ENTREPRENEURSHIP: A GAME OF RISK AND REWARD PHASE I – THE SEARCH FOR OPPORTUNITY

Elizabeth JT Murff
Eastern Washington University
ejtmurff@ewu.edu

Richard Teach
Georgia Institute of Technology
Richard.Teach@mgt.gatech.edu

ABSTRACT

ENTREPRENEURSHIP is a single person or single team, multi-stage business game. Its purpose is to provide a computerized business game environment that replicates some of the decisions entrepreneurs must make along with the possible rewards associated with undertaken risks. The complete game simulates the first five years in the development of a technology-related firm. Phase I of the game uses a simulated decision-cycle of 1 week for the opportunity recognition stage. After the opportunity is selected, the game shifts to a monthly decision cycle for Phase II, which is comprised of the venture capital stage, the product development stage and the market introduction stage. After these stages have all been completed, the game shifts to quarterly decisions for Phase III, running the business for the balance of the five years. Any time the firm cannot make its payroll, the game is over as the firm is deemed "Bankrupt." At this point, the player is encouraged to develop a paper on why the firm failed. To allow for further exploration of mistakes, the player can start the game anew. If the player successfully completes the first five years, the game terminates with the player being congratulated for being a successful simulated entrepreneur. This paper discusses Phase I of this game in detail.

INTRODUCTION

The game ENTREPRENEURSHIP is a non-competitive computer simulation of the first five years of a technology-based start-up firm. It simulates this new firm's development beginning with the identification of a viable opportunity, continues through the process of starting the firm and launching this new product in the marketplace, and finally ends with the firm hopefully surviving to "crossing the chasm." While "player" suggests a singular participant, it also refers to a role that could also be played by a team of players in this game.

Time is a critical factor in this game as the decision cycle varies depending upon the phase of the game being played. Phase I (opportunity recognition) uses a weekly decision cycle. Phase II (startup & launch) uses a monthly decision cycle. Phase III (chasm crossing) uses a three month decision cycle. The simulated time since the start of the game is reported to the player as week / month / year, with the game terminating at 0/0/5 unless the firm goes bankrupt sooner. The game operates on the basis of 4 weeks per month and 12 months per year. It assumes workweek of five 8-hour days for employees and usually the same for the inventor. This is not true for the game player's role of management principal (entrepreneur). This game does not account for holidays, vacations, or any other non-working time periods as it simply assumes these occur in the unaccountable time outside of the 4-week months. At various times throughout the game, some random and some not, the game schedules evening and weekend events for the entrepreneur. The player has the option of participating or not in these meetings; however either decision may lead to unexpected consequences both good and bad.

Due to the segmented nature of this game, only Phase I will be detailed in this particular paper. The first section of this paper is concerned with the game flow of this phase from the player's perspective. The second section of this paper is concerned with the technical detail of the generation of the parameters of an opportunity. The conclusion provides information for instructors on the lessons designed into this phase of the ENTREPRENEURSHIP game.

PHASE I FROM THE PLAYER'S POINT OF VIEW

At the start of the game, the player's role is that of someone who is known to be looking for an opportunity to join with a technology inventor to hopefully create a successful new venture. The market place for this new firm's product will be in the B2B market space; it will not be sold directly into the consumer marketplace. Initially, the player is presented with a new technology-oriented product-concept by an inventor who has already produced a working prototype. The R&D location where the initial work on the invention was done and where the working prototype was produced is also provided; however the invention is currently wholly owned by the inventor without any ownership residing with the previous employer. Furthermore, the player also receives some initial information on the potential market for the product. At the expense of simulated game time, the player has the option of receiving further estimates on viability of this product in its future marketplace in the form of a simplified probability distribution. The process of selecting an opportunity does not consume any money, as this phase simply assumes that the entrepreneur is doing the do diligence while gainfully employed by some unnamed entity.

The initial screen about a proposed product contains the following information in prose form:

- The current simulated time
- An invitation to form a jointly held entrepreneurial firm with the inventor
    - The inventor's name and title
    - The R&D location
    - The name of the invention
    - An assurance by the inventor of the existence of a working prototype
- Proposed details about this possible firm
    - The inventor's potential cash contribution
    - The player's expected cash contribution
    - An assurance that the inventor is willing to sign over the rights to the patented invention to the joint venture
    - A statement that this is to be an equally shared partnership
- Some market information for this product
    - The industry name and NAICS number
    - The primary value proposition
    - Estimates of unit sales during the product's first 5 years on the market
        - The expected unit sales
        - The optimistic unit sales the product has a 10% chance of exceeding
        - The pessimistic unit sales the product has a 10% chance of not exceeding

This initial screen also requires a decision from the player. In each case, the simulation time is advanced one week once the decision is made.

- Accept the offer – Parameters are locked into place and the game moves into phase II.
- Abandon this opportunity permanently – A new opportunity is randomly generated and the cycle repeats.
- Request more information – The player is presented with a new screen of possible choices of information.

The player receives the requested information in the form of an expected value, an optimistic (10% chance of exceeding) value and a pessimistic (10% chance of not exceeding) value. The phrasing of the output to the player is inverted with respect to optimistic and pessimistic when low values are desired, as in hours needed for product development. Each of these cost the player one week of simulation time. The information choices are:

- The expected market price received by the firm at the point of its 100th unit sale.
- The expected per unit materials cost of the 100th unit manufactured.
- The expected amount for the 100th product manufactured of direct labor needed for manufacturing one unit of the product and the current wage rate, including all labor for the intermediate processing, the assembly and final inventorying the product including the palletizing and packaging needs for shipment to the customers.
- The expected number of hours needed in product development before the product has passed its beta test and is ready for the marketplace.
- The amount of plant and equipment investment needed to produce the number of units to fulfill the first six months expected sales. Three sets of values are provided if this is requested:
    - Slow initial growth requiring 5 production employees
    - Intermediate initial growth requiring 10 production employees
    - Rapid initial growth requiring 20 production employees
- The learning curve coefficient for labor costs of the manufacturing process at the point of the 100th product manufactured
- The learning curve coefficient for material costs of the manufacturing process at the point of the 100th product manufactured

The 100th product manufactured is used so as to not to include the costly start-up expenses involved in getting the bugs out of the initial production setups of the equipment need to manufacture the product. A fourth value, the one used in the latter phases of simulation, is also generated for each of these and the expected unit sales; this value is not reported to the player however.

Once the requested information is received, the player is again asked to accept the offer, abandon the opportunity, or request more information. The results of this decision are the same as they are for the initial screen previously discussed. If a player requests the same information on a particular product, he will receive exactly the same information as before and again be charged one week of simulation time. The cycle repeats until the player has chosen an opportunity. Once this has occurred, all of the opportunity information from the initial screen and all of the opportunity information from the request screen, whether requested or not by the player, is passed as parameters to be used to control Phases II and III.

PHASE I FROM THE COMPUTER'S POINT OF VIEW

This phase of the ENTREPRENEURSHIP game enables the player to choose a starting position for the rest of the game. All starting positions are not equal; the choice made in this phase will have a major impact on the success or failure of the player in the latter phases. As predictability in the sequence of opportunities would seriously inhibit the exploration of mistakes through replay, probability distributions are used to generate the parameters of each opportunity. Although four different distributions are used here, their variates may be generated via the use of a uniform random digit generator. Details of this are discussed below.

The discrete uniform distribution is used to determine the inventor's name and title, the R&D location, the name of the invention, the industry name and the primary value proposition. The inventor's potential cash contribution and the player's expected cash contribution values are generated using the normal distribution. The continuous uniform distribution is used repeatedly to obtain the expected value, optimistic value and pessimistic value for unit sales and the additional values that may be requested by the player through the information request screen.

A special, non-symmetric distribution called the ED Distribution developed by the authors for use in simulations where the expected value, an optimistic value and a pessimistic value are used to inform the players about risk is used to determine these three values for unit sales and the additional values that may be requested by the player through the information request screen.

THE DISCRETE UNIFORM DISTRIBUTION

To use the discrete uniform distribution, a list of the possible values for the distribution is required. Then an entry is chosen with equal probability from this list. If one possibility is to have a higher probability of being chosen, it is repeated in the list as in the inventor's title list. The lists provided in this paper are not complete lists for this game; they have been shortened to enhance the brevity of this paper.

Consider the generation of the title and name of the inventor. Three lists will be needed: title, given name and family name. Suppose these lists are as in Table 1. Then a random whole number is chosen with equal probability between 1 and the length of the list inclusive. Now to generate a title and name from these lists:

- A random digit between 1 and 9 inclusive is needed for the title.
- A random digit between 1 and 7 inclusive is needed for the given name.
- A random digit between 1 and 8 inclusive is needed for the family name.

Suppose these digits were 3, 6 and 8 respectively. The inventor for the opportunity being generated would thus be known as "Dr. Mangus Mendez."

Only one list is needed to generate the R&D location. This includes entries such as Georgia Institute of Technology, Cambridge University, University of California – Berkeley, SRI, Harvard University, NRL, Case-Western Reserve, MIT, Purdue University, The Aspen Institute, Rand Corp, and Bell Labs. The method of selection for this list would require a random whole number between 1 and 12 inclusive. Suppose 1 was chosen. The inventor is now "Dr. Mangus Mendez formerly at Georgia Institute of Technology."

To generate the name of the invention, three lists are used in the same manner as for the title and name. Some of the entries in these lists are in Table 2.

Suppose numbers 8, 4, and 4 were randomly chosen. The opportunity under consideration is "the Immersive Cross-platform Buffer invented by Dr. Mangus Mendez while at the

Table 1
Some possible title, given name and family name lists

Dr.	Jane	Ammonds
Dr.	Shoba	Cooper
Dr.	Ian	Sainfort
Dr.	Kymberli	Kubo
Professor	William	Shafer
Professor	Mangus	Bryant
Professor	Jiandong	Abraham
(no title)		Mendez
(no title)		

Table 2
Some possible invention name lists

Anti-aliased	Animation	Aggregator
Client-side	Back-end	Architecture
Dynamic	Bezier	Assistant
Exponential	Cross-platform	Buffer
Hard-coded	Full-motion	Compressor
Hard-wired	Hyperlinked	Emulator
High-end	Motion-blurred	Framework
Immersive	Server-side	Infrastructure
Networked	Texture-mapped	Optimizer
Topographic	Vector-based	Transducer

Georgia Institute of Technology."

Next, suppose the random whole number generated for Table 3 was 5. The opportunity is now "the Immersive Cross-platform Buffer used in Ethyl Alcohol Manufacturing

Table 3
Possible B2B industry names with corresponding NAICS numbers

313312 Textile and Fabric Finishing Mills
321991 Manufactured Home (Mobile Home) Manufacturing
322212 Folding Paperboard Box Manufacturing
325110 Petrochemical Manufacturing
325193 Ethyl Alcohol Manufacturing
325212 Synthetic Rubber Manufacturing
325510 Paint and Coating Manufacturing
326211 Tire Manufacturing
327213 Glass Container Manufacturing
331112 Electrometallurgical Ferroalloy Product Manufacturing
332212 Hand and Edge Tool Manufacturing
332510 Hardware Manufacturing
332710 Machine Shops
333111 Farm Machinery and Equipment Manufacturing
333291 Paper Industry Machinery Manufacturing
333295 Semiconductor Machinery Manufacturing
333313 Office Machinery Manufacturing
333512 Machine Tool (Metal Cutting Types) Manufacturing
333513 Machine Tool (Metal Forming Types) Manufacturing
333613 Mechanical Power Transmission Equipment Manufacturing
333911 Pump and Pumping Equipment Manufacturing
333922 Conveyor and Conveying Equipment Manufacturing
333991 Power-Driven Handtool Manufacturing
334111 Electronic Computer Manufacturing
334220 Wireless Communications Equipment Manufacturing
334413 Semiconductor and Related Device Manufacturing
334512 Automatic Environmental Control Manufacturing
335312 Motor and Generator Manufacturing
336111 Automobile Manufacturing
336312 Gasoline Engine and Engine Parts Manufacturing

Table 4
Some possible value propositions

Reduces energy needs of manufacturing machinery in use by **p/2** %
Reduces CO_2 emissions by **p/1.5** %
Increases cutting tool expected life by **p** %
Reduces the direct labor costs in the manufacturing process of the buyer by **p/2** %
Increases milling and boring machine life by **p** %
Reduces water borne pollutants produced by manufacturing by **p/2** %
Increases mean-time-between-failures of machine tools by **p/1.5** %
Reduces ozone emissions by **p/2** %
Increases the efficiency of motors by **p** %
Increases the fuel efficiency of engines by **p/2** %

(NAICS number 325193) invented by Dr. Mangus Mendez while at the Georgia Institute of Technology."

The value proposition of the new invention involves a randomly selected entry from Table 4 and two values from the list of possible unmodified 5-year unit sales forecasts. This list will be discussed later. To obtain p in Table 4, divide the value drawn from the list by one more than the largest value in the list and multiply by 100. Values in Table 4 are rounded at one decimal place. Suppose the random whole number was 7 and the value of p was 48.6. This gives a primary value proposition of "increases mean-time-between-failures of machine tools by 32.4%."

The randomly generated opportunity is now "the Immersive Cross-platform Buffer which increases mean-time-between-failures of machine tools by 32.4% in Ethyl Alcohol Manufacturing (NAICS number 325193), which was invented by Dr. Mangus Mendez while at the Georgia Institute of Technology."

THE NORMAL DISTRIBUTION

The inventor's potential cash contribution and the player's expected cash contribution values are to be drawn independently from the normal distribution. The inventor's potential cash contribution has a mean of 500,000 and a standard deviation of 100,000. The player's expected cash contribution has a mean of 1,000,000 and a standard deviation of 200,000.

The values used in the game are obtained through an adaptation of the Box-Muller transformation, which generates a pair of independent standard normal variates from two values drawn independently from the continuous uniform distribution on the interval from 0 exclusive to 1 inclusive (Box & Muller, 1958). Let u_1 and u_2 be the two values drawn randomly from U(0,1]. Then,

$$Cash_{inventor} = 500000 + 100000\sqrt{-2\ln(u_1)}\cos(2\pi u_2)$$

$$Cash_{player} = 1000000 + 200000\sqrt{-2\ln(u_1)}\sin(2\pi u_2)$$

These values are then rounded to the nearest thousand. Suppose u_1 and u_2 were 0.275976 and 0.063956, respectively. Thus, "Dr. Mangus Mendez can potentially provide $648,000 to this joint venture and he expects the entrepreneur (player) to provide $1,126,000."

THE CONTINUOUS UNIFORM DISTRIBUTION

The parameters of the various estimates as reported to the player are generated using the following uniform distributions:

Consider the 5-year unit sales forecast. If the uniform random numbers generated were 360, 7, and 2645, the player would be informed on the initial screen that "the Immersive Cross-platform Buffer is expected to sell 360,000 units in its first five years on the market; however this could be as low as 7,000 units and as high as 2,645,000 units." Although the player only automatically sees the 5-year unit sales forecasts, the three values are generated for all ten variables as they are needed in the latter phases of the game.

THE ED DISTRIBUTION

The ED distribution is an asymmetric distribution generated from two normal distributions which have the same mean but different standard deviations. The parameters for this

Parameter generation for variables using the ED distribution
Table 5

Variable, X	Expected value, E_x	Pessimistic value, P_x	Optimistic value, O_x	Round to the nearest…
5-year unit sales forecast (in thousands)	U(50,500)	U(5,25)	U(1000,5000)	whole number
expected material costs* (in dollars)	U(75, 125)	U(25, 50)	U(200,500)	hundredth
expected unit direct labor costs* (in dollars)	U(75, 125)	U(25, 50)	U(200,500)	hundredth
expected price* (in dollars)	U(250,300)	U(150, 175)	U(400, 600)	hundredth
expected product development time (in hours)	U(2500,3500)	U(1500,2000)	U(4000,7000)	whole number
estimated plant and equipment investment for slow initial growth (in millions of dollars)	U(0.7,0.8)	U(0.5,0.6)	U(0.9,1.0)	thousandth
estimated plant and equipment investment for intermediate initial growth (in millions of dollars)	U(1.4,1.6)	U(1.2,1.3)	U(1.7,1.8)	thousandth
estimated plant and equipment investment for rapid initial growth (in millions of dollars)	U(2.9,3.1)	U(2.5,2.7)	U(3.3,3.5)	thousandth
expected learning curve coefficient for labor costs*	U(0.05,0.06)	U(0.02,0.04)	U(0.07,0.10)	hundredth
expected learning curve coefficient for material costs*	U(0.03,0.04)	U(0.01,0.02)	U(0.05,0.07)	hundredth

** Indicates this value is for the 100th unit produced* distribution are:

- E_x – the expected value of variable
- P_x – the pessimistic value which the variable has a 90% chance of exceeding
- O_x –the optimistic value which the variable has a 10% chance of exceeding

Figure 1 provides a visualization of this distribution where these values are 360, 7 and 2645 respectively as in the expected 5-year unit sales (in thousands) example in the last section. The percentages for pessimism and optimism can vary and even be unequal. However these circumstances are not needed for this game and thus they are not presented here.

Let $\sigma_{low} = (E_x - P_x)/1.2816$ and $\sigma_{high} = (O_x - E_x)/1.2816$. Then a normal distribution with mean of E_x and standard deviation of σ_{low} is used to obtain a set of 50 independent random variates for values at or below E_x. Similarly, a normal distribution with mean of E_x and standard deviation of σ_{high} is used to obtain a set of 50 independent random variates for values above E_x. As half of the variates are to be at or below E_x and half are to be above, this is readily achieved by using another adaptation Box-Muller (1958) transformation 50 times. In each iteration, let u_1 and u_2 be the two values drawn randomly from U(0,1]. Apply the transformation (2) and store the results. After all 50 iterations, 100 random variates from the ED distribution have been drawn.

$$X_{low} = E_x - \sigma_{low}\left|\sqrt{-2\ln(u_1)}\cos(2\pi u_2)\right|$$
$$X_{high} = E_x + \sigma_{high}\left|\sqrt{-2\ln(u_1)}\sin(2\pi u_2)\right|$$

If X_{low} is less than zero, its value is reset to zero. Next, these 100 variates are sorted from low to high. The empiric cumulative distribution of the actual values drawn from ED(360,7,2645) may be seen in figure 2.

Next, a uniform random whole number between 1 and 100

Figure 1
The cumulative distribution function for ED(360, 7, 2645)

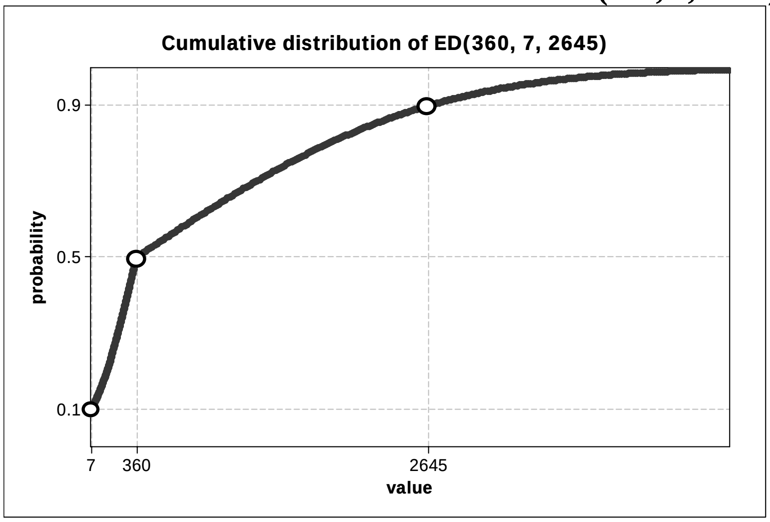
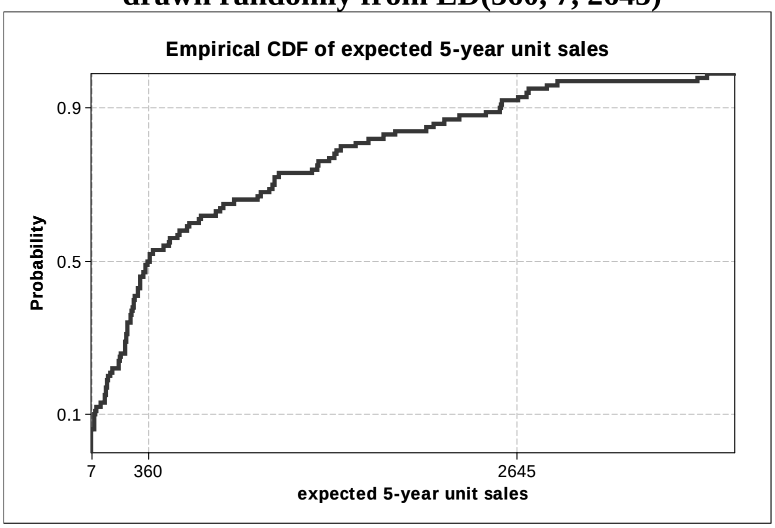


Figure 2
An empirical cumulative distribution function for 100 observations drawn randomly from ED(360, 7, 2645)



inclusive is generated. This is the location in this list of the actual variable value, X. Suppose this value was 87, then the value was chosen from the list is 2197. The actual 5-year demand unknown to the player for “the Immersive Cross-platform Buffer” prior to modifications made by the player’s decisions in the second and third phases is 2,197,00 units. Furthermore, the value of p used in the selection of the primary value proposition is 2197/(4523+1)*100 = 48.6.

While the player may be informed of E_x, P_x and O_x, he is not informed of the actual value of X as this is part of the risk of being an entrepreneur. These four values for each of the ten variables in table 5 are stored to be used in phases II and III

CONCLUSION

In the first phase of the ENTREPRENEURSHIP game, the various parameters used in the second and third phase are generated. In the example presented in this paper, the player was presented with:

> An opportunity to form an equally-owned joint venture with Dr. Mangus Mendez to produce his Immersive Cross-platform Buffer that he invented while at the Georgia Institute of Technology. This B2B product increases mean-time-between-failures of machine tools by 32.4% in the Ethyl Alcohol Manufacturing (NAICS number 325193) industry. The Immersive Cross-platform Buffer is expected to sell 360,000 units in its first five years on the market; however this could be as low as 7,000 units and as high as 2,645,000 units. Dr. Mendez can potentially provide $648,000 to this joint venture and he expects the entrepreneur (player) to provide $1,126,000.

The choice is now up to the player. Should he accept the offer, abandon the opportunity permanently, or request further information? The choice has a serious impact on the viability of his firm when the game moves into phases II and II. The choice is his.

REFERENCES

Box, G. E. P. and M. E. Muller, (1958). “A Note on the Generation of Random Normal Deviates.” *The Annals of Mathematical Statistics*, Vol. 29(2), 610-611.