RISK AND CAPITAL BUDGETING: A CASE STUDY USING FLEXIBLE MANUFACTURING

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Scope and Method of Study: This study examines the issues of and risks involved in choosing between capital investment projects which use either traditional or flexible manufacturing techniques. Three unique measures of risk were developed by the author. The first measure was a ratio of positive net present values to negative net present values. The second measure was a ratio of the lowest cash balance which could be experienced to the minimum cash balance the firm desires to maintain. The third measure of risk was the ratio of the maximum yearly cash outflow experienced in a project to the maximum yearly cash outflow the firm can sustain. The net present value ratio was tested by conducted a Monte Carlo simulation. The other ratios were tested using the worst case information. All the test information used was completely hypothetical and did not concern existing companies.

Findings and Conclusions: All three measures of risk performed well. The net present value ratio was believed to be the most useful measure of risk for most projects. It also has the advantage of being an easily understood measure of risk. Its concept could be easily understood by most executives. The other two measures of risk are also useful, but do not have as wide of a range of applicability as does the first measure.

ADVISOR'S APPROVAL ____________________

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

In today's business climate there is a tremendous need for manufacturers to reduce costs and to increase quality. With the increasing fragmentation of American society there is an increasing demand for variations of a basic product, but with a reduced quantity being produced of each individual variation. This implies that manufacturers may be forced to choose between being the low-cost producer or occupying these smaller market niches by building many variations on a basic product. Being the low-cost producer implies using traditional manufacturing methods and running high volumes through your manufacturing facility. Occupying market niches by building variations on a product indicates the use of the newer flexible manufacturing techniques, both for engineering and for manufacturing.

The purpose of this paper is to examine the investment decision which a manufacturer makes in considering the expansion of the manager's firm's manufacturing capability (product-wise) or manufacturing capacity (volume-wise). A manager's decision should result in an increase of the market value of the firm. Since the investment decision plays such an imortant role in each firm, it is advantageous for the manager to have a scientific approach to the problem. Making investment decisions must not be based upon reading the entrails, i.e., the manager's "gut" reaction. All variables must be taken into account.

Now the question arises, why is the author interested in examining this investment decision? And why consider the way the investment decision relates to flexible manufacturing? In addressing this question the author will first define flexible manufacturing.

Flexible manufacturing involves the use of CAD/CAM systems to both design and manufacture a product. This allows greater quality control and gives the ability to manufacture products in smaller batches and yet remain profitable. Traditional manufacturing, in contrast, restricts the range of product variations which can be made using the facility. Lowering costs is accomplished by increasing the amount of product produced. The reason the author will consider the investment decision when it must be made concerning flexible manufacturing is because all possible factors which can affect the outcome of a business decision will be included.

These factors are:

1. The choice of the consumer may be different than expected.
2. Investment decisions which involve large amounts of money can, in certain circumstances, endanger the existence of the firm.
3. Current investment decisions can affect the future well-being of the firm in the strategic sense. Today's decision can affect the firm's ability to effectively compete ten years from now. For example, many American automobile manufacturing plants are equipped to build only certain sizes of cars. A plant which builds Buick Electras (a large luxury car) is not equipped to build Cheverolet Cavaliers (a subcompact car). The process of modifying the production process from building the one car to building the other car is costly, both in terms of time (lost sales) and in terms of capital investment (money spent on new machinery and in modifying old machinery).

Given the purpose of this paper, the author will develop a research methodology. First there will be literature review. The literature of capital budgeting will be considered first, as this paper is primarily about that subject. The literature on flexible manufacturing will be reviewed next.

After reviewing the literature of both capital budgeting and flexible manufacturing methods, the author will develop some unique measures of risk. This is because the author desires to reduce the risk involved in any capital investment. The purpose of this paper is to add something new to the reservoir of knowledge available concerning the process of making the investment decision. The development of these three measures of risk to reduce the risk of investment will be part of the author's contribution to this subject.

When these unique measures of risk have been constructed, they must be tested under varying conditions. Since the outcome of a decision is not known until after the decision has been made and implemented, a Monte Carlo simulation will be used to model this uncertainty. This will be performed manually by the author. After the simulations have been performed the author will analyze the performance of these three unique measures of risk.

It is now time to conduct the literature review.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter of the author's paper will review the literature of and issues involved in capital budgeting and flexible manufacturing. Risk will be discussed first, capital budgeting will be discussed second, and flexible manufacturing will be discussed last.

Risk

How Risk Arises

This paper deals with how the investment in flexible manufacturing facilities influences risk. Risk differs with the organizational unit being examined. Risk at the plant level can be defined as the probability that in taking an action the plant will be unable to meet the demand that the organization as a whole places upon it. In a manufacturing organization products must be produced in a certain volume, at a certain price. In purchasing a more expensive piece of equipment to increase volume and improve quality, certain risks are taken. This action could increase the average price of each unit of production if volume falls below expectations. Therefore, the plant manager is taking the risk that in purchasing the new equipment the plant will experience an increase in unit costs.

At the organizational level risk can be defined as the probability that in taking an action an unfavorable outcome will occur. This implies that the market value of the firm will decrease. An example of this would be if Ethyl Corporation decided to increase its capacity to manufacture the tetraethyl lead gasoline additive. Sales of leaded gasoline may have been progressively increasing year by year. The EPA may have been ignoring the use of leaded fuel in automobiles equipped with catalytic converters. The projected market for leaded gasoline is expected to increase thirty percent from current levels. The manufacturing capacity is increased. The EPA then decides to phase out leaded gasoline. The probability that leaded gasoline will be prohibited under EPA rules is part of the risk that Ethyl Corporation is assuming in expanding its manufacturing capacity. Another risk that Ethyl Corporation is assuming is that market demand for the additive will be less than projected. Both of these risks will affect Ethyl Corporation's financial health. This in turn will affect the market value of the firm.

Therefore, for this paper, risk is defined as the danger that in taking an action the market value of the firm will be lowered.

Risk does not arise just from capital investment decisions. Any action by a firm involves risk. For example, changing the way an airline markets its services (by presenting a different image, etc.) entails risk, as does the action of not changing its marketing. Either decision could lead to a drop in the market value of the firm. Remember, refusing to make a decision to change is the same as making a decision not to change. The author will now consider the basis for the market value of the firm.

The Basis for the Market Value of the Firm

The market value of the firm is based upon the present value of its cash flows. These cash flows are discounted at the discount rate the market uses for the particular kind of industry involved. As the present value of the cash flows increase, so does the market value of the stock. Now the firm's value can decrease in two ways; the market discount rate can increase or the cash flows can decrease. Either or both of these two factors can cause a decrease in market value. The author will first look at a market discount rate increase.

An increase in the market discount rate will reduce a firm's market value. An increase in the discount rate should be a rare occurrence. Only an overall increase in the riskiness of an industry will cause an increse in this rate. An example of this would occur at the perfection of fusion generation of electricity. A cheap, nonpolluting source of electricity would be the result of this innovation. Almost instantaneously the generating plants of the elecric utilities would be on a short road to obsolescence. The market discount rate would increse dramatically. How cash flow decreases can occur will now be examined.

Cash flows can decrease for several reasons. The raw materials used in the manufacturing process can increase in price while the selling price stays constant. Costs can also stay constant while the selling price drops. Or total sales volume may drop. Even if there are no fixed costs involved in the process of manufacture, cash flow will drop. In general, anything which increases costs or decreases revenues will decrease the market value of the firm.

Now that the subject of risk has been examined, the subject of investment criteria will be considered.

Investment Criteria

When investment in flexible manufacturing facilities is considered, there must be some kind of instrument to measure a potential investment's performance. The four potential approaches to measuring performance which will be examined are:

1. Payback
2. Average return on book
3. Internal rate of return
4. Net present value

Payback, average return on book and the internal rate of return will not be adequate tools for investment decisions because they do not consider the total effect of the firm's cash flows on the organization's stock price.

Payback

Payback is obtained by calculating the number of years an investment project will take to generate cash flow equal to the initial investment in a project. Projects are compared on the basis of their payback periods. Management usually has a rule of thumb about maximum payback periods. However, payback does not consider the overall cash flow for a project. A project which costs $1,000 and generates $500 of cash flow for three years would be chosen over a project which also costs $1,000 but generates $300 of cash flow for fifteen years. Choosing the first project over the second results in reduced long-term cash flow for the firm, which results in a lower market value. In view of this, payback is not an acceptble measuring device.

Average Return on Book Value

The second measuring device is the average return on book value. The average return on book value is calculated by dividing the average net income generated by the project by the average net investment in the project. If the average return on book value is greater than some standard, accept the investment. There are several limitations to this approach. While this approach does consider the entire length of the project, it does not evalute cash flow. Two projects of identical investment and identical length can have identical average return on book value measurements. However, one project can have larger cash flows earlier in its life than the other project, making the present value of its cash flows larger than those of the other project. Since the market value of a firm is the discounted value of its cash flows, accepting a project with a lower present value of cash flows reduces the market value of the firm. Because of this, the average return on book value method of evaluating investment projects is not acceptable.

<u>Internal Rate of Return</u>

The third measuring device the author is examining is that of the internal rate of return. The internal rate of the return is that discount rate which makes the present value of the cash outflows of the investment equal to the present value of the cash inflows of the investment. Any investment project which has an internal rate of return greater than the firm's standard (often called the opportunity cost of capital) is accepted. This device is successful in the fact that the timing effects of cash outflows and inflows are taken into account. Competing projects can be more easily compared. All that is necessary is to see which project has the higher IRR. This is a method which allows easy and accurate comparisons between projects. However, there are two problems which are inherent in using the internal rate of return evaluation device. The first problem comes from the fact that there may be multiple internal rates of return. For each change of sign in the cash flows there is a discount rate that makes the net present value of the cash flows equal to zero. If there are two changes of sign, there will be two values for the internal rate of return. If there are three changes of sign, there will be three values. There is no logical basis on which to determine which value to use as the internal rate of return.

The second problem deals with mutually exclusive projects. This will be encountered in deciding between using conventional manufacturing techniques and using flexible manufacturing techniques. The traditional manufacturing facility may have a higher internal rate of return, but the present value of the cash inflows less the present value of the cash outflows may be higher for the flexible manufacturing facility. An excellent example of this can be found in Brealy and Myers Principles of Corporate Finance.[1] Accepting the traditional manufacturing project instead of the flexible manufacturing project will cause a lesser increase in the market value of the firm. The objective of managers is to maximize the market value of the firm in the long run. Because of this, the decision rules must be those which maximize market value. With this as the criteria, the internal rate of return must be rejected as the evaluation device.

Net Present Value

The decision making device which the author prefers is that of net present value. The net present value of a project is the present value of the project's cash inflows less the present value of a project's cash outflows. The discount rate used is the opportunity cost of capital which will be discussed later. Therefore, by using the net present value method, a manager can maximize (or attempt to maximize) the present value of the firm's cash flows. By doing this the manager is attempting to maximize the firm's market value.

The next question is "How is the correct opportunity cost of capital determined?" Should one use the weighted average of capital which many finance textbooks recommend? Certainly not! In order to maximize the firm's market value, the discount rate which the market uses should be utilized. The author recommends the use of the capital asset pricing model to determine this rate. Although a detailed examination of the capital asset pricing model is beyond the scope of this paper, a very short explanation follows. The capital asset pricing model uses the behavior of all the stocks of firms which are participating in the industry under consideration. Since the desired end result is to maximize the firm's long-run stock price, a stock market-derived discount rate must be used. Because of these reasons the NPV method will be a main anaysis tool. The author will now examine the implications of flexible manufacturing techniques on capital budgeting.

Implications of Flexible Manufacturing Techniques on Capital Budgeting

Flexible manufacturing techniques will have several areas of impact on capital budgeting. The first area which will be affected will be that of costs. In flexible manufacturing a firm trades higher fixed costs for lower variable operating costs. While this implies that more volume is needed to cover fixed expenses, it also means that incremental costs for additional production are lower. Much of the reduction in variable expense comes from a reduction in the labor involved in making a product, from the design stage to manufacturing the product.

The second area to be affected by flexible manufacturing techniques is that of product demand. Since the range of products a manufacturing facility can make will increase, production volume will also tend to increase. Indeed, this increase in volume is one of the main reasons for using flexible manufacturing.

The third effect of using flexible manufacturing techniques will be that the level of inventories a firm must maintain should be reduced. Using flexible manufacturing techniques a larger range of products can be provided to the firm's customer while simultaneously reducing inventory levels. The reason for this is that the type of product being produced can be quickly changed to that of the new order. While flexible manufacturing can reduce finished product and raw materials inventories it cannot eliminate them.

Now that the issue concerning capital budgeting have been examined, it is time to examine the subject of flexible manufacturing.

Flexible Manufacturing

Origins of Flexible Manufacturing

Flexible manufacturing techniques started when General Motors started doing some of its drafting and designing on the computer in 1962. GM then prepared dies for auto body parts using numerically controlled machine tools.

Increased technological sophistication and lower manufacturing costs made the integration of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) more feasible. Parts designed with CAD are then manufacturing using CAM. While CAM previously just prepared control tapes for machine tools, today CAM not only prepares tapes but also orders and moves materials, directly controls machine tools, and oversees quality control.

Why Use Flexible Manufacturing

Many people look at the costs of "traditional" manufacturing facilities, compare them to those of "flexible" manufacturing facilities, and choose to not even consider the latter. Since flexible manufacturing is so much more capital-intensive, why risk the firm's resources in such a facility? The more money invested in a project, the larger the possible loss. What then are the advantages of investing in a flexible manufacturing facility? They will now be listed.

1. Product design and revision processes are conducted more quickly and efficiently. Mal-fitting parts are quickly detected. Engineers are able to accomplish more, frequently handling up to three times the prior workload.
2. Product quality increases. With the manufacturing processes being directly computer-controlled, part specifications are transmitted exactly as they

were designed, with no minor deviations between product design and product manufacture.

3. Fewer manufacturing personnel are needed for the industrial process. In a flexible manufacturing facility, most product movement is accomplished through mechanical systems and robots.
4. Flexible manufacturing systems can be used to manufacture more than one product, or many variations of a product line. As the system grows more efficient, small quantities of a unique product become more profitable.

Disadvantages of Flexible Manufcturing

Flexible manufacturing, while offering many advantages, also has many potential disadvantages. These are:

1. Flexible manufacturing is extremely capital-intensive. Construction of a comparable traditional manufacturing facility would cost substantially less.
2. The need for large numbers of blue collar workers drops. Unions tend to militate against industrial changes which result in greater unemployment among the union ranks.
3. Flexible manufacturing is not a quick fix. The technology must be understood by all levels of management.

This last point, that of understanding the technology, is the biggest hurdle. Frequently management reaches for a potential solution which looks good. This is as dangerous as using a business decision tool the underpinnings of which one does not understand. The solution could easily become a problem. A centralized data base can be almost worthless unless it is properly designed and maintained. And having this centralized data base, to be used for engineering and financial decisions, is one of the primary benefits of having a flexible manufacturing system.

Strategic Implications of Flexible Manufacturing

Increased quality control and more efficient engineering are not the most touted qualities of a flexible manufacturing system. The most proclaimed quality is that of being able to manufacture smaller quantities of different products profitably. Now why is this important?

1. As the American society becomes more and more fragmented, it will demand products which are designed specifically for a certain cultural group or lifestyle.
2. As technology progresses, a broader range of industrial products is required, with many slight variations on individual products. This ends the effect of the learning curve, where product costs fall as production volume increases.

As these effects ripple through our society, a company which chooses a strategy of manufacturing highly standardized products runs a real risk of failure. We could see some large companies experience a permanent loss in market share. Ford Motor Company had this happen when the only color they offered in cars ws black. General Motors allowed customers more choice in colors and options, and through this tactic became the largest automaker in the United States. Indeed, a major portion of the United States Industry have become market nichers. The author will now consider market niche strategies.

Market Niche Strategies

In today's competitive environment each organization looks for an advantage. Companies try to gain advantages by being the low-cost producer, having superior support services, or by filling a special market niche. A market niche consists of a market, usually small, which the major competitors in an industry have ignored or overlooked. Philip Kotler, in his book Marketing Managemnt, listed ten roles open to a firm which wanted to pursue a market-niche strategy. These roles are:

1. End-use specialist - This firm decides to specialize in serving one type of end-use customer.
2. Vertical-level specialist - This firm specializes at some vertical level of the production-distribution system.
3. Customer-size specialist - This firm concentrates on selling to either small, medium or large size customers.
4. Specific-customer specialist - This firm limits its selling to one or a few major customers.
5. Geographic specialist - This firm focuses on the needs of a certain locality, region or area of the world.
6. Product or product-line specialist - This firm produces only one product-line or product.
7. Product-feature specialist - This firm specializes in producing a certain type of product or product-feature.
8. Job-shop specialist - This firm stands ready to make customized products as ordered by the customer.
9. Quality/price specialist - This firm chooses to operate at the low or high end of the market.
10. Service specialist - This firm offers or excels in one or more services not readily available from other firms.[2]

For a market-nicher to successfully utilize flexible manufacturing the market-nicher would probably fall into two of these ten roles. These would be the roles of the product-feature specialist and the job-shop specialist. The product-feature specialist would add unique features to an order of a normally standardized product. For example, a dishwasher could have a second pump added to give a stronger wash spray. Another example would be a manufacturing operation which makes digital clock-radios with special features, such as a cassette player in the top-of-the-line model. The same basic outer shell and the same basic circuit board could be used for all models, with additional circuits and components added to enhance the product's value.

In some ways semi-flexible manufacturing techniques are being utilized today by non-market nichers. One summer the author worked in a factory which made dishwasher and washing machine timers. These timers were made for several different brands of washing machines and dishwashers, including G.E., Whirlpool (including the Kenmore models made for Sears), Hotpoint, and Maytag. Now these timers were not identical, because each of the different brands of machines had different requirements. All of the timers had similar components, such as a central injection-molded monoblock and relay-activating "wafers." The monoblock was different for each timer and so were the wafers. They were all bolted onto a similar "frame," which held together all of the components.

Each model of the timers was different and they had some non-identical components. However, only one factor was needed to manufacture these timers, not multiple factories. The reason these timers could be built in one factory was because of the flexibility of operations. Injection molds could be changed in a short period of time. The dies used to stamp out the sheet metal frames were quickly changed. The kind of wafèr being manufactured could be changed by doing some reprogramming of an automatic machine, and by changing some very small dies. Finally, although there were some differences in assembly, the final assembly line sations would be quickly switched to different assembly operations. In general, the approach was that of flexibility, compared to all stations being fixed for specific uses, as would be the case on the automobile assembly line.

The job shop specialist would also clearly benefit from flexible manufacturing. In fact, the closer link between design and manufacturing makes the choice of a flexible manufacturing set-up a natural choice. No longer would a job-shop be a conglomeration of machine and men. Instead, design specifications would be fed into the operation's main computer. The main computer would translate the specifications into orders for the various machine centers and transmit these orders. At the same time the inventories would be examined to determine if enough of the necessary materials were on hand. If they were not, they would automatically be ordered. Unnecesary labor would be saved by this process. Computer assisted manufacturing would also reduce wasting of expensive materials. This has been found true in the aircraft manufacturing industry, where large savings in pipe bending are being realized. A misbent exotic alloy piece of piping is a grotesquely expensive use of raw materials.

Now that capital budgeting and flexible manufacturing have been examined, the author is ready to construct the testing model and to formulate three unique measures of risk.

CHAPTER TWO REFERENCES

[1]Richard Brealey and Stewart Myers, Principles of Corporate Finance, (New York, McGraw-Hill, Inc., 1981) pp. 70-76.

[2]Philip Kotler, Marketing Management, (4th ed.; Pretince-Hall, Inc., 1980), pp. 285-287.

CHAPTER THREE

THE MODEL

Introduction

In the second chapter of this paper the author examined the issues of capital budgeting and flexible manufacturing. The author decided that the net present value method was the appropriate tool to use in capital investment analysis. The various factors involved in flexible manufacturing, including possible strategies for using flexible manufacturing techniques, were considered. It is now time to discuss the model, develop three unique measures of risk, and consider the data to be used in the simulations. The author will first consider and subject of cash flows.

Cash Flows

Cash flows for any project should be estimated by a number of the firm's personnel, using people with different functional specialities such as production, finance, marketing, and engineering. To derive a single cash inflow figure for each year the author suggests that the team provide a number of cash flows, with their respective probabilities of occurrence, for each year of the project. While a capital investment project would most likely have a continuous range of inflows, it is much easier for the purposes of this paper to deal with a discrete number of possible cash flows. Furthermore, with a capital investment project which uses flexible manufacturing techniques, there will more likely be larger variations on the cash flow, especially toward the upper end of the range. This is a result of a flexible manufacturing facility's ability to turn out either a cheaper product, resulting in reduced costs, or more variations of products, resulting in increased revenues.

In calculating each year's cash flow, the author believes that the following method should be used. After the team has generated its cash flow figures, along with their associated probablities, they are given to the firm's financial analyst. The cash flow figures used in the analysis are obtained by summing, by period, the products of each possible cash flow and its respective probability. In other words, for each time period involved in the analysis, use the following steps:

1. List each possible cash flow and its respective probability.
2. Multiply each possible cash flow and its respective probability together.
3. Add all the resulting products together. This is the cash flow to use for the time period.

The problem with using this particular method is that it does not give an adequate indication of the relative risk of each investment. Three measures of risk will be proposed in the next section which will furnish that.

Other Measures of Performance

Net present value gives us the expected effect of a decision on market value, but other considerations are also important. First of all, management must keep the organization functioning as an ongoing concern. The ownership of a corporation is among the biggest losers when it enters bankruptcy (both liquidation and reorganization forms). Will an investment project have such cash outflows as to endanger the firm? As the subject of financing methods is beyond the scope of this paper, the author will develop two measures of risk which concern cash outflows and cash levels. The first measure which the author proposes to use is the ratio of the lowest cash level the firm will experience to the minimum level of funds which the firm desires to maintain. This measure is more appropriate for a small firm in which the owner desires to risk a certain maximum level of funds and no more than that.

The second measure of risk is the ratio of the maximum cash outflow caused by the project to the maximum cash outflow which the firm can withstand. The closer the measure approaches unity the greater the danger that the firm will be endangered by the product. Because the author wishes to examine the largest effect the project would have on the firm, the author will use the minimum cash inflows when computing these two ratios. The first ratio will be used for Case One, which involves starting a small business. The second ratio will be used for Case Two, which involves a much larger business.

Another measure of risk which the author proposes would consider the relative frequency of positive net present values to negative net present values. A project could have negative NPV's 95% of the time, and yet the other 5% of the time have a large positive NPV so that the expected NPV is positive. This would also give management an indication of the relative riskiness of the project. A Monte Carlo Simulation will be used to calculate this measure for both cases.

Data To Be Used For The Simulation

Simulations for these two cases will be run ten times each. Each of these two cases is fictional, and bear no relationship to any existing company or person. Likewise, the data used is also fictional. The author has fabricated all the information which is used in these cases.

Case One

The first case, hypothetical in nature, shall involve a small job-shop, called the Chapman Company. The Chapman Company is just starting in business and has $400,000 of start-up capital available from Mr. Chapman's bank account. Mr. Chapman was trained as a design engineer at the University of Michigan and had considerable experience with an original equipment supplier to General Motors. Mr. Chapman has just won $500,000 (after taxes) from the Michigan State Lottery. Mr. Chapman decides to go into business for himself, making flywheels for GM starters. Mr. Chapman is faced with a choice of drop-stamping his flywheels, using a more traditional manufacturing arrangement, or he can use a machining center, with two robots, to produce the flywheels. Mr. Chapman already owns a suitable building for production using either method. Even if Mr. Chapman does not enter this business he will continue his ownership of the building. Mr. Chapman wishes to spend no more than $300,000 in set-up expenses, leaving $100,000 as a "buffer amount" in case of problems. One of Mr. Chapman's goals is to have that buffer amount stay the same (no additional cash outflow) or increase (positive cash flow). It will be assumed that the firm is subject to a fifty percent tax rate, with no tax loss carrybacks or carry-forwards. It will also be assumed that Mr. Chapman is a talented engineer and will also attempt to make other machined parts if the flexible manufacturing system is chosen. The data for this case is given in Tables I and II. Sum-of-years digits method will be used to calculate depreciation. It is assumed that at the end of the ten years of the simulation, all the production equipment, except for the robots will need replacing. The robots will be sold at their original purchase price.

The appropriate discount rate to use for this project is ten percent.

TABLE I

Equipment, Personnel and Material Costs for Case One

Traditional Techniques		Flexible Techniques	
Equipment Costs			
One Stamping Press	$90,000	One Machining Center	$100,000
One Die at $10,000	$10,000	Two Robots	$100,000
Yearly Personnel Costs			
One Engineer	$30,000		$ 30,000
One Tool & Die Repairman	$25,000		-0-
One Press Operator	$25,000		-0-
One Salesman	-0-		$ 25,000
One Material Handler	$20,000		$ 20,000
Material Cost Per Unit of Production			
	$ 1.00		$ 2.00

TABLE II

Expected Production and Product Sales Prices for Case One

Expected Sales Prices

Product A - Flywheels	$5.00/Unit
Product B - Gears	$10.00/Unit

Expected Production - Traditional Manufacturing Techniques

Year 1 A	25,000 (.3)	35,000 (.4)	45,000 (.3)		
Year 2 A	10,000 (.2)	25,000 (.2)	35,000 (.3)	45,000 (.3)	
Year 3 A	15,000 (.2)	30,000 (.2)	45,000 (.2)	50,000 (.4)	
Year 4 A	20,000 (.2)	30,000 (.3)	40,000 (.2)	50,000 (.2)	60,000 (.2)
Year 5 A	25,000 (.2)	35,000 (.2)	45,000 (.2)	55,000 (.2)	65,000 (.2)
Year 6 A	25,000 (.5)	60,000 (.5)			
Year 7 A	30,000 (.3)	45,000 (.3)	65,000 (.4)		
Year 8 A	35,000 (.4)	55,000 (.4)	75,000 (.2)		
Year 9 A	40,000 (.4)	55,000 (.4)	90,000 (.2)		
Year 10 A	40,000 (.4)	55,000 (.4)	90,000 (.2)		

Expected Production - Flexible Manufacturing Techniques

Year 1 A	25,000 (.3)	35,000 (.4)	45,000 (.3)		
B	2,000 (.9)	15,000 (.1)			
Year 2 A	10,000 (.2)	25,000 (.2)	35,000 (.3)	45,000 (.3)	
B	4,000 (.9)	18,000 (.1)			
Year 3 A	15,000 (.2)	30,000 (.2)	45,000 (.2)	50,000 (.4)	
B	5,000 (.9)	20,000 (.1)			
Year 4 A	20,000 (.2)	30,000 (.2)	40,000 (.2)	50,000 (.2)	60,000 (.2)
B	7,500 (.9)	22,500 (.1)			
Year 5 A	25,000 (.2)	35,000 (.2)	45,000 (.2)	55,000 (.2)	65,000 (.2)
B	9,000 (.8)	22,500 (.2)			
Year 6 A	25,000 (.5)	60,000 (.5)			
B	9,500 (.8)	24,000 (.2)			
Year 7 A	30,000 (.3)	45,000 (.3)	65,000 (.4)		
B	10,000 (.8)	30,000 (.2)			
Year 8 A	35,000 (.4)	55,000 (.4)	75,000 (.2)		
B	12,000 (.8)	25,000 (.2)			
Year 9 A	40,000 (.4)	55,000 (.4)	90,000 (.2)		
B	12,500 (.8)	25,000 (.2)			
Year 10 A	40,000 (.4)	55,000 (.4)	90,000 (.2)		
B	14,000 (.9)	35,000 (.1)			

The figures in the parentheses are the respective probabilities of the preceding production occurring.

Case Two

Case Two involves the J.J. Warnock Company, a manufacturer of industrial valves. Business has been increasing revealing the necessity of a new plant. C.J. Craig, Company President, is faced with a choice between building another traditional manufacturing facility or investing a much greater sum of money in a flexible manufacturing operation.

Current Status

The Warnock Company has one manufacturing facility, which is both capital and labor-intensive. A large amount of numerically-controlled machine tools are used. Labor on the plant floor is primarily used for transfer of materials to the various machining centers, and then to shipping. There are ten laborers handling material, with one foreman supervising them. Two maintenance personnel handle repairs and periodic maintenance, with a maintenance supervisor over them. Both the maintenance supervisor and the foreman report to a plant supervisor, who reports to a plant manager. There is one quality control technician. On the engineering side there are three engineers, two draftsmen, and one supervisor. The engineers design modifications to present valves, design new valves and write machine code for the numerically controlled machine tools. When orders are obtained for a totally new type of valve, the engineers must also design the valve and program the numerically controlled machines to produce this valve. This affects the quantity of the new valve initially ordered, and the quantity of the valves to be ordered in the future.

Flexible Manufacturing Operational Requirements

The flexible manufacturing facility would require far fewer people to operate, but the operation is much more capital-intensive. All design, drafting and machine-center programming would be done by two engineers and one engineering supervisors, using CAD/CAM equipment. Most of the material placement and movement would be done by mechanical or robotic means, so only three material handlers and one supervisor are needed. Self-diagnostics given by the machine centers reduce repair needs so only one maintenance person and one maintenance supervisor are required. The remaining personnel consists of one quality control technician and one plant supervisor. The lead time for new products is now reduced to one month, with no additional expense of design and programming.

Additional Information

At the end of five years both the machining equipment and the machining centers will need replacement. A fifty percent rate is assumed, with no tax loss carrybacks and carryforwards allowed. This project will not affect the taxes on the other segments of this company. The sum-of-year-digits depreciation method will be used. Materials cost $25.00/unit for the traditional system and $23.00/unit for the flexible system. Salvage value for the building and the material handling systems and the CAD/CAM systems are fifty percent of their purchase price. The appropriate discount rate to use for this project is fifteen percent. The remaining information for Case Two is contained in Tables III, IV and V.

TABLE III

Equipment Costs, Personnel Costs and Product Sales Prices for Case Two

Equipment and Personnel Costs

	Traditional	Flexible
Building and Site	$1,000,000	$1,000,000
Plant Manager	$ 50,000	$ 55,000
Plant Supervisor	$ 42,000	-0-
Quality Control Technician	$ 20,000	$ 20,000
Material Handlers	$ 150,000	$ 45,000
Materials Supervisor	$ 25,000	$ 25,000
Maintenance	$ 40,000	25,000
Maintenance Supervisor	$ 25,000	$ 35,000
Engineering Supervisor	$ 39,000	$ 42,000
Engineers	$ 90,000	$ 70,000
Draftsmen	$ 40,000	-0-
Machining Equipment	$2,000,000	-0-
Machining Centers	-0-	$2,200,000
CAD/CAM System	-0-	$1,000,000
Material Handling Systems	$ 200,000	$ 750,000

Sales Prices

Product A	$50.00/Unit
Product B	$75.00/Unit
Product C	$100.00/Unit

TABLE IV

Expected Production for Case Two Using Traditional Manufacturing Techniques

Year 1	A	75,000	(.8)	50,000	(.2)
	B	-0-	(.9)	5,000	(.1)
	C	-0-	(.9)	8,000	(.1)
Year 2	A	75,000	(.9)	50,000	(.1)
	B	-0-	(.9)	5,000	(.1)
	C	-0-	(.9)	8,000	(.1)
Year 3	A	80,000	(.9)	55,000	(.1)
	B	-0-	(.8)	5,000	(.2)
	C	-0-	(.9)	8,000	(.1)
Year 4	A	85,000	(.9)	55,000	(.1)
	B	-0-	(.7)	5,000	(.3)
	C	-0-	(.9)	5,000	(.1)
Year 5	A	90,000	(.9)	60,000	(.1)
	B	-0-	(.6)	8,000	(.4)
	C	-0-	(.8)	5,000	(.2)

The figures in the parentheses are the respective probabilities of the preceding production occurring.

Table V

Expected Production for Case Two Using Flexible Manufacturing Techniques

Year 1	A	75,000	(.8)	50,000	(.2)
	B	-0-	(.4)	6,000	(.6)
	C	-0-	(.5)	8,000	(.5)
Year 2	A	75,000	(.9)	50,000	(.1)
	B	-0-	(.3)	65,000	(.7)
	C	-0-	(.5)	8,000	(.5)
Year 3	A	80,000	(.9)	55,000	(.1)
	B	-0-	(.3)	68,000	(.7)
	C	-0-	(.5)	8,500	(.5)
Year 4	A	85,000	(.9)	55,000	(.1)
	B	-0-	(.3)	6,800	(.7)
	C	-0-	(.5)	8,500	(.5)
Year 5	A	90,000	(.9)	60,000	(.1)
	B	-0-	(.3)	6,800	(.7)
	C	-0-	(.5)	8,500	(.5)

The figures in the parentheses are the respective probabilities of the preceding production occurring.

Conducting the Simulations

Now that the case information has been assembled, the next step is to conduct the simulation. After this has been done the results will be reported and discussed in Chapter Four of this paper.

CHAPTER FOUR

RESULTS, ANALYSIS AND CONCLUSIONS

Procedures and Examples

The Monte Carlo simulations were performed manually by the author of this paper. Ten simulations were performed for each situation, making a total of forty simulations. A detailed description of how the simulations were performed is given in Appendix One. A copy of each type of simulation (Chapman-Traditional, Chapman-Flexible, Warnock-Traditional, Warnock-Flexible) is included in Appendix Two. Appendix Three contains the calculations computing the expected net present values, and the appropriate cash measures for each case. The simulation results are summarized in Tables VI and VII. The appropriate ratios will now be shown.

Ratios

	NPV Ratio	Lowest Cash Level Ratio	Cash Outflow Ratio
Chapman- Traditional	9:1	1.8	
Chapman-Flexible	10:0	2.0	
Warnock-Traditional	10:0		.64
Warnock-Flexible	9:1		.99

The author will now discuss the implication of these results.

Discussion of Results

Net Present Value Ratios

The ratios provided in the previous section indicate that all of the proposed projects had substantially more positive net present values than negative net present values, as was illustrated by the results of the Monte Carlo simulations. The only projects which exhibited any negative net present values were the Chapman-Traditional Investment Configuration and the Warnock-Flexible Investment Configuration projects. When these capital investment projects were simulated they showed negative net present values only ten percent of the time. This indicates a relatively low level of risk for these investments. The Chapman-Flexible Investment Configuration and Warnock-Traditional Investment Configuration simulations showed no instances of negative net present values, which indicates an even lower level of financial risk. The author will now discuss the second and third measures of risk which deal with cash levels and cash overflows.

Table VI

Summary of the Simulation Results for Case One, The Chapman Company Case

Chapman-Traditional Investment Configuration

	Cumulative PV	Lowest Cash Position
Simulation Number One	$186,595	$300,000
Simulation Number Two	$(22,610)	$268,182
Simulation Number Three	$ 97,543	$300,000
Simulation Number Four	$ 50,778	$240,000
Simulation Number Five	$216,555	$300,000
Simulation Number Six	$143,021	$300,000
Simulation Number Seven	$201,028	$300,000
Simulation Number Eight	$111,627	$300,000
Simulation Number Nine	$197,919	$300,000
Simulation Number Ten	$110,643	$300,000

Chapman-Flexible Investment Configuration

Simulation Number One	$273,131	$200,000
Simulation Number Two	$256,593	$200,000
Simulation Number Three	$235,971	$200,000
Simulation Number Four	$296,568	$200,000
Simulation Number Five	$274,333	$200,000
Simulation Number Six	$265,521	$200,000
Simulation Number Seven	$139,147	$200,000
Simulation Number Eight	$255,455	$200,000
Simulation Number Nine	$202,342	$200,000
Simulation Number Ten	$249,212	$200,000

These results were obtained by the author manually performing a Monte Carlo simulation. A copy of one simulation for each type of investment configuration is contained in Appendix Two. The detailed case information is given in Chapter Three of this paper.

Table VII

Summary of the Simulation Results for Case Two, The J.J. Warnock Company Case

Warnock-Traditional Investment Configuration

	Cumulative PV	Maximum Cash Outflow
Simulation Number One	$ 193,614	$3,200,000
Simulation Number Two	$ 885,513	$3,200,000
Simulation Number Three	$ 585,807	$3,200,000
Simulation Number Four	$ 706,833	$3,200,000
Simulation Number Five	$ 386,270	$3,200,000
Simulation Number Six	$ 56,755	$3,200,000
Simulation Number Seven	$ 585,147	$3,200,000
Simulation Number Eight	$ 228,160	$3,200,000
Simulation Number Nine	$ 288,132	$3,200,000
Simulation Number Ten	$ 786,078	$3,200,000

Warnock-Flexible Investment Configuration

Simulation Number One	$1,002,257	$4,950,000
Simulation Number Two	$ 401,010	$4,950,000
Simulation Number Three	$ 963,028	$4,950,000
Simulation Number Four	$ 180,018	$4,950,000
Simulation Number Five	$ 566,452	$4,950,000
Simulation Number Six	$ (765,888)	$4,950,000
Simulation Number Seven	$ 883,509	$4,950,000
Simulation Number Eight	$ 892,565	$4,950,000
Simulation Number Nine	$ 594,367	$4,950,000
Simulation Number Ten	$1,116,933	$4,950,000

These results were obtained by the author manually performing a Monte Carlo simulation. A copy of one simulation for each type of investment configuration is contained in Appendix Two. The detailed case information is given in Chapter Three of this paper.

Cash Measures

As the author discussed earlier in Chapter Three of this paper, the maximum cash outflow ratio is useful for both large and small firms. The ratio of the lowest cash level for a project to the desired minimum cash level to be maintained is more applicable to an entrepreneural situation, such as occurs in Case One, the Chapman Investment Projects. Since the lowest cash level ratio also measures the magnitude of the cash outflows, this measure was used for Case One, whereas the maximum yearly cash outflow ratio is more suited to a larger organization. This is why the author used this ratio for Case Two.

In Case One both the traditional and flexible capital investments would have had an acceptable effect upon the Chapman Company's cash balances. In the worst case the lowest ratio realized was 1.8. This indicates that the capital investment had an eighty percent safety margin concerning the desired cash reserve. In the simulations for the Chapman Company at no time did the safety margin fall below one hundred percent (a ratio of 2.0). This further supports the author's contention that this is a fairly safe investment project.

Case Two concerned the J.J. Warnock Company. Using the ratio of the maximum cash outflow to the maximum cash outflow allowable, these investment projects appear to be much riskier. The pattern of the cash outflows must be examined in proposed projects such as this. Examination of the worst case data shows that the maximum cash outflow occurs at the beginning of the project when the capital expenditures are made. Even in the worst case simulations the maximum cash outflows do not exceed the allowable yearly cash outflow set by the J.J. Warnock Company.

Conclusions

All three of the proposed measures of risk appear to have worked very well. The ratio of positive net present values to negative net present values appears to be the most valuable of the three measures of risk. This ratio will be more easily understood than the standard deviation of the expected net present values. The author's experience in attempting to convince management to adopt a new measurement tool is that the job is quite difficult. Convincing management to use new financial mesurement tools is difficult enough when using fairly simple tools. Using sophisticated financial analysis measures would in most cases dissuade management from making needed changes in the way they evaluate capital expenditures and their related risks.

The other two measures of risk measure maximum cash outflows and minimum cash levels. Both of these measures can prove invaluable in revealing potential problems which a capital investment project could experience. As the author earlier stated in this paper the minimum cash level measure is more useful to smaller firms than it is to larger firms. The ratio of the largest single cash outflow under the worse expected circumstances to the maximum yearly cashflow allowed by the firm will prove valuable to both large and small firms.

All three of the measures of risk proposed by the author will prove not only useful for those capital investments which require choosing betrween traditional and flexible manufacturing methods, but also for any capital investment project. These measures of risk will be used by the author whenever the author is requested to evaluate capital expenditures.

Recommendations

The author recommends that the following steps be used in evaluating capital expenditures:

1. Calculate the expected net present value of the capital investment project using the expected cash flows.
2. Calculate the author's three measures of risk using Monte Carlo analysis. Monte Carlo analysis is more easily done using a computer package such as the Interactive Financial Planning System.
3. If the expected net present value of the capital project is positive and the author's measures of risk indicate a low possibility of failure, adopt the project.
4. If the expected net present value is positive and there is a high level of risk, attempt to isolate the cause of the risk. The Interactive Financial Planning System can be very useful for this purpose.
5. If the risk can be reduced or the firm is willing to adopt a risky project, adopt the project. Otherwise, the project should be rejected.

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APPENDIX 1

Procedures Used in Performing the Monte Carlo Simulations

The first step which the author performed in the Monte Carlo simulations was to represent the probability of the cash flows with numbers from zero to nine. Each cash flow for each year was represented using these numbers.

The second step was to use the Table of Random Units in the CRC Standard Mathematical Tables (16th Edition). The author started by using the first digit in the first line of the first column to determine the first product volume. The second product volume is determined by using the first digit of the second line of the first column. This general procedure is to be continued until the bottom of the first column is reached, or until all the product quantities have been determined, whichever comes first. When the bottom of the column was reached before all the production volumes were simulated, the author continued using the same procedures, at the top of the next column.

APPENDIX 2

Examples of the Chapman Company
and The J.J. Warnock Company
Monte Carlo Simulations

This appendix contains an example of each Monte Carlo simulation performed for Case One and Case Two. The Monte Carlo simulations were performed using the procedures given in Appendix One of this paper. The detailed case information is contained in Chapter Three of this paper.

CHAPMAN SIMULATION
Traditional Techniques
Simulation Number One

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Investment	$ 100,000										
Volume A		$ 25,000	$ 25,000	$ 30,000	$ 40,000	$ 35,000	$ 60,000	$ 65,000	$ 75,000	$ 99,000	$ 90,000
Sales A		$ 125,000	$ 125,000	$150,000	$200,000	$175,000	$300,000	$325,000	$375,000	$450,000	$450,000
Volume B		-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Sales B		-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total Sales		$ 125,000	$ 125,000	$150,000	$200,000	$175,000	$300,000	$325,000	$375,000	$450,000	$450,000
Material Costs		$ 25,000	$ 25,000	$ 30,000	$ 40,000	$ 35,000	$ 60,000	$ 65,000	$ 75,000	$ 90,000	$ 90,000
Depreciation		$ 18,182	$ 16,364	$ 14,545	$ 12,727	$ 10,909	$ 9,091	$ 7,273	$ 5,455	$ 3,636	$ 1,818
Personnel Costs		$ 100,000	$ 100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Gross Profit		$ (18,182)	$ (16,364)	$ 5,455	$ 47,273	$ 29,091	$130,909	$152,727	$194,545	$256,364	$258,182
Taxes		-0-	-0-	$ 2,728	$ 23,637	$ 14,546	$ 65,455	$ 76,364	$ 97,273	$128,182	$129,091
Net Profit		$ (18,182)	$ (16,364)	$ 2,727	$ 23,636	$ 14,545	$ 65,454	$ 76,363	$ 97,272	$128,182	$129,091
Cash Flow	$(100,000)	-0-	-0-	$ 17,272	$ 36,363	$ 25,454	$ 74,546	$ 83,636	$102,727	$131,818	$130,909
PV of Cash Flow	$(100,000)	-0-	-0-	$ 6,659	$ 24,836	$ 15,805	$ 42,079	$ 42,918	$ 47,923	$ 55,904	$ 50,471
Current Cash Position	$ 300,000	$ 300,000	$ 300,000	$317,272	$353,635	$379,089	$463,635	$547,271	$649,998	$781,816	$912,725
Cumulative PV	$(100,000)	$(100,000)	$(100,000)	$(93,341)	$(68,505)	$(52,700)	$(10,621)	$ 32,297	$ 80,220	$136,124	$186,595

Production is in whole units.
Sales are in whole dollars.

CHAPMAN SIMULATION
Flexible Techniques
Simulation Number One

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Investment	$ 200,000										$ (100,000)
Volume A		$ 25,000	$ 25,000	$ 50,000	$ 40,000	$ 55,000	$ 60,000	$ 45,000	$ 55,000	$ 55,000	$ 55,000
Sales A		$ 125,000	$ 125,000	$250,000	$200,000	$275,000	$300,000	$225,000	$275,000	$275,000	$ 275,000
Volume B		$ 2,000	$ 4,000	$ 5,000	$ 7,500	$ 9,000	$ 9,500	$ 30,000	$ 12,000	$ 12,500	$ 14,000
Sales B		$ 20,000	$ 40,000	$ 50,000	$ 75,000	$ 90,000	$ 95,000	$300,000	$120,000	$125,000	$ 140,000
Total Sales		$ 145,000	$ 165,000	$300,000	$275,000	$365,000	$395,000	$525,000	$395,000	$400,000	$ 415,000
Material Costs		$ 54,000	$ 58,000	$110,000	$ 95,000	$128,000	$139,000	$150,000	$134,000	$135,000	$ 138,000
Depreciation		$ 18,182	$ 16,364	$ 14,545	$ 12,727	$ 10,909	$ 9,091	$ 7,273	$ 5,455	$ 3,636	$ 1,818
Personnel Costs		$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
Gross Profit		$ (2,182)	$ 15,636	$100,455	$ 92,273	$151,091	$171,909	$292,727	$180,545	$186,364	$ 200,182
Taxes		-0-	$ 7,818	$ 50,228	$ 46,137	$ 75,546	$ 85,955	$146,364	$ 90,273	$ 93,182	$ 100,091
Net Profit		$ (2,182)	$ 7,818	$ 50,227	$ 46,136	$ 75,545	$ 85,954	$146,363	$ 90,272	$ 93,182	$ 100,091
Cash Flow	$(200,000)	$ 16,000	$ 24,182	$ 647372	$ 58,863	$ 86,454	$ 95,045	$153,636	$ 95,725	$ 96,818	$ 201,909
PV of Cash Flow	$(200,000)	$ 14,545	$ 19,985	$ 48,664	$ 40,204	$ 53,681	$ 53,650	$ 78,840	$ 44,657	$ 41,060	$ 77,845
Current Cash Position	$ 200,000	$ 216,000	$ 240,182	$304,954	$363,817	$450,271	$545,316	$698,952	$794,679	$891,497	$1,093,406
Cumulative PV	$(200,000)	$(185,455)	$(165,470)	$(116,806)	$(76,602)	$(22,921)	$ 30,729	$109,569	$154,228	$195,286	$ 273,131

Production is in whole units.
Sales are in whole dollars.

WARNOCK SIMULATION
Traditional Techniques
Simulation Number One

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
CAPITAL INVESTMENT	$ 3,200,000					$ (600,000)
Volume A		$ 50,000	$ 75,000	$ 80,000	$ 85,000	$ 90,000
Sales A		$ 2,500,000	$ 3,750,000	$ 4,000,000	$4,250,000	$4,500,000
Volume B		-0-	-0-	-0-	-0-	-0-
Sales B		-0-	-0-	-0-	-0-	-0-
Volume C		-0-	-0-	-0-	-0-	-0-
Sales C		-0-	-0-	-0-	-0-	-0-
Total Sales		$ 2,500,000	$ 3,750,000	$ 4,000,000	$4,250,000	$4,500,000
Material Costs		$ 1,250,000	$ 1,875,000	$ 2,000,000	$2,125,000	$2,250,000
Depreciation	-0-	$ 866,667	$ 692,333	$ 520,000	$ 346,667	$ 173,333
Personnel Cost		$ 521,000	$ 521,000	$ 521,000	$ 521,000	$ 521,000
Gross Revenue		$ (137,667)	$ 661,667	$ 959,000	$1,257,333	$1,555,667
Taxes		-0-	$ 330,834	$ 479,500	$ 628,667	$ 773,834
Net Profit		$ (137,667)	$ 330,833	$ 479,500	$ 628,666	$ 777,833
Cash Flow	$(3,200,000)	$ 729,000	$ 1,023,166	$ 999,500	$ 975,333	$1,551,166
PV of Cash Flow	$(3,200,000)	$ 633,913	$ 773,660	$ 657,187	$ 557,650	$ 771,204
Cumulative PV	$(3,200,000)	$(2,566,087)	$(1,792,427)	$(1,135,240)	$ (577,590)	$ 193,614

Production is in whole units.
Sales are in whole dollars.

WARNOCK SIMULATION
Flexible Techniques
Simulation Number One

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
CAPITAL INVESTMENT	$ 4,950,000					$(1,375,000)
Volume A		$ 75,000	$ 75,000	$ 55,000	$ 85,000	$ 90,000
Sales A		$ 3,750,000	$ 3,750,000	$ 2,750,000	$4,250,000	$ 4,500,000
Volume B		-0-	$ 6,500	$ 6,800	$ 6,800	$ 6,800
Sales B		-0-	$ 487,500	$ 510,000	$ 510,000	$ 510,000
Volume C		$ 8,000	$ 8,000	-0-	-0-	$ 8,500
Sales C		$ 800,000	$ 800,000	-0-	-0-	$ 850,000
Total Sales	$ 4,550,000	$ 5,037,500	$ 3,260,000	$ 4,760,000	$5,860,000	
Material Costs		$ 1,909,000	$ 2,058,500	$ 1,421,400	$2,111,400	$ 2,421,900
Depreciation	-0-	$ 1,191,667	$ 953,333	$ 715,000	$ 476,667	$ 238,333
Personnel Cost		$ 317,000	$ 317,000	$ 317,000	$ 317,000	$ 317,000
Gross Revenue		$ 1,132,333	$ 1,708,667	$ 806,600	$1,854,933	$ 2,882,767
Taxes		$ 566,167	$ 854,334	$ 403,300	$ 927,467	$ 1,441,384
Net Profit		$ 566,166	$ 854,333	$ 403,300	$ 927,466	$ 1,441,383
Cash Flow	$(4,950,000)	$ 1,757,833	$ 1,807,666	$ 1,118,300	$1,404,133	$ 3,054,716
PV of Cash Flow	$(4,950,000)	$ 1,528,550	$ 1,366,855	$ 735,300	$ 802,818	$ 1,518,734
Cumulative PV	$(4,950,000)	$(3,421,450)	$(2,054,595)	$(1,319,295)	$ (516,477)	$ 1,002,257

Production is in whole units.
Sales are in whole dollars.

APPENDIX 3

Calculation of the Expected Net Present Values and the Minimum Sales Cash Flows

Appendix Three contains the workpapers used to compute the expected net present values and minimum sales cash flow calculations for Case One and Case Two. The expected net present values were computed using the expected product sales described in Chapter Three of this paper. The cash flow measures were calculated using the lowest possible sales for each product. The detailed case information is contained in Chapter Three of this paper.

CHAPMAN SIMULATION
Traditional Techniques
Expected Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Investment	$ 100,000										
Volume A		$ 35,000	$ 31,000	$ 38,000	$ 40,000	$ 45,000	$ 42,500	$ 48,500	$ 51,000	$ 56,000	$ 56,000
Sales A		$ 175,000	$ 155,000	$190,000	$200,000	$225,000	$212,500	$242,500	$255,000	$280,000	$280,000
Volume B		-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Sales B		-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total Sales		$ 175,000	$ 155,000	$190,000	$200,000	$225,000	$212,500	$242,500	$255,000	$280,000	$280,000
Material Costs		$ 35,000	$ 31,000	$ 38,000	$ 40,000	$ 45,000	$ 42,500	$ 48,500	$ 51,000	$ 56,000	$ 56,000
Depreciation		$ 18,182	$ 16,364	$ 14,545	$ 12,727	$ 10,909	$ 9,091	$ 7,273	$ 5,455	$ 3,636	$ 1,818
Personnel Costs		$ 100,000	$ 100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
Gross Profit		$ 21,818	$ 7,636	$ 37,455	$ 47,273	$ 69,091	$ 60,909	$ 86,727	$ 98,545	$120,364	$122,182
Taxes		$ 10,909	$ 3,818	$ 18,728	$ 23,637	$ 34,546	$ 30,455	$ 43,364	$ 49,273	$ 60,182	$ 61,091
Net Profit		$ 10,909	$ 3,818	$ 18,727	$ 23,636	$ 34,545	$ 30,454	$ 43,363	$ 49,272	$ 60,182	$ 61,091
Cash Flow	$(100,000)	$ 29,091	$ 20,182	$ 33,272	$ 38,181	$ 45,454	$ 39,545	$ 50,636	$ 54,727	$ 63,818	$ 62,909
PV of Cash Flow	$(100,000)	$ 26,646	$ 16,679	$ 24,998	$ 26,078	$ 28,223	$ 22,322	$ 25,984	$ 25,531	$ 27,065	$ 24,254
Current Cash Position	$ 300,000	$ 329,091	$ 349,273	$382,545	$420,726	$466,180	$505,725	$556,361	$611,088	$674,906	$737,815
Cumulative PV	$(100,000)	$ (73,554)	$ (56,875)	$ (31,877)	$ (5,799)	$ 22,424	$ 44,746	$ 70,730	$ 96,261	$123,326	$147,580

Production is in whole units.
Sales are in whole dollars.

CHAPMAN SIMULATION
Traditional Techniques
Minimum Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Investment	$ 100,000										
Volume A		$ 25,000	$ 10,000	$ 15,000	$ 20,000	$ 25,000	$ 25,000	$ 30,000	$ 35,000	$ 40,000	$ 40,000
Sales A		$ 125,000	$ 50,000	$ 75,000	$100,000	$125,000	$125,000	$150,000	$175,000	$200,000	$ 200,000
Volume B		-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Sales B		-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total Sales		$ 125,000	$ 50,000	$ 75,000	$100,000	$125,000	$125,000	$150,000	$175,000	$200,000	$ 200,000
Material Costs		$ 25,000	$ 10,000	$ 15,000	$ 20,000	$ 25,000	$ 25,000	$ 30,000	$ 35,000	$ 40,000	$ 40,000
Depreciation		$ 18,182	$ 16,364	$ 14,545	$ 12,727	$ 10,909	$ 9,091	$ 7,273	$ 5,455	$ 3,636	$ 1,818
Personnel Costs		$ 100,000	$ 100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$ 100,000
Gross Profit		$ (18,182)	$ (76,364)	$(54,545)	$(32,727)	$(10,909)	$ (9,091)	$ 12,727	$ 34,545	$ 56,364	$ 58,182
Taxes		-0-	-0-	-0-	-0-	-0-	-0-	$ 6,364	$ 17,273	$ 28,182	$ 29,091
Net Profit		$ (18,182)	$ (76,364)	(54,545)	$(32,727)	$(10,909)	$ (9,091)	$ 6,363	$ 17,272	$ 28,182	$ 29,091
Cash Flow	$(100,000)	-0-	$ (60,000)	$(40,000)	$(20,000)	-0-	-0-	$ 13,636	$ 22,727	$ 31,818	$ 30,909
PV of Cash Flow	$(100,000)	-0-	$ (49,587)	$(30,053)	$(13,660)	-0-	-0-	$ 6,997	$ 10,602	$ 13,494	$ 11,917
Current Cash Position	$ 300,000	$ 300,000	$ 240,00	$200,000	$180,000	$180,000	$180,000	$193,636	$216,363	$248,181	$ 279,090
Cumulative PV	$(100,000)	$(100,000)	$(149,587)	$(179,640)	$(193,300)	$(193,300)	$(193,300)	$(186,303)	$(175,701)	$(162,207)	$(150,290)

Production is in whole units.
Sales are in whole dollars.

CHAPMAN SIMULATION
Flexible Techniques
Expected Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Investment	$ 200,000										$ 100,000
Volume A		$ 35,000	$ 31,000	$ 38,000	$ 40,000	$ 45,000	$ 42,500	$ 48,500	$ 51,000	$ 56,000	$ 56,000
Sales A		$ 175,000	$ 155,000	$190,000	$200,000	$225,000	$212,500	$242,500	$255,000	$280,000	$ 280,000
Volume B		$ 3,300	$ 5,400	$ 6,500	$ 9,000	$ 11,700	$ 12,400	$ 14,000	$ 14,600	$ 15,000	$ 16,100
Sales B		$ 33,000	$ 54,000	$ 65,000	$ 90,000	$117,000	$124,000	$140,000	$146,000	$150,000	$ 161,000
Total Sales		$ 208,000	$ 209,000	$255,000	$290,000	$342,000	$336,500	$382,500	$395,000	$430,000	$ 441,000
Material Costs		$ 76,600	$ 72,800	$ 89,000	$ 98,000	$113,400	$109,800	$125,000	$131,200	$142,000	$ 144,200
Depreciation		$ 18,182	$ 16,364	$ 14,545	$ 12,727	$ 10,909	$ 9,091	$ 7,273	$ 5,455	$ 3,636	$ 1,818
Personnel Costs		$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
Gross Profit		$ 38,218	$ 44,836	$ 76,455	$104,273	$142,691	$142,609	$175,227	$183,345	$209,364	$ 219,982
Taxes		$ 19,109	$ 22,418	$ 38,228	$ 52,137	$ 71,346	$ 71,305	$ 87,614	$ 91,673	$104,682	$ 109,991
Net Profit		$ 19,109	$ 22,418	$ 38,227	$ 52,136	$ 71,345	$ 71,304	$ 87,613	$ 91,672	$104,682	$ 109,991
Cash Flow	$(200,000)	$ 37,291	$ 38,782	$ 52,772	$ 64,863	$ 82,254	$ 80,395	$ 94,886	$ 97,127	$108,318	$ 211,809
PV of Cash Flow	$(200,000)	$ 33,901	$ 32,051	$ 39,648	$ 44,302	$ 51,073	$ 45,381	$ 48,692	$ 45,310	$ 45,937	$ 81,662
Current Cash Position	$ 200,000	$ 237,291	$ 276,073	$328,845	$393,708	$475,962	$556,357	$651,243	$748,370	$856,688	$1,068,497
Cumulative PV	$(200,000)	$(166,099)	$(134,048)	$(94,400)	$(50,098)	$ 975	$ 46,356	$ 95,048	$140,358	$186,295	$ 267,957

Production is in whole units.
Sales are in whole dollars.

CHAPMAN SIMULATION
Traditional Techniques
Minimum Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Investment	$ 200,000										$(100,000)
Volume A		$ 25,000	$ 10,000	$ 15,000	$ 20,000	$ 25,000	$ 25,000	$ 30,000	$ 35,000	$ 40,000	$ 40,000
Sales A		$ 125,000	$ 50,000	$ 75,000	$100,000	$125,000	$125,000	$150,000	$175,000	$200,000	$ 200,000
Volume B		$ 2,000	$ 4,000	$ 5,000	$ 7,500	$ 9,000	$ 9,500	$ 10,000	$ 12,000	$ 12,500	$ 14,000
Sales B		$ 20,000	$ 40,000	$ 50,000	$ 75,000	$ 90,000	$ 95,000	$100,000	$120,000	$125,000	$ 140,000
Total Sales		$ 145,000	$ 90,000	$125,000	$175,000	$215,000	$220,000	$250,000	$295,000	$325,000	$ 340,000
Material Costs		$ 54,000	$ 28,000	$ 40,000	$ 55,000	$ 68,000	$ 69,000	$ 80,000	$ 94,000	$105,000	$ 108,000
Depreciation		$ 18,182	$ 16,364	$ 14,545	$ 12,727	$ 10,909	$ 9,091	$ 7,273	$ 5,455	$ 3,636	$ 1,818
Personnel Costs		$ 75,000	$ 75,000	$ 75,000	$ 75,00	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
Gross Profit		$ (2,182)	$ (29,364)	$ (4,545)	$ 32,273	$ 61,091	$ 66,909	$ 87,727	$120,545	$141,364	$ 155,182
Taxes		-0-	-0-	-0-	$ 16,137	$ 30,546	$ 33,455	$ 43,864	$ 60,273	$ 70,682	$ 77,591
Net Profit		$ (2,182)	$ (29,364)	$ 4,545)	$ 16,136	$ 30,545	$ 33,454	$ 43,863	$ 60,272	$ 70,682	$ 77,591
Cash Flow	$(200,000)	$ 16,000	$ (13,000)	$ 10,000	$ 28,864	$ 41,454	$ 42,545	$ 51,136	$ 65,727	$ 74,318	$ 179,409
PV of Cash Flow	$(200,000)	$ 14,545	$ (10,744)	$ 7,513	$ 19,714	$ 25,740	$ 24,016	$ 26,241	$ 30,662	$ 31,518	$ 69,170
Current Cash Position	$ 200,000	$ 216,000	$ 203,000	$213,000	$241,864	$283,318	$325,863	$376,999	$442,726	$517,044	$ 696,453
Cumulative PV	$(200,000)	$(185,455)	$(196,199)	$(188,686)	$(168,972)	$(143,232)	$(119,216)	$(92,975)	$(62,313)	$(30,795)	$ 38,375

Production is in whole units.
Sales are in whole dollars.

WARNOCK SIMULATION
Traditional Techniques
Expected Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
CAPITAL INVESTMENT	$ 3,200,000					$ (600,000)
Volume A		$ 70,000	$ 72,500	$ 77,500	$ 82,000	$ 87,000
Sales A		$ 3,500,000	$ 3,625,000	$3,875,000	$4,100,000	$4,350,000
Volume B		$ 500	$ 500	$ 1,000	$ 1,500	$ 3,200
Sales B		$ 37,500	$ 37,500	$ 75,000	$ 112,500	$ 240,000
Volume C		$ 800	$ 800	$ 800	$ 500	$ 1,000
Sales C		$ 80,000	$ 80,000	$ 80,000	$ 50,000	$ 100,000
Total Sales		$ 3,617,500	$ 3,742,500	$4,030,000	$4,262,500	$4,690,000
Material Costs		$ 1,782,500	$ 1,845,000	$1,982,500	$2,100,000	$2,280,000
Depreciation		$ 866,667	$ 692,333	$ 520,000	$ 346,667	$ 173,333
Personnel Cost		$ 521,000	$ 521,000	$ 521,000	$ 521,000	$ 521,000
Gross Revenue		$ 447,333	$ 684,167	$1,006,500	$1,294,833	$1,715,667
Taxes		$ 223,667	$ 342,084	$ 503,250	$ 647,417	$ 857,834
Net Profit		$ 223,666	$ 342,083	$ 503,250	$ 647,416	$ 857,833
Cash Flow	$(3,200,000)	$ 1,090,333	$ 1,034,416	$1,023,250	$ 994,083	$1,631,166
PV of Cash Flow	$(3,200,000)	$ 948,116	$ 782,167	$ 672,803	$ 568,370	$ 810,978
Cumulative PV	$(3,200,000)	$(2,251,884)	$(1,469,717)	$ (796,914)	$ (228,544)	$ 582,434

Production is in whole units.
Sales are in whole dollars.

WARNOCK SIMULATION
Traditional Techniques
Minimum Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
CAPITAL INVESTMENT	$ 3,200,000					$ (600,000)
Volume A		$ 50,000	$ 50,000	$ 55,000	$ 55,000	$ 60,000
Sales A		$ 2,500,000	$ 2,500,000	$ 2,750,000	$ 2,750,000	$3,000,000
Volume B		-0-	-0-	-0-	-0-	-0-
Sales B		-0-	-0-	-0-	-0-	-0-
Volume C		-0-	-0-	-0-	-0-	-0-
Sales C		-0-	-0-	-0-	-0-	-0-
Total Sales		$ 2,500,000	$ 2,500,000	$ 2,750,000	$ 2,750,000	$3,000,000
Material Costs		$ 1,250,000	$ 1,250,000	$ 1,375,000	$ 1,375,000	$1,500,000
Depreciation	-0-	$ 866,667	$ 692,333	$ 520,000	$ 346,667	$ 173,333
Personnel Costs		$ 521,000	$ 521,000	$ 521,000	$ 521,000	$ 521,000
Gross Revenue		$ (137,667)	$ 18,333	$ 167,000	$ 253,666	$ 402,833
Taxes		-0-	$ 18,334	$ 167,000	$ 253,667	$ 402,834
Net Profit		$ (137,667)	$ 18,333	$ 167,000	$ 253,666	$ 402,833
Cash Flow	$(3,200,000)	$ 729,000	$ 710,666	$ 687,000	$ 600,333	$1,176,166
PV of Cash Flow	$(3,200,000)	$ 633,913	$ 537,366	$ 451,714	$ 343,242	$ 584,762
Cumulative PV	$(3,200,000)	$(2,566,087)	$(2,028,721)	$(1,577,007)	$(1,233,765)	$ (649,003)

Production is in whole units.
Sales are in whole dollars.

WARNOCK SIMULATION
Flexible Techniques
Expected Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
CAPITAL INVESTMENT	$ 4,950,000					$(1,375,000)
Volume A		$ 70,000	$ 72,500	$ 77,500	$ 82,000	$ 87,000
Sales A		$ 3,500,000	$ 3,625,000	$ 3,875,000	$4,100,000	$ 4,350,000
Volume B		$ 3,600	$ 4,500	$ 4,760	$ 4,760	$ 4,760
Sales B		$ 270,000	$ 341,250	$ 357,000	$ 357,000	$ 357,000
Volume C		$ 4,000	$ 4,000	$ 4,250	$ 4,250	$ 4,250
Sales C		$ 400,000	$ 400,000	$ 425,000	$ 25,000	$ 425,000
Total Sales		$ 4,170,000	$ 4,366,250	$ 4,657,000	$4,882,000	$ 5,132,000
Material Costs		$ 1,784,800	$ 1,864,150	$ 1,989,730	$2,093,230	$ 2,208,230
Depreciation	-0-	$ 1,191,667	$ 953,333	$ 715,000	$ 476,667	$ 238,333
Personnel Cost		$ 317,000	$ 317,000	$ 317,000	$ 317,000	$ 317,000
Gross Revenue		$ 876,533	$ 1,231,767	$ 1,635,270	$1,995,103	$ 2,368,437
Taxes		$ 438,267	$ 615,884	$ 817,635	$ 997,552	$ 1,184,219
Net Profit		$ 438,266	$ 615,883	$ 817,635	$ 997,551	$ 1,184,218
Cash Flow	$(4,950,000)	$ 1,629,933	$ 1,569,216	$ 1,532,635	$1,474,218	$ 2,797,551
PV of Cash Flow	$(4,950,000)	$ 1,417,333	$ 1,186,553	$ 1,007,732	$ 842,889	$ 1,390,877
Cumulative PV	$(4,950,000)	$(3,532,667)	$(2,346,114)	$(1,338,382)	$ (495,493)	$ 895,384

Production is in whole units.
Sales are in whole dollars.

WARNOCK SIMULATION
Flexible Techniques
Minimum Sales

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
CAPITAL INVESTMENT	$ 4,950,000					$(1,375,000)
Volume A		$ 50,000	$ 50,000	$ 55,000	$ 55,000	$ 60,000
Sales A		$ 2,500,000	$ 2,500,000	$ 2,750,000	$ 2,750,000	$ 3,000,000
Volume B		-0-	-0-	-0-	-0-	-0-
Sales B		-0-	-0-	-0-	-0-	-0-
Volume C		-0-	-0-	-0-	-0-	-0-
Sales C		-0-	-0-	-0-	-0-	-0-
Total Sales		$ 2,500,000	$ 2,500,000	$ 2,750,000	$ 2,750,000	$ 3,000,000
Material Costs		$ 1,150,000	$ 1,150,000	$ 1,265,000	$ 1,265,000	$ 1,380,000
Depreciation	-0-	$ 1,191,667	$ 953,333	$ 715,000	$ 476,667	$ 238,333
Personnel Cost		$ 317,000	$ 317,000	$ 317,000	$ 317,000	$ 317,000
Gross Revenue		$ (158,667)	$ 79,667	$ 453,000	$ 691,333	$ 1,064,667
Taxes		$ -0-	$ 39,834	$ 226,500	$ 345,667	$ 532,334
Net Profit		$ (158,667)	$ 39,833	$ 226,500	$ 345,666	$ 532,333
Cash Flow	$(4,950,000)	$ 1,033,000	$ 993,166	$ 941,500	$ 822,333	$ 2,145,666
PV of Cash Flow	$(4,950,000)	$ 898,261	$ 750,976	$ 619,052	$ 470,172	$ 1,066,775
Cumulative PV	$(4,950,000)	$(4,051,739)	$(3,300,763)	$(2,681,711)	$(2,211,539)	$(1,144,764)

Production is in whole units.
Sales are in whole dollars.

VITA

Sydney Joseph Frohlich III

Candidate for the Degree of

Master of Business Administration

Report: RISK AND CAPITAL BUDGETING:
A CASE STUDY USING FLEXIBLE MANUFACTURING

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