Chapter 1

Introduction
1.1 What is Operations Research?

Operations Research (O.R.) or Operational Research is a discipline that deals with the applications of advanced analytical methods to help make better decisions. The terms management science and analytics are sometimes used as synonyms for operations research.

Operation research utilizes methods and techniques from the other mathematical sciences, such as mathematical modeling, statistical analysis, and mathematical optimization to acquire desired optimal or close to optimal solutions of complex decision-making problems in various fields.

Operations research coincides with other disciplines like operations management and industrial engineering. Generally the objective in such types of fields are to determine a maximum (like profit, performance, or yield) or a minimum (like loss, risk, time or cost).

Operations research serves a large amount of problem-solving techniques and methods applied in order to improve decision-making and efficiency, such as simulation, mathematical optimization, queuing theory, Markov decision processes, economic methods, data analysis, statistics, neural networks, expert systems, and decision analysis. The construction of mathematical model which describes the problem or the system is a major part in these techniques.

Since all these fields involve a lot of computational procedures and statistical data, O.R. also has strong bonds to computer science. An operations researcher must use a suitable techniques among the above, after analysing the model, its objective and constraints of time and computing power of the technique.

The following is a list of important and contemporary branches of present day in operations research:

(i) Management science

(ii) Information technologies and computing techniques

(iii) Environment, energy and natural resources

(iv) Financial Engineering

(v) Marketing Science
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(vi) Policy planning and public sector work
(vii) Revenue management
(viii) Simulation
(ix) Stochastic models
(x) Transportation

Operations research as a traditional branch, was originated in the efforts of military planners during World War II. The techniques of operation research began to be implemented many years later after the world war ends for solving problems in business, industry and society. In present days operations research is used effectively by all business industries and government throughout the world and is an active area of academic research.

1.2 An introduction to management science

Management science is an interdisciplinary branch of applied mathematics, engineering and sciences that employs various scientific principles, strategies and analytical methods including mathematical modeling, statistics and algorithms to improve an organization’s ability to authorize rational and meaningful management decisions. Management science is about maximizing profit, assembly line performance, crop yield, bandwidth etc. or minimizing expenses, loss, risk, time, etc.

Management science is related with many different areas of study which includes developing and implementing models and concepts, that may prove useful in helping to highlight management issues and solve problems.

There are three levels at which research can be done in management science:

(i) A root level that lies in three mathematical disciplines: probability, optimization, and dynamic systems theory.

(ii) A modeling level that constructs models, collects data and analyzes them mathematically.
An application level just as any other disciplines that has strong urges to make a practical impact in the real world.

Some of the fields that are included in Management Science are:

(i) Supply chain management
(ii) Data mining
(iii) Decision analysis
(iv) Engineering
(v) Forecasting
(vi) Game theory
(vii) Industrial engineering
(viii) Logistics
(ix) Mathematical modeling
(x) Optimization
(xi) Probability and statistics
(xii) Project management
(xiii) Simulation
(xiv) Social network
(xv) Transportation forecasting models

as well as many others.

Applications of management science: Applications of management science are inexhaustible in industry such as airlines, manufacturing companies, service organizations, military branches and in government. Management science has played a large role in providing solutions to problems and issues. It includes:
(i) foreign exchange transaction exposure

(ii) scheduling airlines, both planes and crew,

(iii) deciding the appropriate place to place new facilities such as a warehouse or factory,

(iv) managing the flow of water from reservoirs,

(v) identifying possible future development paths for parts of the telecommunications industry,

(vi) establishing the information needs and appropriate systems to supply them within the health service

(vii) identifying and understanding the strategies adopted by companies for their information systems.

This thesis is based upon one such recent and advanced application in management science namely, **Foreign exchange transaction exposure** which is based upon the classic 'news vendor problem' of inventory management. The “Inventory management” and “the news vendor problem” is explained in the next two sections.

### 1.3 Inventory management

Inventory management is the most popular and highly applied branch of operation research. The term *Inventory* is described as the goods or materials used by a firm for the purpose of production and sale. It also includes the items, which are used as supportive materials to facilitate production. Inventories are materials stored, waiting for processing, or experiencing processing.

There are three basic types of inventory: raw materials, work-in-progress and finished goods.

Raw materials are the items purchased by firms for use in production of finished product. Work-in-progress consists of all items currently in the process of production. These are actually partly manufactured products. Finished goods consists of those items, which have already been produced but not yet sold.
Inventory constitutes one of the important items of current assets, which permits smooth operation of production and sale process of a firm. Inventory management is that aspect of current assets management, which is concerned with maintaining optimum investment in inventory and applying effective control system so as to minimize the total inventory cost.

**Importance of Inventory Management**

Inventory management is important from the view point that it enables to address two important issues:

1. The firm has to maintain adequate inventory for smooth production and selling activities.

2. It has to minimize the investment in inventory to enhance firm’s profitability.

Investment in inventory should neither be excessive nor inadequate. It should just be optimum. Maintaining optimum level of inventory is the main aim of inventory management. Excessive investment in inventory results into more cost of fund being tied up so that it reduces the profitability, inventories may be misused, lost, damaged and hold costs in terms of large space and others. At the same time, insufficient investment in inventory creates stock-out problems, interruption in production and selling operation. Therefore, the firm may loose the customers as they shift to the competitors. Financial manager, as he involves in inventory management, should always try to put neither excessive nor inadequate investment in inventory.

The significance of inventory management could be specified as below:

- Inventory management helps in maintaining a trade off between carrying costs and ordering costs which results into minimizing the total cost of inventory.
- Inventory management facilitates maintaining adequate inventory for smooth production and sales operations.
- Inventory management avoids the stock-out problem that a firm otherwise would face in the lack of proper inventory management.
Inventory management suggests the proper inventory control system to be applied by a firm to avoid losses, damages and misuses.

The basic purpose of inventory analysis, whether in manufacturing, distribution, retail, or services, is to specify
(1) When the items should be ordered? and
(2) How much to order?
Many firms are tending to enter into longer-term relationships with vendors to supply their needs for perhaps the entire year. This changes the “when” and “how many to order” to “when” and “how many to deliver.”
A particular and important inventory problem namely “The news vendor problem,” is introduced in the next section.

1.4 The News Vendor Problem

Every early morning, a newspaper stand owner wants to order newspapers from the press for that particular day for his earnings. If the owner orders too many newspapers, some papers will have to be thrown away or sold as scrap paper at the end of the day. If the owner does not order enough newspapers, some customers will be disappointed and sales and profit will be lost. So the problem of the news stand owner is to determine the optimal (best) number of newspapers to buy that will maximize the his expected (average) profit, when he knows that what is the pattern of the demand of the newspapers and its cost. This famous problem is known as The News Vendor Problem - NVP. In mathematical terms the news vendor problem can be stated as follows:
“To find the optimum value of the order quantity of a perishable product so as to maximize the expected profit, when the demand distribution and cost parameters are known, for a single period selling season.”

The news vendor problem is the most fundamental inventory problem for one-time business decision that occurs in many different business contexts such as:

- Buying seasonal goods for a retailer
- Making the last buy or last production run decision
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- Setting safety stock levels
- Setting target inventory levels
- Overbooking customers

A few examples of news vendor problems:

(i) A vendor selling mangoes has the problem to decide how many mangoes to be ordered because if he buys too many then it may happen that over the time some will get spoiled before he could sell, on the other hand if he buys too less and demand is more than what he had ordered then he will have dissatisfied customers and loss in income as well.

(ii) Generally a cell phone has a fixed life cycle due to evolution in technology. So a cell phone manufacturer have to make a last production run (or last buy) for the product (or its parts) that is near the end of its life cycle. If the order size is very small, the firm will have stockouts and disappointed customers. If the order size is too large, the firm will only be able to sell the items for their salvage value. Hill et al. [50] considered a very similar problem for an aging service parts inventory.

(iii) A swimsuit distributor has to fix the safety stock level of the number of swimsuits (which is a seasonal item). If the safety stock is too low, stockouts will occur has dissatisfied buyers. If the safety stock is too high, the firm has too much carrying cost.

(iv) If an airline overbooks too many passengers, it leads to the cost of giving away free tickets to passengers who could not travel at their desired time. If the airline does not books enough seats, it leads to an opportunity cost of lost income from flying with empty seats.

The two major issues namely- uncertain demand and a perishable product- form the basis of the news vendor problem. In the basic form of the news vendor problem, a seller of an inventory of a homogeneous product attempts to maximize expected profit by deciding on an inventory quantity \( Q \), before knowing exactly how many customers will want to buy an item at an exogenous price, \( P \) (that is, the seller faces stochastic demand). For
each unit of inventory the seller decides to make available for sale, a constant marginal cost of $c$ is incurred, regardless of whether or not the item is ultimately sold.

The news vendor problem has been in the literature for over 100 years[30]. The extension of the NVP for dealing multiple seasons, each with a different price elasticity of demand is given in Gupta et al. [42].

We shall discuss the NVP under discrete and continuous demand in detail in chapter-4. Also its extension with one more objective of pricing is elaborated there. This model is the main platform for our research work on “Foreign exchange transaction risk”.

### 1.5 Foreign exchange risk

In global supply chain when the exchange rate between the currencies of two different countries gets an exposure to unexpected changes, there exists a financial risk and this risk is known as foreign exchange risk (or exchange rate risk). Foreign exchange risk (also known as exchange rate risk or currency risk) is a financial risk posed by an exposure to unanticipated changes in the exchange rate between two currencies of the countries involved. Investors and businesses exporting or importing goods and services, or making foreign investments have an exchange rate risk which can have severe financial consequences; but steps can be taken to manage (i.e. reduce) the risk.

**Hedging:** A hedge is an investment position intended to offset potential losses/gains that may be incurred by a companion investment. In simple language, a hedge is used to reduce any substantial losses/gains suffered by an individual or an organization.

There are three types of exposures which leads to foreign exchange risk namely,

(i)**Economic exposure:**

Economic exposure is the risk that a company’s cash flow, foreign investments, and earnings may suffer as a result of fluctuating foreign currency exchange rates. The economic exposure (also known as operational or forecast risk) collaterally affects the firm in such a way that its market value becomes unstable due to unexpected changes in the exchange rate. This fluctuations influence the firm’s market share position with respect to its competitors, the firm’s future cash flows and ultimately the firm’s value.

Economic exposure can affect the present value of future cash flows. Any transaction that exposes the firm to foreign exchange risk also exposes the firm economically, but economic exposure can be caused by other business activities and investments which may not be
mere international transactions, such as future cash flows from fixed assets. A shift in
echange rates that influences the demand for a good in some country would also be an
economic exposure for a firm that sells that good. Economic Exposures cannot be hedged
as well due to limited data, and it is costly and time-consuming. Economic Exposures
can be managed by, product differentiation, pricing, branding, outsourcing etc.

(ii) Translation exposure:
When a firm pays for its financial obligation such as equities, assets or income in terms of
foreign currency then there exists a financial risk which is known as translation exposure.
Translation exposure is also known as accounting exposure. The firm’s financial report
may also be affected by translation exposure due to fluctuation in exchange rate. At the
end of a financial year every firm prepares its consolidated report and this reporting also
includes the translation of assets, liabilities, or foreign subsidiaries. Thus the company’s
earning statement is affected and consequently the stock price also get fluctuate. So it is
also a factor concern in the business.

(iii) Transaction exposure:
Transaction exposure is the risk, faced by companies involved in international trade, that
currency exchange rates will change after the companies have already entered into finan-
cial obligations. Such exposure to fluctuating exchange rates can lead to major losses for
firms. A firm has transaction exposure whenever it has contractual cash flows (receivable
and payable) whose values are subject to unanticipated changes in exchange rates due
to a contract being denominated in a foreign currency. To realize the domestic value of
its foreign-denominated cash flows, the firm must exchange foreign currency for domestic
currency. As firms negotiate contracts with set prices and delivery dates in the face of
a volatile foreign exchange market with exchange rates constantly fluctuating, the firms
face a risk of changes in the exchange rate between the foreign and domestic currency. It
refers to the risk associated with the change in the exchange rate between the time an
enterprise initiates a transaction and settles it.

Applying public accounting rules causes firms with transactional exposures to be impacted
by a process known as “remeasurement”. The current value of contractual cash flows are
remeasured at each balance sheet date. If the value of the currency of payment or receiv-
able changes in relation to the firm’s base or reporting currency from one balance sheet
date to the next, the expected value of these cash flows will change. It has been noted by
US accounting department that changes in the value of these contractual cash flows due
to currency valuation changes will impact current income.

If the currencies of the two countries doing the business face any of the three exposures, there will be an exchange rate risk. In recent development in the field of research, among all three exposures the effect of transaction exposure on foreign exchange rate is considered as more crucial factor in global supply chain. Today we are living in the world of high end technologies and communication. The business, education, and information sharing is not limited to a particular individual or a company. Everyone is trying their best to expand it all over the globe. So it is required to deal with currencies of two different countries for an individual or company. At the same time there is a recession in many part of the world economy. So the exchange rate between the two countries doing a business keeps on changing or fluctuating. This plays very important role on pricing and ordering policies of the firms involved. Thus it is extremely inevitable to understand and investigate, the effect of foreign exchange transaction exposure, and derive effective and optimal policies for both seller and buyer.

In this thesis, we observe the effect of foreign exchange transaction exposure in news vendor settings for a single period selling season. This requires to understand the concepts of inventory management, news vendor model with pricing and some statistical distributions, and will be discussed in the chapters to follow.