MARGINAL ANALISIS IN DECISION-MAKING

BOSÂNCEANU Alexandru

Ministry of National Defence, Romania

Abstract:

In the conditions of the dynamic development of the economy, the task of making effective managerial decisions is becoming increasingly important. A special role in substantiating management decisions is assigned to marginal analysis. To form a qualitatively new level of management, it is necessary to justify management decisions as fully as possible and evaluate their effectiveness at all levels of management. Margin analysis establishes a correlation between the most important indicators characterizing the activity of any enterprise - costs, volume, and profit. Using this tool, management can predict the amount of profit, and its change compared to the existing level and, based on this information, make the right managerial decisions on choosing an enterprise strategy. With the help of margin analysis, other management decisions are also substantiated: a choice is made of a change in production capacity, the product range is determined, the price of a new product is made, and a decision is made on the purchase or purchase of parts, the effectiveness of accepting an additional order is evaluated, and others. The methodology of marginal analysis is based on the study of the relationship between the most important indicators: costs, the volume of production (sales) of products, and profit, as well as forecasting the magnitude of each of these indicators for a given value of others.

This analysis is also called breakeven analysis since this analysis allows you to find the equilibrium point, i.e. critical sales volume, or break-even point - the point at which the total revenue is equal to the total cost. They represent the sum of fixed and variable costs. The Break-even point is a situation in which the company does not incur losses, but also has no profit. Below the breakeven point mean losses for the management, above the equilibrium point - profit. The key elements of marginal analysis are operational, financial leverage, the stock of financial strength of the enterprise, and the threshold of profitability. This paper explores marginal analysis as a tool for making effective management decisions. The importance of using margin analysis to select an enterprise development strategy is noted. The basis of the marginal analysis is the division of production and marketing costs depending on changes in the volume of production into variables and fixed.

Key words: cost-benefit analysis; margin analysis; management; profit; decision-making

1. Introduction

Decision-making is an integral part of modern management. Essentially, rational or sound decision-making is taken as a primary function of management. Every manager takes hundreds and hundreds of decisions subconsciously or consciously making it the key component in the role of a manager. A manager plans, organizes, staffs, leads, and controls her team by executing decisions. The effectiveness and quality of those decisions determine how successful a manager will be.

2. Decision-Making

Decisions play important roles as they determine both organizational and managerial activities. A decision can be defined as a course of action purposely chosen from a set of alternatives to achieve organizational or managerial objectives or goals. The decision-making process is a continuous and indispensable component of managing any organization or business activities. Decisions are made to sustain the activities of all business activities and organizational functioning.

Decisions are made at every level of management to ensure organizational or business goals are achieved. Further, the decisions make up one of the core functional values that every organization adopts and implements to ensure optimum growth and drivability in terms of services and or products offered.

Decision making is central to all the managerial activities, be it planning, organizing, staffing, directing or controlling.

Decision making is a process of making choices from alternative courses of action, based upon factual and value premises with the intention of moving towards a desired state of affairs. Once a decision is taken, it implies commitment of resources.

The decision that a manager has to take may range from setting of goals and targets for the entire business enterprise to specific decisions regarding day-to-day activities. Some of them may have only short-term implications, while others may have long-term implications on the enterprise. From these points of view, manage-rial decisions can be broadly classified into three categories, namely, strategic, tactical and operational decisions.

a. Strategic decisions:

Strategic decisions are major choices of actions and influence whole or a major part of business enterprise. They contribute directly to the achievement of common goals of the enterprise. They have long-term implications on the business en-terprise.

They may involve major departures from practices and procedures being followed earlier. Generally, strategic decision is unstructured and thus, a manager has to apply his business judge-ment, evaluation and intuition into the definition of the problem. These decisions are based on partial knowledge of the environmen-tal factors which are uncertain and dynamic. Such decisions are taken at the higher level of management.

b. Tactical decisions:

These decisions relate to the implementation of strategic decisions. They are directed towards developing divi-sional plans, structuring workflows, establishing distribution chan-nels, acquisition of resources such as men, materials and money. These decisions are taken at the middle level of management.

c. Operational decisions:

These decisions relate to day-to-day op-erations of the enterprise. They have a short-term horizon as they are taken repetitively. These decisions are based on facts regarding the events and do not require much of business judge-ment. Operational decisions are taken at lower levels of man-agement. As the information is needed for helping the manager to take

rational, well-informed decisions, information systems need to fo-cus on the process of managerial decision making.

1.1 Analysis for decision making

Quite literally, organizations operate by people making decisions. A manager plans, organizes, staffs, leads, and controls her team by executing decisions. The effectiveness and quality of those decisions determine how successful a manager will be.
Managers are constantly called upon to make decisions in order to solve problems. Decision making and problem solving are ongoing processes of evaluating situations or problems, considering alternatives, making choices, and following them up with the necessary actions. Sometimes the decision-making process is extremely short, and mental reflection is essentially instantaneous. In other situations, the process can drag on for weeks or even months. The entire decision-making process is dependent upon the right information being available to the right people at the right times.

The decision-making process involves the following steps:

1. Define the problem.
2. Identify limiting factors.
3. Develop potential alternatives.
4. Analyze the alternatives.
5. Select the best alternative.
6. Implement the decision.
7. Establish a control and evaluation system.

1.2 Different types of Analysis for decision making

Cost Benefit Analysis

Cost Benefit Analysis or CBA is a relatively simple and widely used technique for deciding whether to make a change. As its name suggests, to use the technique simply add up the value of the benefits of a course of action, and subtract the costs associated with it.
Costs are either one-off, or may be ongoing. Benefits are most often received over time. We build this effect of time into our analysis by calculating a payback period. This is the time it takes for the benefits of a change to repay its costs. Many companies look for payback over a specified period of time – e.g. three years.
In its simple form, cost-benefit analysis is carried out using only financial costs and financial benefits. For example, a simple cost/benefit analysis of a road scheme would measure the cost of building the road, and subtract this from the economic benefit of improving transport links. It would not measure either the cost of environmental damage or the benefit of quicker and easier travel to work.
A more sophisticated approach to cost/benefit measurement models is to try to put a financial value on intangible costs and benefits. This can be highly subjective.

Cash Flow Forecasting

Cash Flow forecasts help you to build a model of the way in which cash moves within a project or organization. They help you to predict whether the sales or income you forecast will cover the costs of operation. They also allow you to analyze whether a project will be sufficiently profitable to justify the effort put into it.

Cash flow forecasts can also be useful for analyzing your own personal finances. This is useful when you are about to make difficult financial decisions.

By carrying out a Cash Flow forecast on a spreadsheet package you can investigate the impact of changing factors within the forecast. If you have structured the spreadsheet correctly then you will be able to see, more or less instantly, the effect that changes will have.

Normally we structure Cash Flow Forecasts in a standard way. This is explained below. Other sorts of forecasting can be carried out with spreadsheets. A good way of structuring these is to firstly analyse the system being forecasted with a system diagram. This system diagram will show the relationships between factors. You can then quantify these relationships, and build a model based on them. The structure of the model will depend on the system being modeled.

SWOT Analysis

SWOT analysis (alternately SLOT analysis) is a strategic planning method used to evaluate the Strengths, Weaknesses/Limitations, Opportunities, and Threats involved in a project or in a business venture. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective. The technique is credited to Albert Humphrey, who led a convention at Stanford University in the 1960s and 1970s using data from Fortune 500 companies.

Setting the objective should be done after the SWOT analysis has been performed. This would allow achievable goals or objectives to be set for the organization.

• Strengths: characteristics of the business, or project team that give it an advantage over others

• Weaknesses (or Limitations): are characteristics that place the team at a disadvantage relative to others

• Opportunities: external chances to improve performance (e.g. make greater profits) in the environment

• Threats: external elements in the environment that could cause trouble for the business or project

Identification of SWOTs is essential because subsequent steps in the process of planning for achievement of the selected objective may be derived from the SWOTs.

First, the decision makers have to determine whether the objective is attainable, given the SWOTs. If the objective is NOT attainable a different objective must be selected and the process repeated.

The SWOT analysis is often used in academia to highlight and identify strengths, weaknesses, opportunities and threats, particularly helpful in identifying areas for development.

Critical Path Method

The purpose of the analysis is two-fold: (i) to find the critical path, i.e. the sequence of activities with the longest duration. Once it is found it is marked in bold sequence of arrows on the network. For a simple network as of figure -24 the various sequences can be enumerated and the durations of activities encompassed by them simply added, to find the critical sequence. As stated earlier, one could indeed end up with more than one critical sequence; and (ii) to find the float associated with each non-critical activity.

Some of the **other common decision-making tools** are as follows: -

- Decision Trees – one identifies options, branching out of an initial bipolar choice to make, by projecting likely outcomes. The limitation of this technique lies mainly in that it forces you to address the problem from only two possible avenues of solution right from the start.
- The Pareto Analysis – is a technique to let you get the most "bang for the buck"! It is based on the Pareto Principle whereby you must identify which actions will let you get 80% of the possible positive results by doing only 20% of the work. It is known as the 80/20 rule.
- Pros & Cons – one lists the advantages and disadvantages of each possible decision and attempts to identify the best possible outcome whereby the advantages outnumber the disadvantages.
- PMI – is a variation of the Pros & Cons technique adding a third possibility called "interesting" (plus/minus/interesting).
- Six Thinking Hats – This technique can help reduce some of the shortcomings of any one of decision making styles. Edward De Bono wrote a book, titled "Six Thinking Hats", about this very powerful technique back in 1985.

1.3 Cost Involved In Decison Making

Opportunity Cost

Opportunity cost is the cost of any activity measured in terms of the value of the next best alternative forgone. It is the sacrifice related to the second best choice available to someone, or group, who has picked among several mutually exclusive choices. The opportunity cost is also the "cost" (as a lost benefit) of the forgone products after making a choice. Opportunity cost is a key concept in economics, and has been described as expressing "the basic relationship between scarcity and choice". The notion of opportunity cost plays a crucial part in ensuring that scarce resources are used efficiently.[3] Thus, opportunity costs are not restricted to monetary or financial costs: the real cost of output forgone, lost time, pleasure or any other benefit that provides utility should also be considered opportunity costs.

Sunk Costs

Sunk costs are retrospective (past) costs that have already been incurred and cannot be recovered. Sunk costs are sometimes contrasted with prospective costs, which are future costs that may be incurred or changed if an action is taken. Both retrospective and prospective costs may be either fixed (continuous for as long as the business is in operation and unaffected by output volume) or variable (dependent on volume) costs. Note, however, that many economists consider it a mistake to classify sunk costs as "fixed" or "variable." For example, if a firm sinks $1 million on an enterprise software installation, that cost is "sunk" because it was a one-time expense and cannot be recovered once spent.

Imputed Cost

1. In accounting, the expense of unreimbursed goods and services provided by one entity to another entity.
2. An expense that is borne indirectly. For example, paying cash for a car avoids the direct cost of interest payments to a lender, but it entails the imputed cost of lost income from having funds invested in the car rather than a more productive asset.

Cost that is implied but not reflected in the financial reports of the firm; also called implicit cost. Imputed costs consist of the opportunity costs of time and capital that the manager has invested in producing the given quantity of production and the opportunity costs of making a particular choice among the alternatives being considered.
Imputed cost, also referred to as opportunity cost, is a concept based on an economic theory, which basically states that to obtain anything one must give up something in return. For example, to get a full-time four year college education, one may need to forgo the opportunity of working full time and earning $20,000 US Dollars (USD) per year in that period. The $20,000 USD is the imputed cost. Among other concepts, the imputed cost concept is essential when computing economic profit. This is derived by taking the net accounting profit or loss and deducting the imputed cost.

Relevant Cost

A relevant cost (also called avoidable cost or differential cost) is a cost that differs between alternatives being considered. It is often important for businesses to distinguish between relevant and irrelevant costs when analyzing alternatives because erroneously considering irrelevant costs can lead to unsound business decisions. Also, ignoring irrelevant data in analysis can save time and effort. Non-cash items, such as depreciation and amortization, are frequently categorized as irrelevant costs, since they do not impact cash flows.

Two common types of irrelevant costs are sunk costs and future costs that do not differ between alternatives. Sunk costs are unavoidable because they have already been incurred. Future costs that do not change between alternatives are also essentially unavoidable with respect to the alternatives being considered.

Avoidable Cost

Definition of Avoidable Cost: A cost that can be avoided by not producing a particular good. For example, if you are building cars, an avoidable cost would be the raw materials.
If you stopped producing a car, you would no longer have to pay for the raw materials such as steel and aluminum. However, other costs of a firm maybe unavoidable, at least in the short term. For example, the firm still has the fixed costs such as rent and paying some safety workers.

Controllable And Uncontrollable Cost

Controllable Cost are the costs which can be influenced by the action of a specified member of the undertaking. They are incurred in a particular responsibility centers can be influenced by the action of the executive heading that responsibility centre. For example: Direct labor cost, direct material cost, direct expenses controllable by the shop level management.

These are the costs which can be influenced by the action of a specified member of an undertaking. A business organization is usually divided into number of responsibility centers and an executive heads each such centre. Controllable costs incurred in a particular responsibility centre can be influenced by the action of the executive heading that responsibility centre. For example, Direct costs comprising direct labor, direct material, direct expenses and some of the overheads are generally controllable by the shop level management.

Uncontrollable Cost are the costs which cannot be influenced by the action of a specified member of the undertaking. For example: a foreman in charge of a tool room can only control costs pertaining to the same department and the matters which come directly under his control, not the costs apportioned to other department. The expenditure which is controllable by an individual may be uncontrollable by another individual.

Costs which cannot be influenced by the action of a specified member of an undertaking are known as uncontrollable costs. For example, expenditure incurred by, say, the Tool Room is controllable by the foreman in charge of that section but the share of the tool-room expenditure which is apportioned to a machine shop is not to be controlled by the machine shop foreman.

Replacement Cost

The cost to replace the assets of a company or a property of the same or equal value. The replacement cost asset of a company could be a building, stocks, accounts receivable or liens. This cost can change depending on changes in market value.

Also referred to as the price that will have to be paid to replace an existing asset with a similar asset.

The amount it would cost to replace an asset at current prices. If the cost of replacing an asset in its current physical condition is lower than the cost of replacing the asset so as to obtain the level of services enjoyed when the asset was bought, then the asset is in poor condition and the firm would probably not want to replace it.

Normal and abnormal cost

Normal cost refers to the cost, at a given level of output in the conditions in which that level of output is normally attained. Abnormal cost is a cost which is not normally incurred at a given level of output in the conditions in which that level of output is normally attained.

Normal Cost are the normal or regular costs which are incurred in the normal conditions during the normal operations of the organization. Example: repairs, maintenance, salaries paid to employees.

Abnormal Cost are the costs which are unusual or irregular which are not incurred due to abnormal situation s of the operations or productions. Example: destruction due to fire, shut down of machinery, lock outs, etc.

Marginal Costing

In economics and finance, marginal cost is the change in total cost that arises when the quantity produced changes by one unit. That is, it is the cost of producing one more unit of a good. If the good being produced is infinitely divisible, so the size of a marginal cost will change with volume, as a non-linear and non-proportional cost function includes the following:

- variable terms dependent to volume,
- constant terms independent to volume and occurring with the respective lot size, jump fix cost increase or decrease dependent to steps of volume increase

1.Change in total cost that comes from making or producing one additional item. The purpose of analyzing marginal cost is to determine at what point an organization can achieve economies of scale. The calculation is most often used among manufacturers as a means of isolating an optimum production level.

2.The increase or decrease in a firm's total cost of production as a result of changing production by one unit

Features of marginal costing:

- It is a method of recoding costs and reporting profits.
- It involves ascertaining marginal costs which is the difference of fixed cost and variable cost.
- The operating costs are differentiated into fixed costs and Variable costs. Semi variable costs are also divided in the Individual components of fixed cost and variable cost.
- Fixed costs which remain constant regardless of the volume of production do not find place in the product cost determination and inventory valuation.
- Fixed costs are treated as period charge and are written off to the profit and loss account in the period incurred.
- Only variable costs are taken into consideration while Computing the product cost.
- Prices of products are based on variable cost only.
- Marginal contribution decides the profitability of the Products.

Advantages of marginal costing:

1.Decision regarding pricing:

Any price change has an immediate effect on PVR, BEP and margin of safety. It is generally said that the effect of a price reduction is always to reduce the P/V ratio, to raise the break- even point, and to shorten the margin of safety.

Pricing decision may be based on mainly 3 considerations:

- Percentage of profit on total cost: in this method, the market condition and competitiveness will not be taken care of.
- Percentage of profit on selling cost: the profit on sale suffers the limitations of market conditions ,competitiveness and difficulty of price fixation in case of multiple products.
- Return on investment. Of all, this is considered to be the best method because the investment takes care of all the aspects of net fixed assets and net working capital employed for earning the profit.

2. Decision regarding optimum product mix:

Marginal costing helps the management in deciding the most profitable product-mix.the product-mix which yields the maximum possible profits is the optimum product mix.

3.Decision regarding special offer/discontinue product:

This decision is mainly concerned in adding or discontinuing marginal unit. The management has to decide whether to

- Increase or decrease in the production of a unit
- Add or continue or discontinue a product
- Accept or reject a specific order
- Add, continue or discontinue a specific department.

Thus by analyzing the marginal costs, management can decide whether to increase or decrease the production of the article and so on.

Differential Costing

Differential cost is the difference between the cost of two alternative decisions, or of a change in output levels. The concept is used to reach decisions about which alternatives to pursue, and which to drop. The concept can be particularly useful in step costing situations, where producing one additional unit of output may require a substantial additional cost

A differential cost can be a variable cost, a fixed cost, or a mix of the two – there is no differentiation between these types of costs, since the emphasis is on the gross difference between the costs of the alternatives or change in output. Since a differential cost is only used for management decision making, there is no accounting entry for it.

Differential cost is a business term that refers to the difference in costs for a business when choosing between two alternatives. It is an important tool in the decision-making process for businesses looking to make possible changes to a business model. Closely associated with marginal, a term favoured by economists, it can refer to either fixed or variable costs. The relevance of these costs is obvious when judged alongside of differential revenue to give businesses a perspective on the positives or negatives of a decision.

Definition:

Differential cost is the aggregate of change in fixed cost and variable cost which takes place due to the adoption of alternative course of action or change in the volume of output

Characteristics of differential costing

In order to ascertain the differential costs, only total cost is needed and not cost per unit. Existing level is taken to be the base for comparison with some Future or forecasted level.

Differential cost is the economist's concept of marginal cost.

It may be referred to as incremental cost when the difference in Cost is due to increase in the level of production and detrimental costs when difference in cost is due to decrease in the level of production.

Uses of Differential Costing in policy decisions like:

1. The introduction of a new plant.
2. Make or buy decisions.
3. Lease or buy decisions.
4. Discontinuing a product, suspending or closing down a segment of the business.
5. The profitability of a change in product mix.
6. Acceptance of an offer at a lower selling price.
7. Change in the methods of production.
8. The determination of the most profitable levels of production and price.
9. Submitting tenders.
10. The determination of price at which raw materials can be purchased.
11. Equipment replacement decisions.
12. The profitability or otherwise of further processing.
13. The opening of a new sales area or territory.

Differences between marginal and differential cost:

Differential Cost Analysis is a costing technique used for decision-making purpose with the use of differential revenue and differential cost

Marginal Costing Analysis is a technique used in ascertaining the marginal cost and effect on changes in profit due to changes in volume

The differential costing can be applied in varied alternative proposals hence the scope is wider. The scope of marginal costing is comparatively lesser.

The differential costing uses the accounting information and it can only be part of accounting system.The marginal costing system can be included into accounting system

The main analytical tools used in differential costing are, incremental/ decremented cost, incremental revenue and incremental/ detrimental profit. In marginal costing, the main analytical tools are, P/V ratio, Break-even point, contribution, CVP analysis etc

The differential costing can be used for short-term, medium-term and long-term decision-making. The marginal costing is mainly used for short-term and medium-term decision-making

1.4 Information for decision making

The need for a decision arises in business because a manager is faced with a problem and alternative courses of action are available. In deciding which option to choose he will need all the information which is relevant to his decision; and he must have some criterion on the basis of which he can choose the best alternative. Some of the factors affecting the decision may not be expressed in monetary value. Hence, the manager will have to make 'qualitative' judgements, e.g. in deciding which of two personnel should be promoted to a managerial position. A 'quantitative' decision, on the other hand, is possible when the various factors, and relationships between them, are measurable. This chapter will concentrate on quantitative decisions based on data expressed in monetary value and relating to costs and revenues as measured by the management accountant.

Elements of a decision

A quantitative decision problem involves six parts:

a) An objective that can be quantified Sometimes referred to as 'choice criterion' or 'objective function', e.g. maximisation of profit or minimisation of total costs.

b) Constraints Many decision problems have one or more constraints, e.g. limited raw materials, labour, etc. It is therefore common to find an objective that will maximise profits subject to defined constraints.

c) A range of alternative courses of action under consideration. For example, in order to minimise costs of a manufacturing operation, the available alternatives may be:

i) to continue manufacturing as at present

ii) to change the manufacturing method

iii) to sub-contract the work to a third party.

d) Forecasting of the incremental costs and benefits of each alternative course of action.

e) Application of the decision criteria or objective function, e.g. the calculation of expected profit or contribution, and the ranking of alternatives.

f) Choice of preferred alternatives.

Relevant costs for decision making

The costs which should be used for decision making are often referred to as "relevant costs". CIMA defines relevant costs as 'costs appropriate to aiding the making of specific management decisions'.
To affect a decision a cost must be:
a) Future: Past costs are irrelevant, as we cannot affect them by current decisions and they are common to all alternatives that we may choose.
b) Incremental: ' Meaning, expenditure which will be incurred or avoided as a result of making a decision. Any costs which would be incurred whether or not the decision is made are not said to be incremental to the decision.
c) Cash flow: Expenses such as depreciation are not cash flows and are therefore not relevant. Similarly, the book value of existing equipment is irrelevant, but the disposal value is relevant.
Other terms:
d) Common costs: Costs which will be identical for all alternatives are irrelevant, e.g. rent or rates on a factory would be incurred whatever products are produced.
e) Sunk costs: Another name for past costs, which are always irrelevant, e.g. dedicated fixed assets, development costs already incurred.
f) Committed costs: A future cash outflow that will be incurred anyway, whatever decision is taken now, e.g. contracts already entered into which cannot be altered.
g) Opportunity cost: relevant costs may also be expressed as opportunity costs. An opportunity cost is the benefit foregone by choosing one opportunity instead of the next best alternative.

1.5 Decision Making considerations

Thousands of business decisions are made every day – and not all will "MAKE" or "BREAK" the organization. But each one adds a measure of success (or failure) to the operations, i.e. all decisions have some influence- large or small- on performance. e.g. Arçelik Co. managers must decide which of the several potential products to develop. An electronics manufacturer must decide whether to invest in a new process or to stay with a "proven" one that is producing defective chips at a rate of 1 in 3.

Does the ability to make good decisions come "naturally" or it can be learned? Management scientists hold that education, scientific training, and experience can improve a person's ability to make decisions. The idea of management as a "science" is founded on its similarity to other sciences as expressed below.

- Organized principles of knowledge,
- Use of empirical data,
- Systematic analysis of data,
- Repeatable results.

First, the principles and methodology of management, e.g. organization theory, span of control, form an organized or codified body of knowledge.

Second, real world data are available for analysis. The business world is essentially a laboratory for the management scientist.

Third, an objective and systematic analysis of the data can be made.

Fourth, another decision maker could use the same data and arrive at consistent results.

Decisions range from simple judgments to complex analyses – which can also involve judgment. Judgments typically incorporate basic knowledge, experience and what we often refer to as "common sense". They enable us to blend objective and subjective data to arrive at a choice. Fortunately the human brain is capable of selecting and integrating relevant information into a meaningful decision. Quantitative methods of analysis add to the objectivity of such decisions.

The appropriateness of a given type of analysis

1. The significance and long-lasting of the decision. - e.g. A plant investment may deserve more thorough analysis than a short-term decision to stock Christmas trees for Christmas and New Year eve.
2. The time availability and the cost of analysis. - e.g. There must be adequate time to study the complete financial ramifications of a project proposal.
3. The degree of complexity of the decision. Complexity increases when:

a. many variables are involved,
b. the variables are highly interdependent or sequentially related,
c. the data describing the variables are incomplete or uncertain. - e.g. New factory location decisions are complex, because they involve economic, social, and environmental concerns.

Business decision makers have always had to work with incomplete and uncertain data. In some situations a decision maker has (or is assumed to have) complete information about the decision variables; at the other extreme no information available. Managerial decisions are made all along this continuum.

Complete Certainty in decision making requires data on all elements in the population. If such data are not available, large samples lend more certainty than do small ones. Beyond this, subjective information is likely to be better than no data at all.

1.6 Framework for decision making

An analytical and scientific framework for decision implies several systematic steps as explained below. Not all managers follow this formal process- nor all decisions necessitate it.

Regardless of the situation, experience and good judgment are always important ingredients in decision making.

The steps for scientific decision making are:

1. Define the problem and its parameters (relevant variables),
2. Establish the decision criteria (objectives, to reflect the goals and purpose of the work efforts),
3. Formulation of a model relating the parameters to the criteria. Models can be:
    a. Verbal (words and descriptions),
    b. Physical (modified scale. Three dimensional representations of other objects.),
    c. Schematic (diagrams and charts, graphs and maps),
    d. Mathematical (equations and numbers) - mathematical models are most useful for understanding complex business problems.
4. Generate alternatives by varying the values of the parameters. A decision alternative is a course of action or a strategy that can be chosen by the decision maker.

5. Evaluate the alternatives and select the alternative that best satisfies the criteria.All possibilities must be considered. The results may be undesirable. Outcomes over which the decision maker has little or no control are called "States of Nature".
6. Implement the decision and monitor the results.

"Decision Making" is, therefore, the act of selecting a preferred course of action among alternatives. The act of decision making enters into almost all of a manager's activities. Managers must reach decisions about objectives and plans for their organizational units. They must decide how to direct, how to organize, how to control. They must not only make many decisions, but also guide subordinates in reaching decisions of their own. Much of manager's time is spent in gathering and evaluating information so that he or she will know if a decision is needed and the necessary background information will be available if it is.

Businesses and other organizations survive by making and implementing enough of the right decisions; they fail either because they make the right decisions but are unsuccessful in implementing them, or because they make wrong decisions and succeed in implementing them. The success of business and nonprofit organizations hinges on their ability to make good decisions and to implement their decisions well.

1.7 Types of decision making environments

The types of decisions people make depend on how much knowledge or information they have about the problem scenario. There are three decision making environments.

Type 1: Decision Making Under Certainty

Decision makers know for sure (i.e. with certainty) the outcome or consequence of every decision alternative. Naturally, they will select the alternative that will result in the best outcome. Linear programming, goal programming, and integer programming are all examples of decision modeling techniques suited for decision making under certainty.

Type 2: Decision Making Under Uncertainty

The decision maker has no information at all about the various outcomes or states of nature that he or she does not know the probabilities of the various future outcomes. e.g. The probability that Saadet Partisi will control Turkish parliament 20 years from now is not known. It is also impossible to assess the probability for that.

Type 3: Decision Making Under Risk

The decision maker has some knowledge regarding the probability of occurrence of each outcome or state of nature. e.g. The probability of being dealt a club from a deck of cards is ¼. The probability of rolling a 5 on a die is 1/6. In decision making under risk, the decision maker attempts to identify the alternative that optimizes his or her expected profit or cost.

1.8 The concept of the margin

Economists tend to concentrate on decisions that are taken at the margin. This is the point at which the last unit of a product is produced or consumed. Marginal analysis is based on the idea that decisions are often based on whether to do a little more or a little less of something. For example, a producer whose aim is profit maximisation will carry on producing a product until marginal revenue is equal to marginal cost.

The marginal cost is extremely useful to economic agents in the decision-making process. For example, the decisions of consumers, operating as economic agents, can be analysed in terms of marginal utility. This refers to the additional satisfaction that is gained from the consumption of one more unit of a product. It is very important to distinguish between marginal utility, which is the additional satisfaction of consuming one more unit, and total utility, which is the total satisfaction of consuming a number of units.

The decisions of producers, operating as economic agents, can be analysed in terms of marginal cost. This is the additional cost of producing one more unit of a product. It is important to distinguish between marginal cost, which is the additional cost of producing one more unit, and total cost, which is the total cost of producing a number of units. Marginal cost and marginal revenue are crucial to the decision making of producers because a firm will maximise its profits when marginal cost is equal to marginal revenue, i.e. through selling one more item of a product, a firm will gain in revenue exactly the same amount as the cost of producing this last unit.

The advantage of this situation is that it is economically efficient, i.e. scarce resources are allocated efficiently because the price that a consumer is willing to pay for the last unit of a product consumed is exactly the same as the cost of producing that last unit.

Rationality involves decisions being taken and choices made on the basis of preferences. For example, consumer or household rationality occurs when a consumer chooses the feasible alternative that he or she most prefers. Where an alternative is chosen that is not the most preferred choice, this can be regarded as irrational. The result is an optimal level of benefit or utility for the individual consumer. Most economic theories are based on the idea that all individuals will act rationally. These theories have been questioned, however, by behavioural approaches to economic behaviour which challenge the underlying rationality of consumers.

Rationality can also be applied to decisions taken by firms. A firm that is choosing what to produce and how much to produce will take into account the costs and benefits of such decisions. The balance between the two will help a firm make a rational decision, especially concerning the costs of producing something compared with the revenue gained from selling it.

Rationality can also be applied to decisions taken by governments. For example, a decision as to whether to spend more on health or to spend more on education would be based on rationality. A good example of such an approach would be when the benefits and drawbacks of a major public investment project are contrasted, such as whether to build a new runway or a new railway line. Cost–benefit analysis is used to help governments take the most rational decision.

The concept of rationality, therefore, is an extremely useful way of understanding the behaviour of different economic agents, such as households, firms and governments.

3. Cost-Benefit Analysis considerations

Military Cost-Benefit Analysis (CBA) offers a vital tool to help guide governments through both stable and turbulent times. As countries struggle with the dual challenges of an uncertain defense environment and cloudy fiscal prospects, CBA offers a unique opportunity to transform defense forces into more efficient and effective 21st century organizations.

Faced with severe budget cuts and an uncertain threat environment, defense officials around the world confront urgent decisions on whether or not to approve specific projects

(e.g. infrastructure—military housing; training, and maintenance facilities, etc.) or programs (e.g. weapon systems—Unmanned Aerial Vehicles (UAVs), Armored Personnel Carriers (APCs), Cyber Defense, etc.). Military CBA offers a valuable set of analytical tools to increase the transparency, efficiency, and effectiveness of critical defense decisions.

A synthesis of economics, management science, statistics, and decision theory, military CBA is currently used in a wide range of defense applications in countries around the world: i) to shape national security strategy, ii) to set acquisition policy, and iii) to inform critical investments in people, equipment, infrastructure, services, and supplies.

The French engineer Jules Dupuit (Dupuit 1844) is widely credited with an early concept of CBA called "economic accounting." The British economist Alfred Marshall (Marshall 1920) later developed formal concepts that contributed to the analytical foundations of CBA.

At the heart of Cost-Benefit Analysis (CBA) is the economists' concept of "allocative efficiency," in which resources are deployed to their highest valued use to maximize social welfare. A related and intuitively appealing definition called "Pareto Efficiency" underpins CBA. An allocation is Pareto-efficient if no alternative allocation can make at least one person better off without making someone else worse off (Pareto 1909).

At the highest national strategic level, "benefits" of a specific defense policy might be measured in terms of its impact on long-term economic growth, peace, and prosperity—all key contributors to social welfare. For example, suppose resource costs to achieve specific military goals are viewed as insurance payments against hazardous states of the world. Suppose further that defense policy decisions that achieve specific military goals reduce risk premiums associated with domestic and foreign direct investment (FDI). Empirical evidence suggests FDI boosts economic growth and in turn contributes to peace and prosperity.8 In this example, high-level defense decisions could ideally be made with the aim of increasing social welfare by encouraging investment, boosting GDP, and thereby generating a virtuous cycle of peace and prosperity.

It is clear that politics influences defense decisions. It is also true that public officials can manipulate CBA for their own personal strategic interests. Politicians likely win more votes highlighting a program's benefits and downplaying its costs, and public administrators may be similarly rewarded. While it is clear pork-barrel politics often plays an important role in defense decisions, this book attempts to take the high road. It encourages the application of military CBA with a strict focus on national security interests.

While employment, income distribution, and regional impacts of defense investment decisions often play a role in political decisions, a clean CBA can inform the process by revealing the true (opportunity) cost of decisions that drift too far from the goal of making the best use of scarce resources for the security of the country. Ideally, a carefully constructed military CBA focused strictly on national security concerns could be used to inform voters and counter special interest lobbying and rent-seeking that often leads defense firms to inefficiently spread production across key voting districts to promote their programs.

A risk for any military CBA is that benefit and cost estimates might be strategically manipulated by self-interested agencies or individual decision- makers.

While politics still dominates major defense decisions, the importance of military CBA rises alongside growing demands for transparency and accountability.20 Costly defense procurement scandals reinforce the need for objective CBA approaches to improve transparency in vendor selection decisions.

Meanwhile, painful recovery from the global financial crisis, combined with emergent threats, fuel public demand to carefully apply tools such as military CBA to build efficient, effective, and accountable security forces.

Outline

CBA can reduce budget pressures and improve defense decisions that contribute to national security. The dual purpose of CBA is to encourage more efficient and effective allocation of society's scarce resources to increase social welfare.

Governments often employ CBA to rank (mutually exclusive) portfolios of projects or programs.

The typical CBA involves at least eight steps:

1) The first step is to identify key decision-makers (and other stakeholders) to clarify goals, objectives, preferences, and constraints (including realistic funding projections).
2) The second step is to carefully structure the problem and identify feasible alternatives that contribute to those goals/objectives and that satisfy the constraints.
3) The third step is to determine the relevant time horizon over which the CBA will be conducted and to select an appropriate discount rate.
4) The fourth step is to estimate relevant time-phased costs of each alternative over the relevant period.
5) The fifth step is to forecast time-phased benefits that will accrue over the relevant period.24 This edited volume offers alternative approaches to structure a military CBA when benefits cannot be monetized. If benefits can be monetized, then the project or program with the highest Net Present Value (NPV) can be recommended.25
6) The sixth step is to recognize uncertainty and conduct sensitivity analyses to determine whether results change with changes in key parameters (costs, benefits, budgets, discount rates, etc.).26
7) The seventh step is to report the results of the analysis (rankings of projects, programs, etc., along with key assumptions).
8) The final step is to make well-informed recommendations.

2.1 What Is a Cost Benefit Analysis?

All CBAs provide decision-makers with facts, data, and analysis required to make an informed decision. There is no prescribed length to a CBA. Quality is genuinely more important than quantity.

A CBA:

- Is a decision support tool that documents the predicted effect of actions under consideration to solve a problem or take advantage of an opportunity.
- Is a structured proposal that functions as a decision package for organizational decision- makers.
- Defines a solution aimed at achieving specific Army and organizational objectives by quantifying the potential financial impacts and other business benefits such as:
  - o Savings and/or cost avoidance
  - o Revenue enhancements and/or cash-flow improvements
  - o Performance improvements
  - o Reduction or elimination of a capability gap
- Considers all benefits to include non-financial or non-quantifiable benefits of a specific

course of action (COA) or alternative.
• An analysis of needs and problems, their proposed alternative solutions, and a risk analysis to lead the analyst to a recommended choice before a significant amount of funds are invested by the billpayer.
• Must be tailored to fit the problem, because finding the optimal solution is the focus of the CBA.
• Supports the decision making process, but will not make a final decision. That will be the responsibility of the decision maker/leadership.
• Is not a substitute for sound judgment, management, or control.

Finally, a CBA is a living document. It is important for the preparer to keep the CBA updated so that the decision maker can make an informed decision based upon the best available information.

2.2 Who Can Perform a Cost Benefit Analysis?

Cost benefit analyses may be performed by government employees and/or contractors. However, any CBA developed by a contractor should be reviewed and validated by the government.

2.3 When Should a Cost Benefit Analysis Be Performed?

A CBA must be performed to support leadership decisions, specific examples are:
• Per Army Program Guidance Memorandum (APGM)
• With Force Design updates and Concept Plans or as part of VCSA portfolio analyses.
• When issues will be considered by ACP, BRP, or AR2B.
• In response to directives from Army leadership, OSD
• When the organization is requesting capital budget funds.

2.4 Cost Benefit Analysis and the Military Decision Making Process (MDMP)

The CBA process and the MDMP have much in common. They are both designed to produce a well-reasoned solution to an identified problem. The MDMP is described in Appendix B of FM 5-0: "The Operations Process." The MDMP helps leaders apply thoroughness, clarity, sound judgment, logic, and professional knowledge to understand situations, develop options to solve problems and reach decisions. Like the CBA methodology, it is an iterative process.

The two processes are essentially complementary. The only meaningful difference of note is that the MDMP does not specifically address financial cost as part of its analysis. Financial resourcing considerations are not required in the development of operation plans (OPLANs) and operation orders (OPORDs).

The primary objective of developing a CBA is to identify and obtain approval of the optimum course of action to solve a specific problem or capitalize on a specific improvement opportunity.
• A CBA is needed when there is a choice to be made between several options. A CBA is not needed if there are no other options, e.g., when legislation, directives, or instructions mandate the funding of a given project.

• The CBA team should include subject matter experts.
• The recommendation should include a concise value proposition to catch the attention of the decision maker and emphasize why the recommended COA is the best choice.
•The MDMP methodology is very similar to that of the CBA. The essential difference between the two decision-making methodologies is the MDMP is not affected by financial resources.

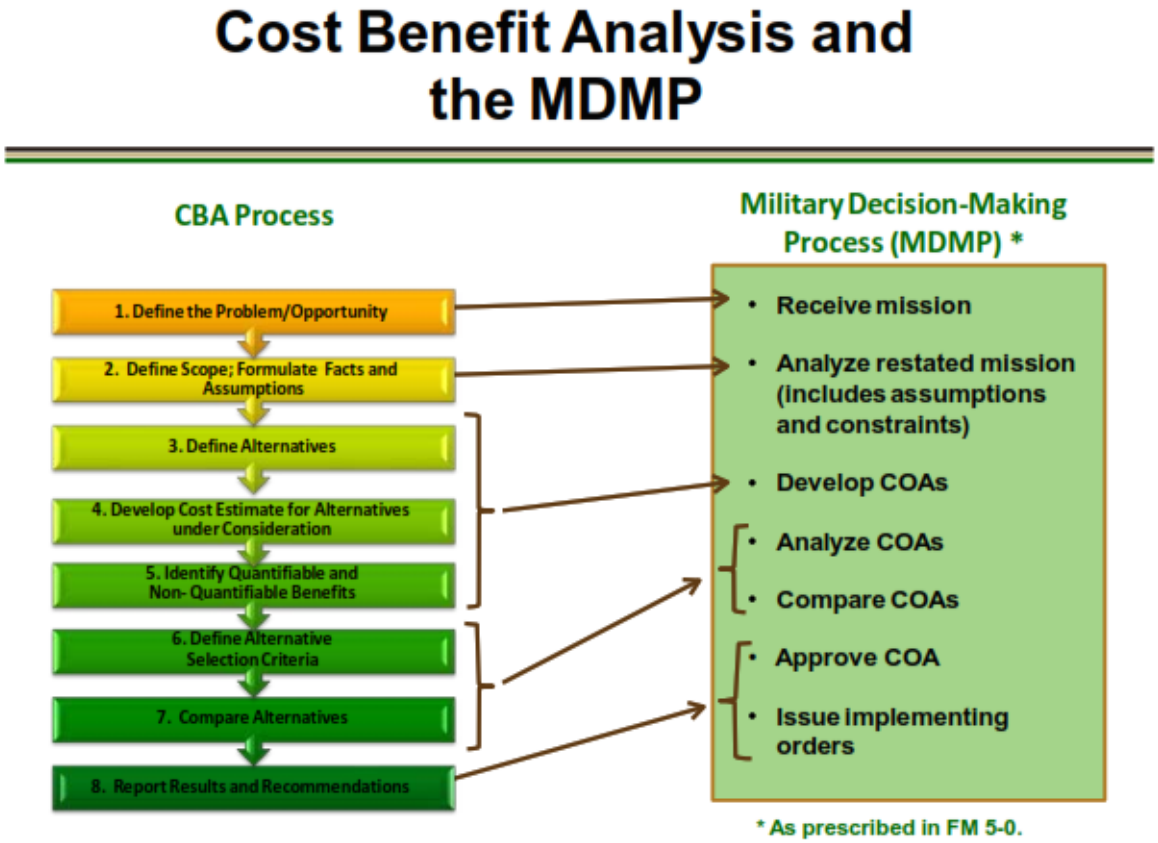

Fig.1 -Cost Benefit Analysis and the MDMP

3. Marginal Analysis considerations

"Marginal analysis involves changing the value(s) of the choice variable(s) by a small amount to see if the objective function can be further increased (in the case of maximization problems) or further decreased (in the case of minimization problems)" (Thomas & Maurice, 2012, pp. 91). Marginal analysis is known as "the central organizing principle of economic theory" for its importance and applicability to many aspects of our daily lives as well as our careers (Thomas & Maurice, 2012, pp. 94). The key concepts of marginal analysis include total benefit, total cost, marginal benefit, marginal cost and net benefit. These concepts all come together to play a significant role in the use of marginal analysis to reach the optimal desired outcome. The use of the concepts underlying marginal analysis are not limited to the business area, as they can substantiate also capabilities planning and resource management,

as "a fiscally informed CBP process can not be achieved without estimating the costs (both financial, economic and of other natures) of the resources used for the capabilities development and generation". (Constantinescu, 2010, pg. 54)

Net benefit is highly important in the understanding of marginal analysis. While using marginal analysis, the decision maker is seeking to receive the maximum net benefit from the activities being performed. Net benefit can be calculated by subtracting the total cost of a level of activity from the total benefit of that level of activity. The optimal level of activity is identified as the "level of activity that maximizes net benefit" (Thomas & Maurice, 2012, pp. 93). If you were to graph total cost and total benefit, the maximum net benefit would be represented by the widest point in between the two curves. A net benefit curve is represented by a curve that increases, gradually reaches a maximum point (the optimal level of activity) and then decreases at the same rate at which it originally increased. This curve is reflected in Panel B of Figure 3.1 in the textbook (Thomas & Maurice, 2012, pp. 92). A very important piece of information to realize about the optimization of net benefit is that it does not usually result in the maximization of total benefit because the total cost is also greater at that level.

Total cost and total benefit are two key concepts for marginal analysis that together lead to the net benefit. As previously mentioned total benefit minus total cost equals net benefit. Panel A of Figure 3.2 in the textbook shows the standard curves of total cost and total benefit (Thomas & Maurice, 2012, pp. 96). Although many people may feel that the intersection of total benefit and total cost in the graph represents an optimal point this is in fact far from accurate. At the intersection of total benefit and total cost on a graph, that level of activity yields no more benefit than performing absolutely no activity. The total cost curve is represented by a concave up, increasing curve. This curve starts with a gradual rise and becomes increasingly more steep, which yields a positive slope. The total benefits curve is represented by a concave down, increasing curve. This curve starts with a steep rise and becomes more gradual before turning downward, which yields a negative slope. The combination of these curves result in the net benefits curve.

Lastly, marginal cost and marginal benefits are important to be able to fully understand and use marginal analysis. Marginal cost (benefit) is the change in total cost (benefit) caused by an incremental change in the level of activity (Thomas & Maurice, 2012, pp. 95). In these definitions incremental is referring to small change relative to the total level of activity. Marginal cost is representative of the slope of the total cost curve and marginal benefit is the slope of the total benefit curve. The intersection of these two lines on a graph represent the point where the net benefit is maximized, or the optimal level of activity.

Net benefit, total benefit, total cost, marginal benefit, and marginal cost are the key concepts that are utilize in the understanding of marginal analysis. Each of these factors is important and interacts with the others to demonstrate the effect of incremental changes in the activity level. As these small changes are made, the goal is to reach the point where net benefit can no longer be increased. "The optimal level of activity – the level that maximizes net benefit – is attained when no further increases in net benefit are possible for any changes in the activity, which occurs when the activity level for which marginal benefit equals marginal cost: MB = MC" (Thomas & Maurice, 2012, pp. 99).

3. Aviation Safety Improvement using Cost Benefit Analysis

The objective of this project is to improve aviation safety through the development of a novel safety approach. This approach will allow aviation stakeholders (from EASA, to civil aviation authorities, airlines, airports, air traffic control, and manufactu rers) to understand and manage the effective risk reduction when adopting a safety measure; to prioritise their safety investments when multiple options are potentially feasible; to increase safety as much as possible within the limiting budgets available; to justify investments in safety from a cost perspective. The safety approach will consist of a methodology enabling aviation stakeholders to assess the effects of their technical, managerial and political decisions at the safety level, together with the associated costs and benefits. The approach will support decisions such as whether or not to introduce a safety measure, by making priorities for investments in safety, based on the most beneficial outcome. The methodology will be implemented into a Decisi on Support System (DSS) providing a step-by-step procedure that will support the user throughout the different phases for assessing the cost effectiveness of safety measures. The DSS will incorporate a data pool for the estimation of risk reduction and cos ts related to the implementation of specific safety measures. Cost benefit analysis of safety measures is a relatively new concept in the aviation community and decision on safety related matters are taken without knowing precisely what will be the final e ffect of such decisions. This project will provide the means for taking decision at different levels (i.e. policy, procedures, and operational level) in order to understand the consequences on safety of both viewpoints: policy makers and regulator on one side, industry on the other. While for policy makers and regulators the objective is safety with affordability as a requirement, for the industry the objective is affordability with safety as a requirement.

4.1 The Importance Of Safety Risk Management

A large part of the Director of Safety's job is to analyze statistics. Accident rates, cost-benefit analysis, risk analysis, hazard analysis, etc. just scratches the surface on the data analyses involved in running a safety program. An understanding of how accident statistics are compiled, and what they mean will better equip the safety director in keeping a healthy safety program.

Accident Rates

A common practice in calculating accident rates is accidents per flight hour. When considering the data from Boeing on accidents from 1959-2013, there is a disparity between the accident rate per flight hour and accident rate per departure. According to Boeing, there were a total of 1859 major accidents in the airline industry over the course of 1,204,000,000 flight hours (Statistical Summary, 2014). This rate, when multiplying by one million turns out to be 1.54 accidents per one million flight hours. Furthermore, when considering accident rate per departure, the rate comes out a little different. Boeing reports that there were 660 million departures from 1959-2013 (2014). Considering an accident rate of 1859 accidents over the course of 660,000,000 flights will show a rate of 2.8 accidents per one million flights. Since it doesn't make much sense to go by flight hours, simply because a flight that lasts four hours is not four times more likely to crash than a one hour flight, number of flights seems like a more accurate figure (Wood, 2003). Because of so few accidents occurring, these rates may not paint a very accurate picture. An airline may go years without a single accident, but then have

multiple accidents in the same year. It proves that no matter how good an accident rate is, there is no room for complacency (Wood, 2003). While it is good to be happy about a favorable accident rate, it is also an appropriate time to turn up the heat, so to speak, to keep the organization from getting complacent. This could come in the form of training, audits or spot checks.

Cost-Benefit Analysis

Cost-benefit analysis is one of the toughest jobs of the Director of Safety. It is difficult to prove a negative effect, which is no accidents, or an accident prevented. Who's to say that the accident was going to happen anyways? Since the data is inherently inaccurate, then the numbers can be manipulated to get the desired outcome (Wood, 2003). This type of practice can be used to go both ways. In other words, it can be used to justify spending just as much as it can be used to justify not spending money on equipment. Industry wide numbers can be used with accuracy to justify spending, to an extent. To use an earlier example, fall protection equipment is heavily used in aircraft maintenance. The cost of a single fall fatality has been monetized to approximately one million dollars (General Information, n.d.). The opportunities for a person to fall while working on the aircraft is generally a high number, since scheduled air carriers tend to use very large aircraft. Investing money in fall protection could very well be used to save the company money by ensuring that the fall hazard has been mitigated. Another way to monetize safety is when considering that investing in protective gear will reduce insurance premiums. This way, expressing a flat rate of investing in gear will cause a reduction over time in insurance premiums. As long as the service length of the protective equipment exceeds the insurance premium rate reduction, it would seem like a wise investment to upper management.

Risk Assessment and Hazard Analysis

Risk assessments and hazard analysis is a way of quantifying risks and hazards. Risk is the probability that an event will occur. A hazard is an event that may cause injury, damage to equipment, loss of material or deduction of ability to perform a certain function (Rodrigues & Cusick, 2012). In a way, the two go hand in hand. In aviation safety, risk is quantified to find the probability of a hazard occurring. In many cases, the hazard can also be quantified by degree of severity. This is known as Safety Risk Management (SRM) in terms of SMS. A risk assessment can be achieved by using a similar matrix as the one above. A range of number values will be assigned to the frequency of occurrence of the risk. For example, using one through five, one being infrequent, and five being the most frequent will generate the value for how often a person is exposed to a hazard. At the same time, the hazard will be assigned a number value for severity of the hazard. Once again, the range will be one through five, one being negligible, and five being catastrophic. This is considered a 5x5 matrix (Rodrigues & Cusick, 2012). The report is prepared by multiplying the frequency number value by the severity number value, and getting a number between one and twenty five. Typically an activity between one and six will be considered low risk, which is acceptable. A number between seven and twelve can be considered medium risk, which is undesirable, so a management decision will need to be made to mitigate the risk. Finally, any number higher than twelve is unacceptable, and the number needs to be reduced by reducing either the frequency, severity, or both (Wood, 2003). Hazard analysis is usually used to identify all possible hazards, and then coming up with practical ways to eliminate or reduce the hazard. Normally this is done with the use of PPE.

Opinion Surveys

Some of the most valuable safety analysis comes from the experts in the field. Not necessarily the highest paid management in the corporate ladder or the engineers who design aircraft. These experts work on the aircraft or fly them every single day. These experts are the very employees that the department is trying to keep safe. Some of the best data comes from the very people who work at the air carrier because they see the day to day operations every day. One way to get this data is by issuing anonymous opinion surveys to all personnel (Wood, 2003). These opinion surveys are designed to get workers or pilot's expert opinion in an honest manner. This is why anonymity is so important. Some effective questioning on these surveys can be, for example, what they think the next accident will be caused by. Also, a follow up to that would be what can be done to prevent it. Some other subjects to tackle could be their opinion on the safety program. Also, what can be done to improve it, or what standards are being followed or ignored? This line of questioning can be very helpful in analyzing the current state of the safety program. The key here is to see what the people who are in the thick of operations are doing, and how they are operating.

Safety data analysis is useful in the ability to quantify safety expenditures, as well as putting a numerical value to the risk factor of certain activities within the organization. These numbers can be used to justify expenditures or to gauge whether or not certain policies are having an effect on safety, and if they are, to what degree. All of this data helps in gaining a visualization of the current state of the safety program, which, if done effectively, can lead to improvements to the safety program.

4.2 Implementing SMS Cost management

As any other industry and all business-oriented organisations, aviation is a highly cost sensitive environment. As much as safety is paramount, financial stability is equally important to prevent bankruptcy. As such, sooner or later the cost implications of safety will come under investigation. It is therefore important to be able to understand and differentiate the various costs related to safety. The cost of an accident, the cost of preventing an accident, the cost of producing a safety case, the cost of maintaining an effective SMS, are only a few of the cost expressions we can come across.

The cost of an accident comprises only the direct cost of the event. These would be the equipment lost, the cost of emergency response team, the cleaning, containment and protection of the accident site, as well as any penalties, fines, insurance premiums or claims. The cost of preventing an accident does not represent an actual cost incurred, as we cannot assess an accident that has not yet happened.; but rather a cost-benefit value. Therefore, it is better described as a value and should take into consideration of the lost production, social responsibilities and liabilities, reputation recovery etc. As having a SMS does not guarantee the absence of accidents, it should NOT be considered an accident prevention cost.

For the initial design of a safety case it is sometimes better to summarise all the cost together into a Cost of Safety value, which would include both the direct and indirect costs. As an indicative cost by CASA, for a small operator, SMS set-up should not need more than $25,000 with an annual cost of $2,000. For a maintenance organisation or a service provider this cost is significantly lower.

A cost-benefit analysis is an effective tool to clarify the concerns of the typical management dilemma, that is production versus protection. Cost-benefit analysis should consider the direct

cost of a safety case but also the indirect costs of time and resources allocation. It is not rare to see the perceived benefits underweight the financial negatives.

A really great benefit which is almost impossible to measure, is the increase in productivity, reduction in absence and sick leave and the increased loyalty of the staff when working is a safe environment. Modern software are inexpensive and can save a lot of man-hours and resources. Cost usually involves training the required personnel and the lost productivity time. But benefits will outweigh this cost. For big organisations, cost analysis is better performed at a departmental level rather than company level, or on a project-based level.

An indication of the Return on Investment of an SMS would include the following annual costs: safety personnel salaries and training, software and hardware, safety tools, office material and equipment. However the saving would include much more, like: reduced insurance premiums, compensations, absentees-sickness reduction, fines, damages, equipment downtime and disruptions.

4.3 Return on Investment for Aviation SMS Implementations

While the safety benefits are often stressed far more than the financial benefits of aviation safety management systems (SMS), this is a mistake. When companies benefit financially from a safety initiative, what this means is that they benefit financially because the safety initiative is actually improving safety.

Return on investment for aviation SMS implementations is actually not as confusing to calculate as you might think. When we are talking about return on investment, we are talking about how an aviation SMS affects companies finances.

When it comes to implementing an aviation SMS, there are two wonderful facts regarding SMS and finances:

- Effective aviation SMS initiatives are relatively inexpensive; and
- Negative safety outcomes are often extremely expensive, and preventing even just one accident per year can save organizations many millions of dollars.

Reduce Expenses Implementing Aviation SMS

Small aviation SMS implementations simply require a safety manager, (maybe) an assistant, an aviation safety database, and promotional expenses, such as:

- aviation SMS training;
- safety newsletters; and
- safety posters.

Modern technology like aviation SMS software and automated recurrent SMS training dramatically cut down on promotional costs by removing many hours of manual work. Moreover, preventing even a couple of small safety incidents can more than pay for an aviation SMS' yearly expenses.

Smart managers adopt technologies that amplify the efforts of their safety teams. For example, an aviation SMS database subscription provides aviation service providers with the framework and risk management processes to successfully implement and manage the SMS initiative.

Early Adoption of Technology Reduces SMS Implementation Expenses

For a quick example of capitalizing on technology, consider that a safety manager may spend weeks creating an aviation SMS manual--carefully creating and documenting the organization's risk management processes. In many cases, operators don't have any existing documentation, and in others, they may have considerable documentation from their legacy safety program. Pulling all this together and getting acceptance from the accountable executive and operational department heads will require considerable effort.

In the case of acquiring an SMS database subscription, the safety manager can start with an SMS manual template that comes with industry-accepted risk management processes. This becomes a fast sell to safety managers who can get all the necessary SMS data management tools, plus:

- an SMS manual template;
- predefined, industry-accepted risk management processes;
- safety reporting system; and
- risk management system with alerts and notifications.

Of course, there are other benefits to acquiring an SMS database, but they really become evident after about three to five years into the SMS. By this time, your aviation SMS will have accumulated sufficient safety data to allow your company to detect trends and participate more fully in predictive risk management activities.

Payback calculation for Aviation SMS

Payback is simply a word for "savings as a result of having an aviation SMS." Yet trying to calculate payback is generally what deters or derails safety professionals. For the most part, it's actually quite straightforward. It simply involves the following equation: CostAfterSMS – CostBeforeSMS = payback.

Estimated Paybacks and Investments for ROI

Estimated investment costs require only moderate estimation. It simply requires:

- Being able to track how much time employees are spending on safety tasks;
- Average salary compensation for employees; and
- Being able to estimate costs for developing particular solution to a problem.

Estimated payback of incident mitigation and/or avoidance is a bit more difficult because it involves estimates. These estimates are twofold when it comes to safety issues:

At what point during a safety incident (or series of incidents) did the SMS implementation make a difference to successfully mitigate/avoid the problem?

What would costs (i.e., from damages) have been had there been no SMS in place to mitigate/avoid the problem?

For example, before SMS, an aircrew with no pre-flight procedure for deicing during winter weather conditions. During one flight, they did not turn off the aircraft air vents during deicing, and deicer spray leaked into the cabin, causing an adverse reaction from one passenger. This resulted in eventual litigation and damages awarded that totaled 40,000. Additionally, following the press release of the incident, the company saw a sudden and unexpected 5% downturn in sales the next month, or about $50,000. Total avoidable damages were $90,000.

Had there been an SMS in place, this safety event would likely have been avoided, for a payback total of $90,000. Total cost estimated for implementing this procedure solution are:

- 60 employees @ $60/hour, with 1 hour of training per employee = $3600 in training costs
- Safety manager time developing and testing the procedure is 8 hours @ $75/hour = $600
- New equipment monitoring system to ensure that vents are off = $8000
- Total cost for solution development: $12,200

To calculate our ROI for this solution: (Payback:90,000 - Investment:12,200) / 12,200 = 6.39 or 639% return on investment.

If applicable, management can analyze payback savings on relevant incidents and over the course of a year establish a total financial estimate for incident payback.

An SMS implementation does provide a return on investment, but guess what? You have to work the process! Otherwise, your SMS implementation investment will be merely a paper-exercise that may pass regulatory scrutiny, but not offer the promised value.

4.4 SMS Cost-Benefit Analysis

A good cost-benefit analysis, conducted alongside with safety management activities, will support your decision-making process and aid in the allocation of resources to the safety program(s) to reduce risks to an acceptable level.

This section provides an overview of elements to consider in cost-benefit analysis, structured around the International Civil Aviation Organization (ICAO) SMS framework components and elements.

This overview and the tables below can help determine the costs and benefits of SMS, as well as ideas for metrics to estimate the efficiency of the investment. Although the items contained in the tables are representative, they are not meant to be all inclusive. The lists of items can be expanded and are not intended to be the only costs, benefits, and ideas for metrics to measure the ROI.

The tables include direct and indirect costs and benefits. Depending on the organization's structure, the phase of SMS implementation, and the nature of safety action, the categorization of costs and benefits as either direct or indirect may change (for example, staff training may be considered a direct cost if it is an ad-hoc training course, or an indirect cost if it is embedded into the organization's regular training activities). For a balanced view, the indirect benefits, although difficult to quantify, must be included when considering the cost-benefit analysis.

The "Potential Metrics" columns provide some proposals for performance measures that can be used to help quantify the effectiveness of SMS implementation. Use of an SMS effectiveness coefficient is proposed to obtain a realistic determination of SMS ROI.

a. General Costs and Benefits (for the Whole SMS/Organization)

As with any element of the management system, there are costs and benefits that can be attributed to the overall organization. Therefore, it makes sense to build on what is currently in place at each organization. This will be cost effective and should take less time. To maximize the benefits of SMS, you must have all the SMS components in place and effective. Similarly, the SMS should be implemented across the entire organization and address all your aviation services.

Upon initial implementation, a description of your system and processes should be available. You are likely to have a system description as part of your existing operating manuals or QMS. In this case, you could build on that existing system description by adding the safety risk and safety assurance focus. Likewise, if your organization has already implemented typical QMS processes for regular management reviews, internal auditing, follow-up of actions, performance measurement, and control of suppliers, you may build on those same processes and tools to implement SRM, which will help minimize the costs for the general administration of your SMS.

For example:

• Standard office software to track corrective actions could easily be adapted to also track risk mitigation actions;

and

• Standard tools to report process inefficiencies or suggest improvements may be adapted for internal safety reporting.

For initial SMS implementation, you also need to clearly define the boundaries of your organization and the compliance and safety-critical interfaces both within the organization and with third parties, such as partner organizations, contractors, or suppliers. The better the understanding of the overall system and the interactions between your management, operational, and support processes, the better you will be able to proactively identify opportunities for improvement and identify and manage non-compliances and risks associated with your activities.

Following initial implementation, the system description will be helpful in managing risks related to organizational or operational changes and should help ensure your SRM processes are properly embedded into your operational processes. Therefore, the costs associated with the initial effort to implement SMS, including a thorough analysis of your system and processes, may pay off through increased operational efficiency, safety performance, and regulatory compliance, as well as a decrease in insurance premiums and workers compensation premiums.

b. Safety Policy and Objectives

ICAO SMS Framework component 1, Safety Policy and Objectives, includes the "PLAN" component of the "PLAN-DO-CHECK-ACT" cycle.

This covers five distinct elements:

- Management commitment and responsibility, including the obligation to do the following:
  - Define a safety policy and safety objectives as a basis for performance measurement;
  - Implement safety reporting procedures, applying just culture principles.
- Safety accountabilities, including the obligation to document and communicate safety responsibilities, accountabilities and authorities;
- Appointment of key safety personnel, including the appointment of a safety manager;
- Coordination of emergency response planning; and
- SMS documentation, including the development of an SMS manual and processes.

The elements that are generally directly associated with SMS implementation costs are:

(1) appointing a safety manager,

(2) creating and maintaining documentation associated with the SMS,

(3) implementing internal safety reporting schemes, and
(4) introducing additional safety meetings that may have not previously existed.

Related costs will depend on the level of integration with existing systems and processes. The costs for appointing or recruiting a safety manager partially or exclusively dedicated to SMS-related tasks may be a significant investment upon initial SMS implementation. Depending on the resources available and the complexity of aviation products or services, the organization may choose to assign responsibilities for the implementation and maintenance of the SMS to one or more persons as their sole function or combined with other duties, as long as those assignments do not result in any conflicts of interest.

Resources spent on communicating the safety policy, demonstrating management commitment to safety, and promoting open reporting are vital to the success of your SMS. Creating a positive safety culture, although not measurable in financial terms, will contribute to the success of the overall system.

	Direct Costs	**Indirect Costs**	**Benefits**
Initial Implementation	- *Consultancy* - *Additional resources or reallocation of existing resources* - *Developing manuals and procedures*	- *Communication of the policy* - *Dissemination of the objectives and review of existing documents* - *Time spent in meetings - attendance of managers/personnel*	- *Providing clear direction and framework for safety performance measurement* - *Senior management commitment* - *Improved organizational (safety) culture* - *Better control over safety and business risks* - *Facilitates work of the safety manager* - *More proactive behavior (safety culture)*
SMS Operation	- *Maintaining manuals and procedures*	- *Maintaining policy and reviewing objectives (management reviews)* - *Demonstrating commitment* - *Time spent in meetings - attendance of managers/personnel*	

Potential Metrics to Determine an SMS Effectiveness Coefficient

- *Awareness of safety policy at all levels*
- *Evidence of senior management commitment:*[2]
  - *Number of management walk-arounds dedicated to safety/SMS per month/quarter/year*
  - *Number of management meetings dedicated to safety per month/quarter/year*
  - *Attendance of key managers at safety meetings*
- *Safety reports*
  - *Number of reports received per month/quarter/year and trend*
  - *Percentage of reports for which feedback to reporter was provided within 10 working days*
  - *Percentage of reports followed by an investigation*

Table 1: Costs and Benefits for SMS Component "Safety Policy and Objectives"

c. Safety Risk Management

Safety Risk Management covers the following elements:

- Hazard identification through reactive and proactive methods; and
- Analysis, assessment, and control of safety risks associated with identified hazards and mitigation.

Managing safety risks is at the heart of your SMS. This means trying to prevent bad things from happening, or if something does go wrong or slips through the cracks, trying to minimize the consequences of the event. To be able to manage your safety risks, your organization must have effective and active hazard identification processes and a sound safety culture. You can manage safety risks only if you are aware of the potential hazards connected to your organization's operations.

The ability to recognize hazards is at the heart of your organization's SRM process. It is also important to manage the life cycle of your risks to ensure the assumptions made for the hazard identification and risk assessment are still valid.

	Direct Costs	Indirect Costs	Benefits
Initial Implementation	• *Data collection and analysis system* • *Action tracking system* *(those two could be part of a general SMS software package)* • *Training costs (development and delivery)* • *Analyst (recruitment/training)* • *Changes to systems or hardware*	• *Analyst (reallocation of staff – retraining)* • *Implementation time (downtime – retraining of staff)*	• *Prevention of occurrences (reducing severity/probability)* • *Increased awareness of potential safety issues and opportunities for improvement* • *Demonstration of due diligence* • *Informed decision making* • *Targeted management of risks* • *Regulatory compliance* • *Increased productivity* • *Recognition by customers and partner organizations* • *Market access* • *Improved competitiveness*
SMS Operation	• *Collection and analysis system, and tracking system maintenance* • *Recurrent training costs (analyst, etc.)*	• *Changes in operational documentation and procedures (such as training syllabi, work cards, check lists, and standard operating procedures (SOP))* • *Downtime during safety analysis/investigations*	
Potential Metrics to Determine an SMS Effectiveness Coefficient			

• *Overall risk score per activity*
• *Overall risk score for the organization*
• *Number of high severity risk events*
• *Reporting culture (safety reports):*
  ○ *Ratio of proactive versus reactive reports*
  ○ *Ratio of voluntary reports to mandatory reports*
• *Number of safety committee meetings (planned versus actual)*
• *Event reoccurrence rate*
• *Additional funds allocated to new risk controls (not included in the initial budget)*			

Table 2: Costs and Benefits for SMS Component "Safety Risk Management"

One clear benefit that will materialize with widespread SMS implementation is the increase in shared risk reduction across industry. For example, if you are an operator and both operators and design approval holders implement SMS, it is much easier to see how their systems can work together. This facilitates sharing of information, interconnection between operation and design, and, hopefully, better risk management.

The assessment of costs and benefits associated with specific operational risks is straightforward compared to the assessment of less tangible SMS elements. Appendix 2, *ROI Examples for Specific Safety Actions*, contains some examples of safety actions for specific operational risks. They provide basic ROI calculations to help determine how the SRM process can be seen from a business point of view.

d. Safety Assurance

Effective safety assurance in your organization will be directly visible to your aviation authority. Safety assurance includes three elements:

- Monitoring and measuring safety performance against the safety objectives;
- The management of change – making use of the established safety risk management process; and
- Continuous improvement of the SMS.

The first element is often seen as the more challenging one within safety assurance. Once you've defined your safety objectives (see Section 4b, *Safety Policy and Objectives*), you will need to identify safety performance indicators (SPI) that are connected to your safety objectives and to the risks in your operation. General indicators should be defined with regard to the safety objectives, and operational indicators can be defined for specific risk mitigation actions. You also use SPIs to measure how well your risk management processes are working, so it is important for you to select indicators that are reflecting the risks in your operations. To maximize the investment in a set of SPIs, results obtained through the collection, analysis, and interpretation of SPIs must be conveyed to your organization's management for decision and action.

The second element, effective change management, plays an important role in ensuring sustainability of any organization. Managing change requires a planned and systemic process to identify and mitigate risks entailed by a change as well as to identify and maximize opportunities. Managing the changes may rely on existing system descriptions and will make use of the established SRM processes and tools. However, setting up the management of change process and the supporting documentation such as a safety case template will incur direct costs. Effective management of change is widely recognized as a

	Direct Costs	***Indirect Costs***	***Benefits***
Initial Implementation	• *SPI development: expertise required* • *System to collect data and monitor SPIs (could be part of a general SMS software package)*	• *Reallocation of resources*	• *Authority confidence* • *Stakeholder confidence* • *Demonstration of commitment to manage risk* • *Targeted assurance of risk controls* • *Validation of system performance* • *Better resource allocation* • *Safe and efficient implementation of changes*
SMS Operation	• *SPI monitoring and revision of the set of SPIs* • *Internal audits/internal evaluations* • *Safety cases (change management)* • *Collation of data into performance reports*	• *Maintenance of data collection systems*	
Potential Metrics to Determine an SMS Effectiveness Coefficient			
• *Achievement of operational safety targets* • *Reduction in number of findings from internal/external audits* • *Reduction in reoccurrence of findings* • *% of follow-up audits carried out within the agreed post change safety assurance plan.* • *% of changes to standard operating procedures (SOPs) for which a formal safety risk assessment has been performed* • *Increase in annual safety survey scores* • *Number of safety audits carried out*		

precondition for operational efficiency, and financial results will reflect this through a better allocation of resources and reduction or elimination of subsequent rework or adjustments in production or operations.

The third element in safety assurance is continuous improvement of SMS. The SMS is working in organizations where things change all the time, including the environment, aviation technology, and regulations. The SMS should be checked and updated to reflect those changes, and the organization should strive to improve its operation and maintain the SMS as a living system for the benefit of all users.

Table 3: Costs and Benefits for SMS Component "Safety Assurance"

e. Safety Training and Promotion

This covers two elements, which are interrelated:

- Safety training and education, and
- Safety communication.

Safety training is essential when implementing and running the SMS. You should consider who is best placed to deliver SMS training and whether it is done internally or using external trainers. Effective training takes time to develop, and safety managers may not always have the time or the training skills to deliver it. SMS training can be used to gather hazard information, which can bring additional benefits.

The accountable manager plays a key role when promoting safety culture in your organization. His or her attitude in daily discussions and refresher seminars when talking with staff can help cover important aspects of safety promotion. The organization´s safety policy is often written by the accountable manager, so he or she is the best person to share its content with the staff. The only cost of this kind of promotion is duty time of the accountable manager and staff.

All key personnel should have some dedicated safety management training, ideally integrated into other training courses and directly relevant to their areas of responsibility. For your accountable manager and safety manager, it could be reasonable to participate in external training courses, which also serve as a means to demonstrate senior management commitment. This investment may then be exploited further by having the safety manager relay important information and new concepts to the rest of the organization.

Training for and promotion of SMS should be integrated with your daily business so the safety aspect can be embedded in all your aviation activities. Discussing safety topics while performing daily work may be an effective way to spread the knowledge and foster a positive safety culture.

	Direct Costs	Indirect Costs	Benefits
Initial	• *Training needs analysis* • *Training material development* • *Potential consultancy* • *Training delivery* • *Promotion delivery*	• *Production downtime*	• *Tailored education* • *Increased competence* • *Positive safety culture – more SMS buy-in* • *Reinforcing corporate decision-making process* • *Demonstrating due process* • *Increased effectiveness and efficiency in SRM* • *Active risk reduction* • *Improved horizontal communication and cooperation* • *Improved corporation with partner organizations, industry associations, or federations*
Follow-up	• *Monitoring the effectiveness of training* • *Recurrent training* • *Promotion delivery, also considering SRM outcomes*	• *Production downtime*	
Potential Metrics to Determine an SMS Effectiveness Coefficient			

• *Increase in reporting rates*
  ○ *All reports*
  ○ *Reports suggesting process improvements without any associated safety events*
• *% of time and money spent on SMS training, including HF training, compared to other training*
• *Personnel awareness of safety communication*
• *Number of meetings and information sessions*
• *% of new employees given SMS induction training*
• *% of personnel who have completed required training*
• *Average score on SMS training exams*
• *Number of SMS courses reviewed for improvement*
• *Number of audit findings related to the training program*		

Table 4: Costs and Benefits for SMS Component "SMS Training and Promotion"

5. Marginal Analysis and CBA implications in defense planning

Defense spending is characterized by cyclicality, and in crisis periods, like the period 2008-2010, budget crunches could put pressure on important programs, could exacerbate the under funding of other programs and could stop the recapitalization process of materiel used in recent operations.

The portfolio management is an approach inspired from economics, is an effective instrument for the treatment of risk, based on a top-down mechanism evaluation equipped with cost-effectiveness analysis and the mathematics of aggregation. In strategic decision-making, the use of orthogonal strategies is limited by the scenario space of the possible strate- gies, but the optimal output should be filtered and mixed, because of the multiple objectives and the use of strategy. In the classic portfolio- management approach, investments are operated in different types to realize a balance among conflicting objectives.

In defense planning, objectives are more complex and is difficult to asses the likelihood of subsystems/ elements but a portfolio might involve activities capable to support the general objectives, to maintain the military capability, and to avoid different

types of risks. In this approach setting priorities and adjusting the weights of effort within the portfolio is important in the context of limited resources.

In the literature on defense planning (Davis, Gompert, Kugler,1996; Davis, 2002; Hillestad, Davis, 1998; Dreyer, Davis, 2005) are also presented the key aspects of a portfolio- management framework, that responds to military restrictions: the routine to use portfolio management tools; it responds to assessment of critical-component capabilities, costs, and benefit-cost ratios (near, mid, long term, anticipation of strategic adaptations); portfolio adjustment fill gaps, balance risks and opportunities, prioritize by packages, and conduct marginal or chunky marginal analysis;it offers more levels of zoom where needed in a clear assessment; it offers parametric capability models for comprehensive analysis; it permits the development of families of models, games, experiments.

This framework should support the commander's decision regarding the adjustment/ tuning of the portfolio so as to fill the gaps, balance risks/ opportunities, prioritize by groups rather than by discrete activities, and even to conduct investment analysis, such as marginal or chunky marginal analysis. Commanders are focused on the dynamics of the adjustment, the flexibility of levels of zoom or drill-down. The treatment and the representation of the risk within a portfolio-management DSS is based on the following risks: acquisition risks (feasibility, cost), at-the time strategic risks (warning and decision time, allied permission to use bases), operational (effectiveness in achieving the principal effect sought, control of collateral damage, perceptions, behaviors), subsequent strategic-effect risks (the risk that a coalition will disintegrate, the fragility of domestic support). The set of risks includes risks involved in acquiring the capabilities in the first place, risks associated with their usability when needed in crisis or conflict, operational risks when actually employed, and risks associated with negative strategic effects (e.g., international perceptions) even if the operation itself is successful and achieves the desired operational- level effects. The representation of different types of risks in a portfolio- oriented DSS is difficult to be realized in a top-down architecture that needs to achieve comprehensibility. Some authors (Davis, Shaver, 2008) propose the following principles in the treatment of risks: the use of measures of effectiveness for both normal and extreme risk cases; the use of composite risk indicators.

Portfolio - management instruments are well adapted for the top-down perspective, but not for going into much depth. A candidate ingredient is the exploratory analysis, in which all of the key parameters are varied simultaneously so that one can understand results as a function of those parameters in the complex n-dimensional space. In the cost benefit analysis (CBA) the most important issues are the following: a mechanism for exploring the consequences of different perspectives about the relative importance of different missions and constraints and the relative probabilities of various risks; there is a need for marginal analysis (where to spend/ cut) and a more chunky type of analysis that uses larger increments of spending/ cuts; the use of cost-benefit strategic comparisons on large composite options.

In most countries, the defence sector absorbs substantial scarce resources with many valuable alternative uses (schools, hospitals, etc.). Whereas defence expenditures are well known within each country, there is no single indicator of value (or benefit) of overall defence output. This contrasts with the valuation of private sector outputs in market economies. In defence, the economist's solution to measuring output assumes output equals

inputs (a convention widely used across the public sector), or that the value of defense output is roughly equivalent to expenditures made to produce that output.

In sharp contrast, measuring the value of market outputs is not usually regarded as a policy problem. Market economies 'solve' the problem through market prices that reflect choices of large numbers of buyers and sellers. Defence, however, differs in several key ways from private markets, which helps explain the challenge in measuring and valuing defence output.

An important step to apply military cost-benefit analysis to evaluate security investments is to discuss output measures. Economic theory offers some policy guidelines for determining the optimal defence output for any society. As an optimising problem, the rule is to aim at the socially desirable or optimal level of defence output. This is achieved by equating additional or marginal costs of proposed defense expenditures with additional or marginal benefits. While the economics approach is difficult to 'operationalise' into a set of clear, unambiguous policy guidelines, it does provide a framework for designing valuations for defence outputs and activities.

Defence is a classic example of a public good, and its desired outcome in the form of peace is also a public good. A public good is non-rival and non- excludable. For example, living as neighbors in the same city, my consumption of air defence protection does not affect your consumption and, once provided, I cannot exclude you from its consumption nor can you exclude me. In sharp contrast, private goods such as motor cars and TV sets are rival and excludable. Your payment and consumption of those items means that I cannot simultaneously use them (unless you choose to share), and private property rights guarantee your exclusive ownership, so that you can legally exclude me from using them.

The public goods features of defence provide incentives for free-riding. Since I cannot exclude you from the benefits and you cannot exclude me, each of us is inclined to let the other pay for protection. Free-riding is a contentious issue both within a nation and between nations in a military alliance (e.g. NATO, and U.S.-Canadian security). This ultimately results in a nation's citizens failing to reveal their true preferences for, and valuations of, defence. A challenge for the state in providing and financing defence is that it does not know the true preferences of the potential beneficiaries of defence: It cannot easily quantify the volume of the defence public good demanded by consumers and estimate the true price the beneficiaries are willing to pay (Engerer 2011).

Theoretical solutions exist to estimate the optimal amount of a public good, but are difficult to operationalise in practice (Cornes and Sandler 1996). Public opinion polls can be used, but these are a limited mechanism for accurately assessing society's opinions on defence spending and defence policy and the willingness of citizens to pay for defence (Zaller and Feldman 1992).

Alternatively, one can frame the question of "how much defence is enough?" presenting it as an optimization where the economic decision rule is to achieve a socially desirable or "optimal" defence output. In principle, this is found by equating marginal costs with marginal benefits. This approach is difficult to 'operationalise' into a set of clear and unambiguous policy guidelines. As discussed in the introductory chapter, marginal costs and especially marginal benefits of many defense investments are not immediately obvious, and are difficult to quantify. The economic model assumes a social welfare function showing society's preferences between defence (security) and civilian goods: Again, this is an attractive concept but not one which is readily operationalised or easily identifiable for any society. Moreover, the benefits of defence are complicated by its

public good and free-riding characteristics. Voting systems may also not be reliable and accurate methods of revealing preferences for specific public goods and services. Typically, elections involve choices between political parties that offer various tax and spending policies, where defence budgets and security policies are often buried in a wider policy platform. Problems can also arise in attempting to aggregate voter preferences into a ranking for society as a whole (the voting paradox: Tisdell and Hartley 2008). Further problems arise since the economic model assumes maximising behaviour on the part of individuals, when most agents might instead be satisficers, willing to settle for acceptable solutions short of the optimum (Hartley 2010b).

There are several major differences between private markets and public (defence) markets. Private markets involve prices that reveal society's valuation of outputs, where these prices reflect market incentive and penalty mechanisms. Goods that are 'private' rather than public are characterized by both excludability and rivalry; large numbers of private consumers and buyers; rivalry between firms; motivation and rewards through profits; and a capital market that imposes penalties on poor economic performance through take-overs and the ultimate sanction, bankruptcy (with managers often losing their jobs).

Public bureaucracies such as the Armed Forces lack such incentive and penalty mechanisms, and they consequently tend to be slow to adjust to change. Often, change in the Armed Forces results from budget pressures, new technology, victories and defeats, and occasionally, views of senior military leaders (Solomon et al. 2008). In contrast to private markets, there is no market price for publicly provided defense forces: For example, there are no market prices for submarine or tank forces.

Although some rivalry exists between suppliers (Navy, Army, Air Force, etc.), there is no profit motive for public suppliers, nor capital market pressures corresponding to take-overs and bankruptcy in private markets. Defence has another distinctive feature reflected in the state-funding and state provision (ownership) of its Armed Forces. Governments are monopsony buyers and monopoly providers of Armed Forces.

This contrasts with private markets where there are large numbers of buyers and rivalry amongst suppliers. State-owned and funded defence markets are less likely to undertake worthwhile changes (Tisdell and Hartley 2008, Chapter 10). There is also a unique military employment contract which differs drastically from private sector employment contracts. The military employment contract requires military personnel to obey commands which relate to type, duration, location, and conditions of work (e.g. world-wide deployments) with significant probability of injury and even death. Such a contract contains elements resembling indentureship and command systems.

Each of the Armed Forces is a monopoly supplier of air, land, and sea systems with monopoly property rights in the air, land, and sea domains. There are barriers to new entry which prevent rival internal Armed Forces from offering competing products. For example, armies often operate attack helicopters and unmanned aerial vehicles (UAVs) which are rivals to close air support and surveillance provided by air forces. Similarly, land-based aircraft operated by air forces are alternatives to naval carrier-borne aircraft. Efficiency requires that there be a mechanism for promoting such competition; instead, each Service guards its traditional monopoly property rights in the air, land, and sea domains thereby creating barriers to new entry.

This has an impact on efficiency. Specifically, is the correct amount of output being produced? Is the correct mix of inputs being used? As monopolies with significant barriers to entry, each of the Armed Forces lacks strongly competing organisations and,

hence, has less incentive for efficiency improvements and for innovation (where efficiency embraces both allocative and technical efficiency).

Allocative efficiency requires the choice of socially desirable output, and technical efficiency requires the use of least-cost methods to produce that output. Again, problems arise in determining allocative efficiency (see a discussion below on principal-agent models). Technical efficiency, however, can be assessed by allowing activities traditionally undertaken 'in-house' by the Armed Forces to be 'opened-up' to competition from private suppliers (market testing leading to military outsourcing). Indeed, the formulation of such competitions can offer improvements in allocative efficiency (e.g. by inviting competition for different levels of service in order to identify true marginal costs for different levels of output or service).

Internal defence markets lack other incentives of private markets. There are no profit incentives to stimulate and reward military commanders to search for and introduce productivity improvements or to identify new and profitable opportunities (for example, the role of entrepreneurs in private markets). The absence of a capital market also means that military managers are unlikely to lose their jobs for poor performance and that there are no capital market opportunities for promoting and rewarding mergers and take- overs. For example, a military commander of a regiment cannot merge with another regiment to achieve economies of scale and scope, nor can an Army regiment acquire Air Force and Naval transport units where such mergers might offer both cost savings and output improvements (such as horizontal, vertical, and conglomerate mergers).

There is one further key difference between defence and private markets. Defence aims to avoid conflict, but where conflict arises it often destroys markets and valuable infrastructure and creates disequilibrium as resources are re-allocated to military forces to gain strategic advantage, with consequent opportunity costs in civilian goods and services. War involves the destruction of labour and capital. In contrast, private markets seek the optimal mix of labour and capital to provide goods and services through voluntary trading and exchange. Resource allocation is based on price and profit signals that lead to "creative destruction" reflected in continuous investment in new innovations, inventions and the output of new goods and services.

Another contribution from economic theory to output measurement comes in the form of the military production function. This is an input- output relationship that attempts to relate all defence inputs to a final defence output. Inputs comprise technology, capital (bases, equipment, spare parts, etc.), and labour (military personnel in the form of conscripts and/or volunteers, civilians, contractors, etc.)

While measuring inputs is a challenge, identifying, measuring, and valuing defence output is even more challenging. Economic theory simply asserts the concept of defence output without exploring its definition and multi-product nature. Few published studies have estimated military production functions. Typically, such studies have estimated readily identified measures of effectiveness, such as providing an air defence capability, the numbers of aircraft destroyed, or the number of aircraft sorties per day. This approach is used in cost-effectiveness studies that focus on intermediate defence outputs (Hildebrandt 1990; 1999).

For example, a cost-effectiveness study of air defence would compare the costs and effectiveness of alternatives such as land-based air defence missiles versus manned fighter aircraft; or anti-submarine capability would compare land-based maritime patrol aircraft versus naval frigates; or anti- tank capability would compare missiles and attack

helicopters. A different approach used in a more recent study estimated a military production function where various defence inputs were used to estimate the probability of winning in various conflict scenarios (Middleton et al. 2011).

6. Assessing Defence Outputs: Problems and Challenges

Defence outputs involve a complex set of variables concerned with security, protection, and risk management, including risks avoided, safety, peace, and stability. Private markets routinely provide benefit measures such as sales, labour productivity, and profitability. Unlike private markets, there are no concise benefit measures for defence output.

Defence inputs are more easily identified, measured, and valued than outputs as reflected in many nations' annual input-oriented defence budgets. For economists, questions then arise as to whether annual defence budget information provides sufficient data to assess the efficiency and effectiveness of military expenditure: How do expenditures on inputs correspond to desired defense outputs? Do defence budgets provide policy- makers and politicians with the sort of data needed to conduct military cost- benefit analyses?

Questions could include assessing the benefits and costs of alternative defence forces; expanding (or contracting) the Army, Navy, or Air Force; substituting equipment (capital) for military personnel (labor); or substituting national guard and reserves for regular (active) forces. Various defence budgets used by nations include: input budgets, output budgets, management budgets, and resource accounting budgets.

Input Budgets

Input budgets provide some limited information on defence inputs such as the pay of military and civilian personnel, as well as the cost of land, machinery, and internal financial transactions, such as write-offs of various types of losses (see Table 3.2). The information in Table 3.2 and particularly the first 10 items show the inputs used by the Canadian Department of National Defence (DND) in the production of national security outputs. More than half of the budget is spent on personnel, but there is no information on the proportion dedicated specifically to civilian, regular, and reserve personnel. The last two items referred to as Transfer and Subsidies, detail payments in the form of grants and contributions to various national and international organizations, capital assistance (subsidies) to industry, research grants, and other assistance towards research carried on by non– governmental organizations. These might be considered as intermediate outputs.

Output Budgets

Output budgets, also known as programme budgets, are much closer to the economist's production function model of defence budgets (Hitch and McKean 1960). Together with their costs, they provide information on some intermediate outputs of defence such as nuclear strategic forces, air defence, aircraft carriers, infantry regiments, and reserve forces. Output budgets also provide information on substitution possibilities (e.g. between nuclear and conventional forces and also between reserves and regulars).

There are at least two major limitations with output budgets. First, the expenditure figures used in output budgets are unlikely to be least-cost solutions due to lack of competition and market incentives. Second, whilst they are known as output budgets, there remains a problem in identifying the overall output of defence. Often, outputs are defined in

terms of the numbers of military personnel, aircraft squadrons, warships, and infantry regiments. These published data, however, are measures of intermediate, rather than, final outputs such as protection, security, safety, peace, and stability.

The international experience of measuring defence output reveals some useful intermediate output measures, usually in the form of specific defence capabilities. These are improvements on the traditional emphasis on inputs that have typically included numbers of military personnel and equipment (e.g. combat aircraft, tanks, and warships). By themselves, input measures offer little indication of the value of overall defence capabilities such as peace, protection, deterring conflicts, and insurance against future threats

A starting point in answering the central research questions is to apply cost-benefit analysis: to identify the costs of defence and then ask whether defence provides at least a comparable level of benefits in the outputs produced. It is also important to capture non-economic benefits in addition to measurable economic benefits in measuring the overall benefits of defence spending. For example, if defence spending costs $X billion, does it provide overall benefits of a similar value? Similar questions can be asked about the costs and benefits of conflict and peacekeeping operations.

Next, the cost-benefit analysis can focus on incremental (or marginal) changes. If defence spending is increased or decreased by 10%, what are the effects on defence outputs (benefits)? Such marginal analysis can be assessed as a whole (on overall defense output), or by each military service (on intermediate dense outputs, e.g. what would be the impact of a 10% increase or decrease in the size of the Army?).

Specifying the important questions is the first stage in any evaluation; but who raises and answers the questions? In a democracy, elected politicians are ultimately responsible for determining the size of military expenditures and its allocation among each of the services. Typically, unelected agents within the military propose many of these choices, This reinforces the importance of developing meaningful defense output measures to guide future military investment and divestment decisions.

7. Conclusion

Uncertainty dominates defence policy. Defence policy has to respond to a range of future threats, some of which are unknown and unknowable.

Economic theory offers some policy guidelines for determining the optimal defence output for any society. As an optimising problem, the economics rule is to aim at the socially desirable or optimal defence output which is achieved by equating additional or marginal costs with additional or marginal benefits. While the economics approach is difficult to 'operationalise' into a set of clear unambiguous policy guidelines, it does provide a framework for designing valuations for defence outputs and activities.

Measuring defense output is a necessary step to successfully apply military cost-benefit analysis to evaluate alternative security investments. This can be seen as a higher-level "macro- economic" perspective of overall defense output that encompasses total defense spending.

Assumptions are needed about likely future allies and their responses to threats, the location of threats, new technologies, and the time dimension of threats (e.g. today, in 10–15 years, or 30–50 years ahead where uncertainties are greatest). These uncertainties mean that forces have to be capable of adapting to change, and that today's defense investments must

be capable of meeting tomorrow's threats. Admittedly, the private sector also faces considerable uncertainty about future markets and new technologies, and these unknowns extend over lengthy time horizons. Defence is different, however, in that uncertainties are dependent upon, and determined by, governments, nation states, and some non-state actors, rather than by the actions of large numbers of private individuals as consumers, workers, and shareholders.

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