many reasons for instructor ambivalence toward using simulation technology, quality and fidelity issues are two major issues. In fact, instructors are correct in shunning the use of a commercially developed simulation due to an inability to make a proper judgment of the simulation as a teaching tool. As of the time this dissertation was planned and written, however, there is no objective process for an instructor to accurately make this assessment. A major contribution of this paper is to fill this need by developing two tools that can be used to judge the pedagogical merit and economic fidelity of a business simulation: a checklist for developing an effective simulation, and a methodology to test a simulation's economic fidelity.

The creation of the General Framework for Effective Simulation Development which currently does not exist is a significant contribution of this project Derived from existing research, these 12 elements represent the best practices employed by successful simulation users and developers and will serve as guide for the future development of simulations. Adherence to these principles will enable more faculty members to confidently adopt simulation technology in their classes and improve the learning experience for business students.

Another concern among faculty members is the economic fidelity of the simulations that are marketed to them. Because the algorithms are buried within the simulation engine, the nature of the functions is not exposed. A great risk is a developer may not be familiar with the true nonlinear relationships between inputs and outcomes that are understood from economic theory and real world experience. As a consequence, the simulation may be driven by the simpler mathematics of linearity, or approximated by quasi-linear methods such as the step function rooted in branching "if-then" statements. This produces a model with flawed outcomes and can lead to not only confusion for the students, but a misunderstanding of the nature of business and decision-making. Due to the power of simulation as a teaching and learning tool, this is a grave mistake.

This dissertation offers two remedies for that problem. First, all of the mathematics used to model the test simulation, SimWrite!, are published and accompanied by the underlying economic theory that forms the basis for the functional relationships. Secondly, a methodology and tool, The Economic Theory Input-Output Matrix, now is developed and is available to users to implicitly test the economic fidelity, and even generate an absolute measure of fidelity via the Fidelity Ratio.

Another contribution of this work is that many faculty members may desire to create their own simulations but don't know where to begin. The detailed narrative comprising Chapter Four is intended to be a blueprint for them to develop a high quality teaching simulation that is, consistent with the General Framework for Effective Simulation Development and that ensures economic fidelity. The blueprint provides a simplified development process that should be within the ability of many individual faculty members, and certainly within the capabilities of a small team of colleagues.

Limitations of the Study

There are two possible limitations of this dissertation. The tools for assessing simulation pedagogy and economic fidelity were tested on a single simulation; that is, a simulation created to represent a model of a quality simulation based on the General Framework for Effective Simulation Development. While it is assumed that the checklist is both accurate and comprehensive, it may be that further research could provide evidence for an enhanced checklist. Secondly, the entire project assumes that economic theory in fact is a valid representation of business activity. (Appendix I is a summary of the economic theory applied to this project.) In a similar manner, it is assumed that the simulation player is a "rational man" as characterized in traditional economic theory. That is, the player is interested in maximizing some measure of economic value rather a social value such as employment levels or environmental concerns. Of course it is possible to create a simulation with a behavioral or normative objective in mind, but SimWrite! is not intended to be used as such.

Further Research

As noted in the prior section, applying the tools and methodology developed herein can be replicated with other simulations. Of particular interest is an examination of those simulations that have been marketed effectively and are currently used in business school courses.

Another use for simulation was inspired by the series of fidelity tests in Chapter Five. Rather than using simulation exclusively as a teaching apparatus, the data generated can be collected and employed to conduct other research. In other words, the simulation itself can serve as a research instrument. For instance, various financial metrics can be plotted as a function of number of plays and a learning curve or pattern may emerge. Comparing patterns within groups and between groups may generate insights about learning environments that a faculty member can adapt to. For instance, determining an effective number of team members, or assessing whether cross-functional teams perform better than a team with the same major. A second use of a simulation such as SimWrite! that has a replay option and database capabilities, is to use the database in to teach and demonstrate multivariate statistics. Specifically, modeling tools such as multiple regression and predicative analytics using Logit or Probit Analysis can be demonstrated and tested by students in a lab setting. The possibilities for using simulation as a research instrument are infinite.

It may interest behavioral economists to use simulation in two ways. Simulation can be used as a teaching and learning tool in non-profit organizations where financial measures are not established as goals but rather are constraining variables. With the increase in non-profits and the financial challenges faced by religious organizations, the opportunities in this segment are substantial. Another research application is to test the rationality assumption of decision makers.

These are very ambitious research agendas but are viable extensions of the discoveries and methodology presented in this dissertation.

Conclusion

Writing this dissertation was a challenging and intense task! The outcome is most satisfying to the author. The body of knowledge in the domain of business simulations has been extended. Best practices have been identified and codified into a General Framework for Effective Simulation Development. This framework led to the creation of a checklist that can be used to evaluate the pedagogical elements of business simulations being marketed, and will provide guidance to those who will create future business simulations. A methodology was established to use another new tool brought forth, The Economic Theory Input-Output Matrix that can be used to assess the economic fidelity of existing simulations, and establish a threshold for future simulations.

As a result of this dissertation, business simulation as a teaching and learning tool will continue to evolve as a superior technology and all impacted by the business school will benefit.

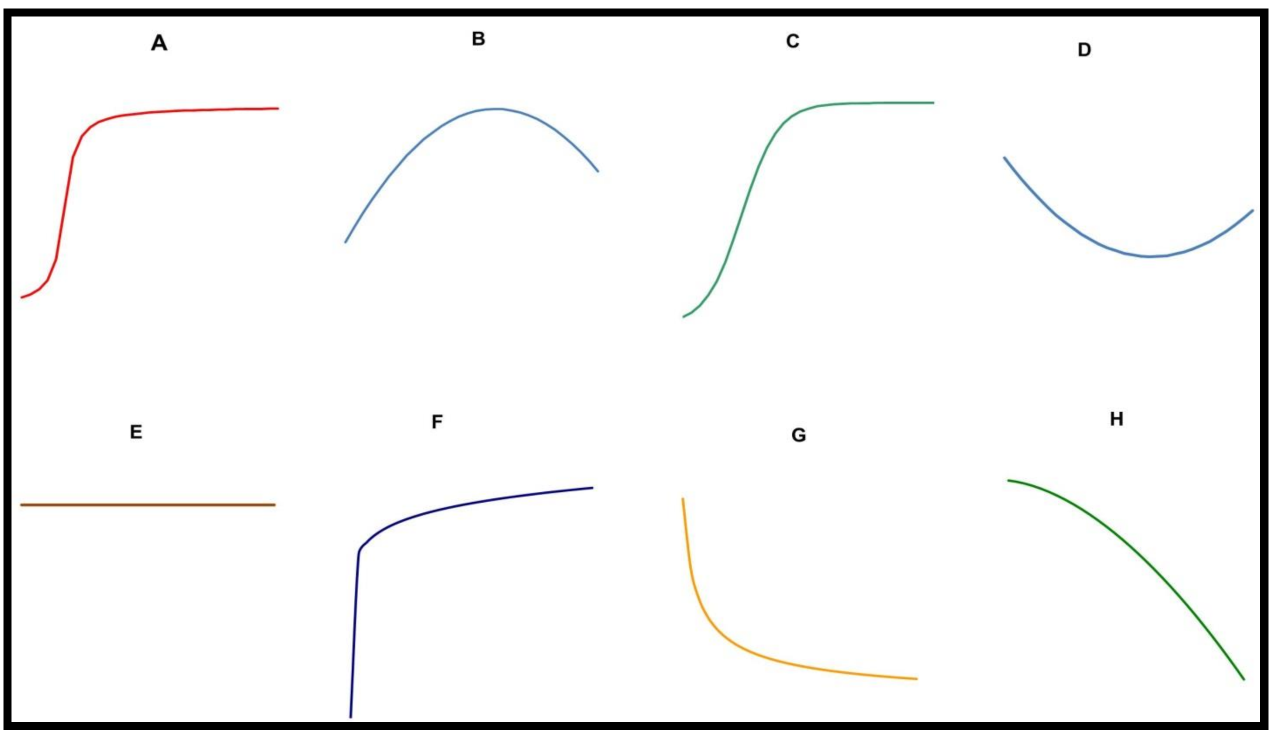
Appendix I: A Review of Economic Theory

Note: The descriptions and graphs of economic associations and theory can be corroborated from many sources, several of which are cited in the bibliography (Berman, Knight, & Case 2006; Brigham & Houston, 2001; Chamberlin, 1939; Copeland, Weston, & Shastri, 2005; Cowell, 2006; Hubbard & Obrien, 2010; Huselid, 1995; Marshall, 1920; McConnell & Brue, 1999; Samuelson & Nordhaus, 2003; Schiller, 2013). It is from this body of theory the expected economic theory input-output matrix was derived that is used to assess the economic fidelity of simulation results. Below is a summary of the theoretical associations between the input or independent variables and output or dependent variables selected for this dissertation. For convenience of the reader, the graphical references are reproduced here along with the technical note for each function.

Independent Variable	**Dependent Variables**
Units Produced	Units sold and revenue will increase until production equals demand. At that point, units sold and revenue will flatten out. It will appear as graph C. All other dependent variables will assume a parabolic shape such as graph B and will attain their respect maxima when production and demand are in equilibrium.
Quality	As quality improves, units sold and revenue will increase at an exponentially dampened rate as in graph F. The function dampens due to the law of diminishing utility among consumers and the law of diminishing returns to inputs. All other dependent variables will assume a parabolic shape such as graph B and will attain their respect maxima when tradeoffs between quality and the respective dependent variable are maximized.
Price	Units sold will appear as a classic downward sloping concave curve such as graph G due to the law of diminishing marginal utility of consumers. All other dependent variables will assume a parabolic shape such as graph B and will attain their respect maxima when tradeoffs between price and the respective dependent

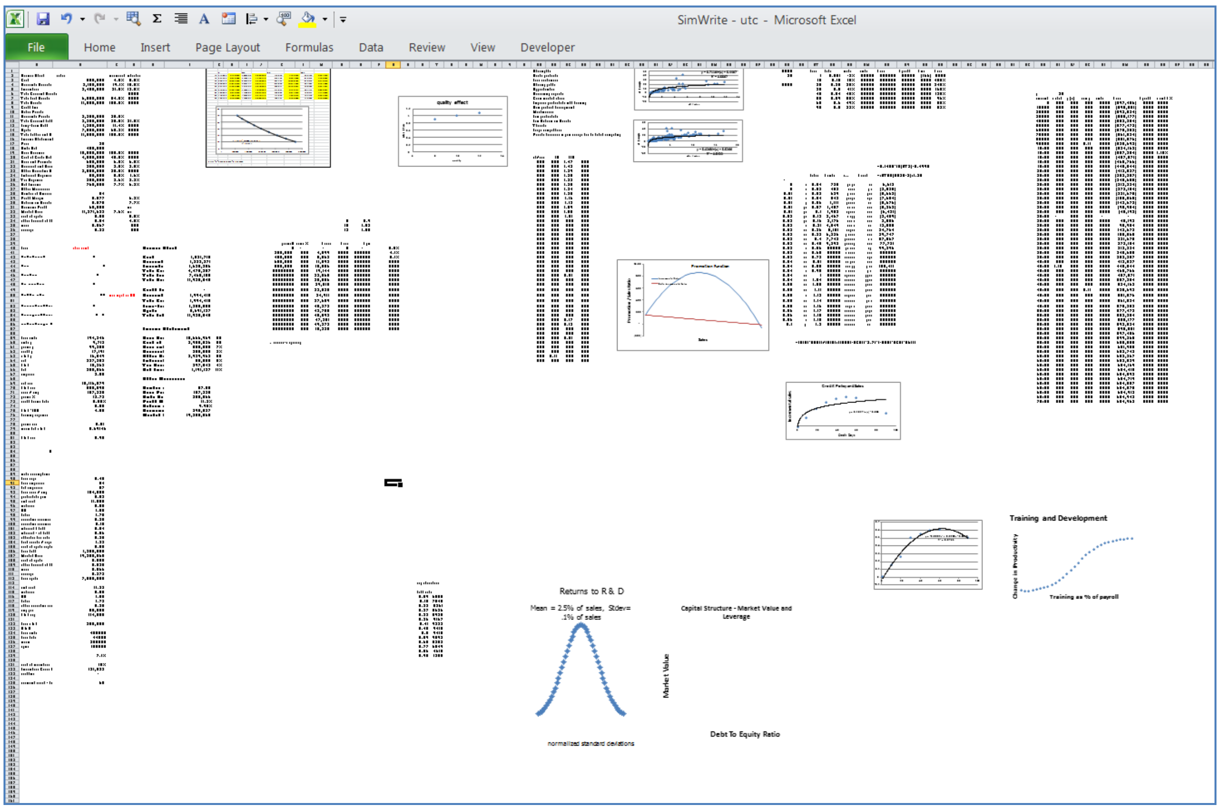
	variable are maximized.
Promotion Dollars	The relationship between promotion, sales units, and sales revenue is a logistic function such as graph A. As promotion increases, the dependent variable increases at an accelerating rate due to a limited range of increasing returns and then continues increasing at a decreasing rate due to the law of diminishing returns to factor inputs. All other dependent variables will assume a parabolic shape such as graph B and will attain their respect maxima when tradeoffs between promotion and the respective dependent variable are maximized.
Credit terms	As credit days offered increase, units sold and revenue will increase at an exponentially dampened rate as in graph F. The function dampens due to the law of decreasing value of opportunity cost dollars to the buyer. All other dependent variables will assume a parabolic shape such as graph B and will attain their respect maxima when tradeoffs between the opportunity cost of credit and the respective dependent variable are maximized.
Research & Development Dollars	In the immediate period an increase in R & D may generate new products, or product improvements resulting in a logistic curve such as graph A. In other cases the gains from R & D will have no impact on unit sales and revenue dollars and graph E will capture the relationship. All other dependent variables will assume a parabolic shape such as graph B and will attain their respect maxima when tradeoffs between R & D and the respective dependent variable are maximized. An exception is the case when there is no current term benefit. Then graph H, a decreasing convex relationship will best describe the short-term measures of profitability due to increased opportunity costs of the R & D resources. In either case, Market Value will still be parabolic if long-term benefits of R & D can be realized.
Training Dollars	Returns to training and development in terms of sales and revenue will increase logistically as graph A describes. The first inflection point is associated with learning curve effects. The overall increase in sales and revenue is expected due to increases in productivity of sales and marketing personnel. Productivity gains also explain the increase in the other profit oriented dependent variables. At some point, the marginal returns due to productivity gains will be eclipsed by marginal cost and the common parabolic function depicted by graph B suggests an optimal level of training relative to each dependent variable. The exception is profit margin. While overall profitability will

	increase over some range of training and development, it is increasing at an incrementally decreasing rate and overall profit margin will drop and appear as graph H.
Increase In Long-term Debt	According to financial theory, an increase in debt alters the capitalization of a firm and is an exchange of a less expensive form of capital (debt) for a more expensive source of capital (equity). This is explained by a risk differential. Debt holders have priority claim on assets during liquidation. Financial theorists have demonstrated empirically that at some level of debt, generally close to 50% of total assets, the cost of debt will be more costly that equity due to bankruptcy possibilities associated with greater leverage. The market value then will follow a parabolic function such as graph B. Independent of market value, the current profit related values will decrease as debt increases due to the cost of interest. Because interest rates will rise in correspondence to the increased risk of leverage, the association between debt and net income, profit margin, and economic profit will follow the pattern of graph H.



Appendix 2: Screen shots of selected algorithms

Developers often speak of their sim engine. Others refer to this as the black box which is always hidden from users. This screen (not intended to be read but rather displayed to view the big picture) contains the functions that can be expressed concisely with efficient mathematics. These formulas are on the left of the page and will be described more fully in the following three screen shots that capture the essence of the model. The tables and graphs on the right are used to fit the data mathematically.



The first screen shot captures the model assumptions contained in rows 90 through 135. The data set is a combination of benchmarked constant values, industry relationships such as expected productivity, and production cost components.

89	model assumptions	
90	base cogs	0.45
91	base employees	54
92	tot employees	=+B91+B67
93	base sales / emp	184000
94	productivity gain	=+(F71-B93)/B93
95	unit cost	=+B96+B97+B97
96	materials	8
97	OH	1.5
98	Labor	1.75
99	operating expense - base fixed	0.2
100	operating expense - base variable	0.15
101	interest lt debt	0.04
102	interest - st debt	0.06
103	effective tax rate	0.25
104	fixed assets / cogs	1.33
105	cost of equity capital	0.08
106	base debt	1250000
107	Market Value	=MAX((+F66/B110)*(1+B129),0)
108	cost of equity	0.08
109	after taxcost of ltd	=0.04*0.75
110	wacc	=((+F53/F54)*B108)+((((F54-F53)/F54))*B109)
111	leverage	=+(F54-F53)/F54
112	base equity	7500000
113		
114	unit cost	=+B115+B116+B117
115	materials	=+B44
116	OH	1.5
117	Labor	=1.75*(1-B94)
118	other operating expense	=+B99+(B100*(1-B94))
119	emp pay	50000
120	t & d exp	=+B119*F70*B54
121		
122	base r & d	250000
123	R & D	
124	base units	400000
125	base delta	=0.11*B124
126	mean	250000
127	sigma	100000
128		
129		= +(-2.4253*B111^2)+(1.5374*B111)-0.1678
130		
131	cost of inventory	0.15
132	Inventory Carry Cost	=+F44/2*B131
133	creditline	=+F49
134		
135	payment period - days	60

This is the system of equations used to derive the demand curve. Rows 42 through 56 are linked to the decisions screen. Rows 59 through 66 contain the equations to determine demand. The equations in rows 59 to 66 reference modifying calculations based on the functional relationships associated with other inputs such as quality, promotion, training expenditures, and credit policy. These functions are in rows 71 through 81.Other function terms are linked to the assumptions/benchmarking data displayed previously.

39			
40	decs		later relink
41			
42	**Units Produced**	**=+decs!D4**	
43			
44	**Quality**	**=+decs!D6**	
45			
46	**Sales Price**	**=+decs!D8**	
47			
48	**Promotion Dollars**	**=+decs!D10**	
49			
50	**Credit Terms - in days**	**=+decs!D12**	max input o
51			
52	**Research and Development**	**=+decs!D14**	
53			
54	**Training and Development % of payroll**	**=+decs!D16**	
56	**Issue / Retire Long-term Debt**	**=+decs!D18**	
58			
59	base units	=ROUND(+(21*B46^2.325)-(15428*B46)+600000,0)	
60	units q	=ROUND(IF(B44=6,B59*-0.25,IF(B44=8,0.05*B59,0.08*B59)),0)	
61	promo q	=ROUND(B78*B59,0)	
62	credit q	=IF(B50=0,-0.5*B59,(-0.0002*B50^2+0.0208*B50-0.0358)*B59)-79000	
63	r & d q	=ROUND(+((B79*B125*2)-B125),0)	
64	sub	=SUM(B59:B63)	
65	t & d	=ROUND(+(B81/10)*B59,0)	
66	tot	=IF(B46=47,5,IF(B46=48,4,IF(B46=49,3,IF(B46=50,2,MAX(+B64+B65,0)))))	
67	employee	=MAX(ROUND(+B70/B71,0),0)	
68			
69	sub rev	=+B64*B46	
70	t & d rev	=+B65*B46	
71	sales / emp	=+B69/54	
72	promo %	=+B48/(B46*B59)*100	
73	credit terms delta	=IF(B50=0,-0.005,0.1458*LN(B50)-0.5)	
74		=+(B52-B122)/(B122*0.4)	
75	t & d *100	=+B54*100	
76	training expense		
77			
78	promo calc	=(4*125)/(4+((125-0)*10^(-125*0.00125*B72)))/200	
79	norm dist r & d	=NORMDIST(B52,B122,B122*0.4,TRUE)	
80			
81	t & d calc	=+(0.05*1.2)/(0.05+(1.2--3)*2.71^(-1.2*1.2*B75))	
82			
83			
84	=COUNT(decs!D4:D18)		
85			

The simulation engine generates new financial statements and performance measures for each iteration of play. Rows 42 through 54 are the balance sheet formulas, rows 59 through 66 are the income statement formulas, and rows 70 through 76 are the financial measures. Each of the financial statements is linked to a combination of the assumption/benchmark formulas and the system of equations that comprise the demand function.

40	**Balance Sheet**		
41			
42	**Cash**	=IF(F53+F52+F50>F46+F44+F43,(F53+F52+F50-F46-F44-F43),0)	
43	**Accounts Reeivable**	=IF(B50=0,0,ROUND(+F59/(360/B50),0))	
44	**Inventory**	=ROUND(+MAX(0,(B42-B66)*B114),0)	
45	**Total Current Assets**	=+F44+F43+F42	
46	**Total Fixed Assets**	=ROUND(+B104*B114*B42,0)	
47	**Total Assets**	=+F46+F45	
48			
49	**Credit Line**	=MAX(+F47-F50-F52-F53,0)	
50	**Accounts Payable**	=ROUND(0.5*F60,0)	
51	**Total Current Liabilities**	=+F49+F50	
52	**Long-term Debt**	=+B106+B56	
53	**Equity**	=+B112+F66	
54	**Total Liabilities and Equity**	=+F49+F50+F52+F53	
55			
56			
57	**Income Statement**		
58			
59	**Sales Revenue**	=+F72*B46	=+F59/$F$59
60	**Cost of Goods Sold**	=+B114*F72	=+F60/$F$59
61	**Sales and Promotion**	=+B48	=+F61/$F$59
62	**Research and Development**	=+B52	=+F62/$F$59
63	**Other Operating Expense**	=+(B118*F59)+B120+B132	=+F63/$F$59
64	**Interest Expense**	=+B101*(B106+B56)	=+F64/$F$59
65	**Tax Expense**	=+IF(F59-F60-F61-F62-F63-F64<0,0,(F59-F60-F61-F62-F63-F64)*B103)	=+F65/$F$59
66	**Net Income**	=+F59-F60-F61-F62-F63-F64-F65	=+F66/$F$59
67			
68	**Other Measures:**		
69			
70	**Number of Employees**	=ROUND(+F59/F71,0)	
71	**Sales Per Employee**	=+B71	
72	**Units Sold**	=MIN(B66,B42)	
73	**Profit Margin**	=IF(F59=0,0,+F66/F59)	
74	**Return on Assets**	=+F66/F47	
75	**Economic Profit**	=+F66-((F54-F50)*B105)	
76	**Market Value**	=+B107	
77			
78			
79			

References

2011 Training Industry Report. (2011, Nov. - Dec.). *Training*, 32-39.

ATX Key Statistics | Cross (A.T.). *Yahoo! Finance - Business Finance, Stock Market, Quotes, News*. Retrieved December 27, 2012, from http://finance.yahoo.com/q/ks?s=ATX+Key+Statistics

Advertising-to-sales ratios for the largest ad spending industries. *Business to Business Advertising & PR*. Retrieved December 23, 2012, from http://www.creativepartnersgroup.com/index.php/component/content/article/1-latest-news/86-2007-advertising-to-sales-ratios-for-the-largest-ad-spending-industries

Aldrich, C. (2005). *Learning by doing: a comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences*. San Francisco, CA: Pfeiffer.

Anderson, P., & Lawton, L. (2006). The relationship between student success on a simulation exercise and their perception of its effectiveness as a PBL problem. *Developments in Business Simulation and Experiential Learning,* Volume, 33, 41-47.

BI essentials. *Comparisons*. Retrieved December 22, 2012, from bi.galegroup.com/essentials/company/302227?

Barton, J. (1974). How to create your own business game with IMAGINIT. *Bernie Keys Library*, *1*, 15-20.

Bass, G., & Geary, W. (1997). Education Research Abstracts. *Issues in Accounting Education*, 12(2), 607-613.

Benninga, S. (2008). *Financial modeling* (3 ed.). Cambridge, Mass.: MIT.

Berman, K., Knight, J., & Case, J. (2006). *Financial intelligence*. Boston: Harvard Business

School Press.

Brigham, E. F., & Houston, J. (2001). *Fundamentals of financial management* (9th ed.). Chicago: Dryden Press.

Brown, S. L., & Vaughan, C. C. (2009). *Play: how it shapes the brain, opens the imagination, and invigorates the soul*. New York: Avery.

Camerer, C. (2003). *Behavioral game theory: experiments in strategic interaction*. New York, N.Y.: Russell Sage Foundation.

Cannon, H. (1995). Dealing with the complexity paradox in business simulation games. *Developments in Business Simulation & Experiential Exercises*, *22*, 96-102.

Cannon, H., Friesen, D., Lawrence, S., & Feinstein, A. (2009). The simplicity paradox: another look at complexity in design of simulations and experiential exercises. *Developments in Business Simulation and Experiential Learning*, *36*, 243-250.

Capelo, C., & Dias, J. (2009). A system dynamics-based simulation experiment for testing mental model and performance effects of using the balanced scorecard. *SystemsDynamics Review*, *23*(1), 1-34. doi:10.1002/sdr:413

Chamberlin, E. (1939). *The theory of monopolistic competition; a re-orientation of the theory of value,* (3d ed.). Cambridge: Harvard University Press.

Chamberlin, E. (1961). The origin and early development of monopolistic competition theory. *The Quarterly Journal of Economics*, *75*(4), 515-543.

Chin, J., Dukes, R., & Gamson, W. (2009). Assessment in simulation and gaming - a review of the last 40 years. *Simulation and Gaming*, *40*(4), 553-567.

Cooper, A., & Reimann, R. (2003). *About face 2.0: the essentials of interaction design*. New York: Wiley.

Cooper, A. (2004). *The inmates are running the asylum* (2. ed.). Indianapolis, IN: Sams.

Copeland, T. E., Weston, J. F., & Shastri, K. (2005). *Financial theory and corporate policy* (4th ed.). Reading, Mass.: Addison-Wesley.

Cowell, F. A. (2006). *Microeconomics: principles and analysis*. Oxford: Oxford University Press.

Csikszentmihalyi, M. (1990). *Flow: the psychology of optimal experience*. New York: Harper & Row.

Dyson, G. (2012). *Turing's cathedral: the origins of the digital universe*. New York: Pantheon Books.

Eckhardt, R. (1987). Stan Ulam, John Von Neumann, and the Monte Carlo Method. *Los Alamos Summer Special Issue 1987, 1*, 131-141.

Edman, J. (2004). Information use in a business simulation game. *Developments in Business Simulation and Experiential Learning*, *31*, 203-209.

Edman, J. (2006). A price game with product differentiation in the classroom. *Developments in Business Simulation and Experiential Learning*, *33*, 334-340.

Ericsson, K. A. (1992). *Toward a general theory of expertise: prospects and limits*. Cambridge: Cambridge University Press.

Faria, A., & Wellington, W. (2004). A Survey of simulation game users, former users, and never users. *Simulation and Gaming*, *35*, 178-207.

Faria, A. J., Hutchinson, D., & Wellington, W. (2009). Developments in business gaming: a review of the past 40 years. *Simulation and Gaming*, *4*(August), 464-487.

Feinstein, A., & Cannon, H. (2001). Fidelity, verifiability, and validity of simulation: constructs for evaluation. *Developments in Business Simulation and Experiential Learning*, *28*, 57-

67.

Feinstein, A., Mann, S., & Corsum, D. (2002). Computer simulation, games, and role-play: drawing lines of demarcation. *Developments in Business Simulation and Experiential Learning*, *29*, 58-64.

Fink, L. D. (2003). *Creating significant learning experiences: an integrated approach to designing college courses*. San Francisco, Calif.: Jossey-Bass.

Frazer, J. (1980). Some issues in game design. *Developments in Business Simulation and Experiential Learning*, *7*, 184-186.

Free Pens, Mechanical Pencils, and Parts industry report - Bplans. *Free Sample Business Plans and Business Plan Software - Bplans*. Retrieved December 28, 2012, from http://www.bplans.com/industry_reports/report/pens_and_mechanical_pencils/3951

Free Plastics products Sector Corporation Financial Reports by BizStats *Free Business Statistics, Financial Ratios and Industry Statistics by BizStats*. Retrieved December 21, 2012, from http://www.bizstats.com/corporation-industry-financials/manufacturing-31/plastics-and-rubber-products-manufacturing-326/plastics-products-326100/show

Garris, R., Ahlers, R., & Driskell, J. (2002). Games, motivation, and learning: A research and Practice Model. *Simulation & Gaming*, *33*(4), 441-467.

Gjerde, K., & Hughes, S. (2007). Tracking performance: when less is more. *Management Accounting Quarterly*, *9*(1), 1-10.

Gladwell, M. (2008). *Outliers: the story of success*. New York: Little, Brown and Co.

Gleick, J. (2011). *The information: a history, a theory, a flood*. New York: Pantheon Books.

Gold, S. (2003). The design of a business simulation using a system-dynamics-based approach. *Developments in Business Simulation and Experiential Learning*, *30*, 1-9.

Goldman, D., Nance, R., & Wilson, J. (2009). A brief history of simulation. *Proceedings of the 2009 Winter Simulation Conference*, *1*, 310-313.

Goosen, K. (2010). The effect of advertising on demand in business simulations. *Developments in Business Simulations and Experiential Learning, Volume 37*, 79-94

Goosen, K., Mauri, A., Ritchie, W., & Wolfe, J. (2001). Helping new game adopters: four perspectives. *Developments in Business Simulation and Experiential Learning*, *28*, 80-91.

Gosenpud, J., Bush, J., & Scott, T. (1995). A comparison of a stand alone version of the traditional competitive version. *Developments In Business Simulation & Experiential Exercises*, *22*, 63-66.

Gosenpud, J., & Washbush, J. (2010). The relationship between learning and performance in a total enterprise simulation: revisited and new data. *Developments in Business Simulations and Experiential Learning*, *37*, 95-98.

Hall, J., & Cox, B. (1994). Complexity: is it really that simple. *Developments In Business Simulation & Experiential Exercises*, *21*, 30-34.

Hall, J. (2004). Computer simulation: a design architectonic. *Developments in Business Simulation and Experiential Learning*, *31*, 166-175.

Hall, J. (2005). Computer business simulation design: the rock pool method.. *Developments in Business Simulations and Experiential Learning*, *34*, 144-154.

Halpin, A. (2013). A review of the simulation research in the academy of management journal provides suggestions for strengthening the research conducted by ABSEL members.

Heer, J., & Agrawala, M. (2006). Software design patterns for information visualization. *IEEE Transactions on Visualization and Computer Graphics*, *12*, 5.

Hubbard, R. G., & Brien, A. P. (2010). *Economics* (3 ed.). Upper Saddle River, N.J.: Pearson Prentice Hall.

Huselid, M. (1995). The impact of human resource management practices on turnover, productivity, and corporate financial performance. *The Academy of Management Journal*, *38*(3), 635-672.

Jacobson, J. (2008, May). Teach tomorrow's leaders. *Training*, *45*, 18.

Juul, J. (2001). Games telling stories. . *The International Journal of Computer Game Research*, *1*, 1-12.

Kearney, P., & Pivec. Recursive loops of game-based learning: a conceptual model. *WWW.MajaPivec.com*. Retrieved February 18, 2012, from www.majapivec.com/files/recursive%20loops%20of%20gbl.pdf

Keeffe, M., & Cozan, C. (1985). General management policy simulations: which games are popular, and why do professors stop using games? *Developments In Business Simulation & Experiential Exercises*, *12*, 101-104.

Kelton, A., Tuttle, B., & Pennington, R. (2010). Presentation format on judgment and decision making: a review of the information systems research. *Journal of Information Systems,* *24*(2), 79-105.

Kennworthy, J. (2005). Evaluation of the effectiveness of using computer-based training simulations to develop managerial competency.. *A thesis submitted in partial fulfillment for the degree of Doctor of Business Administration*, 1-192.Klabbers, J. (2009). Terminology ambiguity: game and simulation. *gaming and simulation*, *40*(1), 446-463.

Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, N.J.: Prentice-Hall.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of It: how difficulties in recognizing one's own incompetence lead to inflated self-assessments . *Journal of Personality and Social Psychology*, *77*(6), 121-1134.

Lainema, T., & Lainema, K. (2007). Advancing acquisition of business know how: critical learning elements. *Journal of Research on Technology in Education*, *40*(2), 183-198.

Laseter, T., & Sarasvathy, S. (2012). Three games of strategic thinking. *Strategy + Business*, (Summer 2012), 27-31.

Lim, G. (2002). Evaluating business school undergraduates' situation analytic ability. *Journal of Management Education*, *26* (February), 19-39.

Mankiw, N. G. (2004). *Principles of macroeconomics* (3rd ed.). Mason, Ohio: Thomson/South-Western.

Markulis, P., & Strang, D. (2003). A brief on debriefing: what it is and what it isn't. *Developments in Business Simulation and Experiential Learning*, *30*, 177-184.

Marshall, A. (1920). Chapter 4: Income and capital. *Principles of Economics* (8 ed., pp. 43-44). London: Macmillan. Accessed from http://oll.libertyfund.org/title/1676/36091 on 2010-10-16

McConnell, C. R., & Brue, S. L. (1999). *Economics* (14th ed.). New York: McGraw-Hill.

McGonigal, J. (2011). *Reality is broken: why games make us better and how they can change the world*. New York: Penguin Press.

Miller, C., Nentl, N., & Zietlow, R. (2010). About simulations and Bloom's learning taxonomy. *Developments in Business Simulations and Experiential Learning*, *37*, 161-171.

Miller, C. (2012). Play it forward: the design and development of a forward contract simulation. *Developments in Business Simulations and Experiential Learning, 39*, 1-20.

Miller, G. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review*, *63*(2), 81-97.

Morecroft, J. (1999). Visualizing and rehearsing strategy. *Business Strategy Review*, *10*(3), 17-32.

Morgan, S., & Dennehy, R. (1995). Organizational storytelling: telling tales in the business classroom. *Developments in Business Simulation & Experiential Learning*, *22*, 160-165.

NAICS 339941 - FINTEL Industry Metrics Profile. *FINTEL- Business Benchmarking Tools | Financial Benchmarking Tools | Industry Data | Industry Standards*. Retrieved December 20, 2012, from http://secure.fintel.us/industry-metrics/naics/339941-pen-and-mechanical-pencil-manufacturing?action=PersistReport

Nentl, N., & Miller, C. (2002, October 24). SimSeries. *Learning by playing: teaching business learners using computer simulations.* Retrieved January 25, 2012, from http://www.mhhe.com/business/marketing/simseries_website/Craigs%20Simulation%20white_paper.doc

Nentl, N. J., & Miller, C. (2003). *SimSales Management Student Manual*. New York: McGraw-Hill Irwin.

Nentl, N. J., & Miller, C. (2004). *SimMarketing student playbook*. Boston: McGraw-Hill/Irwin.

Peach, B., & Roberts, R. (1999). Assessing the effects of feedback: multi-methods and multi-directions in multi-pedagogical courses. *Developments in Business Simulation and Experiential Learning*, *26*, 124-129.

Perotti, V., & Pray, T. (1990). Visual modeling of business simulations. *Developments in Business Simulation & Experiential Learning*, *27*, 34-41.

Pray, T., & Gold, S. (1982). Inside the black box: an analysis of underlying demand functions in contemporary business simulations. *Developments In Business Simulation & Experiential Exercises*, *9*, 110-116.

Pray, T., & Gold, S. (1990). Modeling demand in computerized business simulations. *Guide to business gaming and experiential learning* (pp. 117-138). East Brunswick: Nichols/GP Pub. ;.

Rahn, D. (2009). Enhancing web-based simulations with game elements for increased engagement. *Developments in Business Simulation and Experiential Learning*, *36*, 303-311.

Ravulapati, K., Rao, J., & Das, T. (2004). A reinforcement learning approach to stochastic business games. *IIE Transactions*, *36*, 373-385.

Rhodes, R. (1986). *The making of the atomic bomb*. New York: Simon & Schuster.

Robson, C. (2002). *Real world research: a resource for social scientists and practitioner-researchers* (2nd ed.). Oxford, UK: Blackwell Publishers.

Salas, E., Held, J., & Weissmuller, J. (2009). Performance measurement in simulation-based training. *Simulation and Gaming*, *40*(June), 328-376.

Samuelson, P. A., & Nordhaus, W. D. (2003). *Economics* (1. ed.). Buenos Aires: McGraw-Hill.

Schiller, B. R. (2013). *The Economy Today* (13 ed.). New York: McGraw-Hill Higher Education.

Seijts, G., Latham, G., Tasa, K., & Latham, B. (2004). Goal setting and goal orientation: an Integration of two different yet related literatures. *Academy of Management Journal*, *47*(2), 227-239.

Shubik, M. (2009). It is not just a game!. *Simulation and Gaming*, *40*(5), 587-601.

Snow, S., Gehlen, F., & Green, J. (2002). Different ways to introduce a business simulation: the effect on student performance. *Simulation & Gaming*, *33*(December), 526-532.

Snyder, L. (1997). An exploration into the non-use of business simulations. *Developments In Business Simulation & Experiential Learning,*, *24*, 164-165.

Stern, E. Why EVA Is the best measurement tool for creating shareholder value - Full Article - QFINANCE. *Financial resources, articles, concepts and opinions from QFINANCE - QFINANCE*. Retrieved October 16, 2010, from http://www.qfinance.com/business-strategy-best-practice/why-eva-is-the-best-measurement-tool-for-creating-shareholder-value?full

Stobbeleir, K. D., Ashford, S., & Buyens, D. (2011). Self-regulation of creativity at work: the role of feedback-seeking behavior in creative performance. *Academy of Management Journal*, *54*(4), 811-831.

Stock, J. H., & Watson, M. (2011). *Introduction to econometrics* (3. ed.). Boston: Addison-Wesley.

Tangedahl, L. (1998). An excel workbook for student planning and interface with a simulation game. *Developments in Business Simulation and Experiential Learning*, *25*, 109-109.

Teach, R. (1990). Designing business simulations. *Guide to business gaming and experiential learning* (pp. 93-116). East Brunswick: Nichols/GP Pub.

Teach, R., & Patel, V. (2007). Assessing participant learning in a business simulation. *Developments in Business Simulation and Experiential Learning*, *34*, 76-84.

Teach, R., & Murff, E. (2008). Are the business simulations we play too complex? *Developments in Business Simulation and Experiential Learning*, *35*, 205-211.

Thorelli, H. (1999). Simulation scenarios - rationale and illustration. *Developments in Business Simulation and Experiential Learning*, *26*, 364-365.

Von Neumann, J., & Morgenstern, O. (1944). *Theory of games and economic behavior,* ([3d ed.). Princeton: Princeton University Press.

Watters, C. (2006, August). 10 reasons why an 'evolved' simulation beats a 'custom' one. *Training*, *43*, 15.

Weinstein, M. (2007, April). Winning games. *Training*, *44*, 16-18.

Wellington, W., & Faria, A. J. (2006). Validating business simulations: do simulations exhibit natural market structures? *Developments in Business Simulation and Experiential Learning, Volume*, *33*, 118-123.

Wenzler, I. (2009). The ten commandments for translating simulation results into real-life performance. *Simulation and Gaming*, *40*(1), 98-108.

Wiener, N. (1948). *Cybernetics: control and communication in the animal and the machine*. New York: Wiley.

Williams, J. R., Haka, S. F., & Bettner, M. S. (2005). *Financial & managerial accounting: the basis for business decisions* (13th e[d]. ed.). Boston: McGraw-Hill/Irwin.

Wilson, k., Bedwell, W., Lazzara, E., Salas, E., Burke, C., Estock, J., et al. (2009). Relationships between game attributes and learning outcomes. *Simulation and Gaming*, *40*(2), 217-265.

Wolfe, J., & Gold, S. (2007). A study of business game stock price algorithms. *Simulation and Gaming*, *38*(2), 153-178.