South Valley University

Purchasing and Inventory Management

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Chapter 1

Introduction to Purchasing management

Introduction:

No organization expects to succeed in today's business world without being competitive and world class companies have no question over the importance of purchasing and supply management in helping drive business success. This chapter addresses the following subjects:

1. What is purchasing?
2. Evolution, Trends and development of purchasing.
3. Effective Purchasing Managers' needs
4. Types of purchasing
5. Purchasing objectives and roles in corporate strategy.
6. Ethical Principles for Purchasing

What is purchasing?

Purchasing is the act of buying the goods and services that a company needs to operate and/or manufacture products. Many people are ignorant of what purchasing is all about. “Purchasing” is the term used in industries, commerce, public corporations to denote the act of and the financial responsibility for procuring material, supplies and services. It simply describes the process of buying. However, in a broader sense, the term involves determining the needs, selecting the supplier, arriving at a proper price, terms and conditions, issuing the contract or order, and following up to ensure proper delivery. It is known also by the process of purchasing or obtaining materials in the

right quantity, in the right quality, at the right price, at the right time, and from the right supplier and delivering to the right place.

Materials Management

The basic **material management definition** is "the planning and controlling of all material and equipment so they are requested in advance, obtained at a reasonable cost and are available when needed." This definition includes not only materials that go directly into the product and the equipment to produce it, but also the spare parts needed for maintenance, in order to ensure uninterrupted operations.

Direct materials

Direct materials are those that go directly into the product being sold, and therefore represent the cost and benefit of the product itself. Availability and quality of direct materials are vital for project success. Poor planning for direct materials can cause significant losses and repercussions to the business.

Indirect materials

Indirect materials are those that are part of the process, but do not go into the product itself. These materials may include items such as equipment and spare parts, etc. Their value to the product cannot be easily quantified, but their absence or breakdown will negatively impact the process and results.

Importance of material management

The importance of the **material management process** is often overlooked, but its poor execution will have severe, negative

consequences. To appreciate this, it helps to understand the weight of a material manager's responsibilities. The material manager must ensure the following:

- The right materials
- In the right quantities
- At the right time and place
- From the right source
- At the right price

Failure to achieve any of these can result in operational disruptions, cost overruns and wasted materials, not to mention loss of profits, market share and professional reputation.

Objectives of material management

The objectives of an effective materials plan fall into three general categories:

- Lower operating costs
- Optimal material selection
- Ideal inventory control

We will explore each of these objectives below.

Lower operating costs

Operational problems cause significant losses in profits, and material management errors can easily throw the process. while , an uninterrupted flow of materials lowers cost by helping to maximize

productivity and efficiency. Material managers play a key role in controlling costs with their choices and control of both direct and indirect materials.

Optimal material selection

An experienced material manager will get the best price possible on high-quality materials to maximize profits. This involves keeping up with changing variables, such as material availability and price fluctuations, and adjusting the plan accordingly. Businesses rely on **material requisition** of suitable, low-cost options without compromising quality or supply.

Ideal inventory control

Maintaining an ideal inventory is key to an effective material management plan. material manager should minimizes storage requirements and waste, while ensuring direct and indirect materials are available when needed. This means establishing re-ordering plans and projecting inventory levels to hold for work in progress and other needs.

How to develop a material management system

Regardless of whether the tools being used are manual, digital, or a hybrid of the two, the requirements of a useful system remain the same. Again, one may ask **"What is material management?"** in the context of a specific organization. In the broadest terms, the system must include:

- Identification of reliable, alternate sources for direct and indirect materials. Having alternate sources promotes healthy competition in cost and quality.
- An appropriate method for determining the optimal combination of price, quantity, quality and purchasing schedule of direct and indirect materials.
- Multiple options for shipping materials, including for materials with shipping restrictions.
- A plan for cost-effective inventory storage that minimizes waste without compromising supply.
- Relationships of trust and goodwill with suppliers and transport companies.
- Streamlined procurement procedures and operations to ensure a smooth flow of materials.
- Appropriate training for all workers who handle or make decisions about materials.
- An impeccable record-keeping system of purchases and inventory with an audit trail that can be validated.
- Good relationships with colleagues in departments throughout the organization.

Future of material management

Currently, as in all industries, business processes are undergoing a digital transformation aimed at increasing productivity and profits,

reducing waste and ensuring sustainability. The use of integrated digital tools enables decision-makers to access critical information on material availability, cost, order status and inventory.

Historically, the importance of an unbroken supply chain has been undervalued, with minimal attention paid to the vulnerabilities inherent in “just-in-time” inventory models. The COVID-19 epidemic brought this to light, accelerating digital innovations that save costs and make “just in case” models more feasible. These innovations include automated software applications for tasks like material procurement and tracking, inventory management, analytics and more. Eventual end-to-end digitization of business processes will be critical in balancing efficiency and resilience.

Outsourcing

Outsourcing is the use and rental of competencies, powers, individuals, means and services from institutions, companies, or third parties (foreign or local). Certain responsibilities, powers, structures and activities that were usually carried out (self) and performed internally by the requesting agency, through contracting by signing contracts and cooperation agreements that arrange and regulate the duration and subject of recourse, achievements, duties, rights and obligations, filling the gaps and meeting the interests and objectives of the requesting entity.

For example, if a company or institution employs a person to guard a place or something such as a building, equipment, or the like, but to save effort and money, the hiring company has transferred this task with the help of third-party services (external source, external resources) capable of carrying out the task of guarding And security instead of the guard who was her employee.

Businesses are taking note. A recent study from FM Global, an insurer of commercial and industrial property, found risks to the supply chain were of most concern to financial executives in the UK – more than terrorism or sabotage, which were not viewed as a significant business threat. The survey of 500 financial executives, at companies in Europe and North America with at least GBP300m of annual turnover, found 31 per cent of UK respondents cited supply chain issues as the leading property-related threat.

Purchasing's Place In Business

What is the role of purchasing in business management? Why is it important? To answer these questions, the purchasing function will be observed from three points of view: first, as a function of business, second, as one of the basic elements required to accomplish productive work; and third, as the department responsible for outside manufacturing.

i) Purchasing as a function of business

Purchasing is one of the basic functions common to all types of business enterprise. These functions are basic because no business can

operate without them. All businesses are administered or managed by co-ordinating and integrating these six functions:

1. Creation, the idea or design function.
2. Finance, the capital acquisition and financial planning and control function.
3. Personnel, the human resources and labor relations function.
4. Purchasing, the acquisition of required materials, services and equipment.
5. Conversion, the transformation of materials into economic goods and services.
6. Distribution, the marketing and selling of goods and services produced.

ii) Purchased Materials as Resources or Elements of productive work

The basic goal of any industrial activity is the development and manufacture of products that can be marketed at profit. This goal is accomplished by the appropriate blending of what management authorities historically have called the five Mis: machines, manpower materials, money, and management. Materials today are the lifeblood of industry. No industrial organization can operate without them. Materials of the appropriate quality must be available at the right time, in the proper quantity, at the needed location, and at an acceptable price. Failure to fulfill any of these responsibilities concerning materials adds to company costs and decreases company profit just as surely as do

outmoded production methods, inefficient personnel, and ineffective selling.

iii) Purchasing as the manager for outside manufacturing

The materials which go into a typical company's products can originate from either of two sources. The company's production department is the first source; this department converts raw materials into processed parts. The company's purchasing department is the second source. This department not only purchases raw materials, which the production department converts into processed parts, but it also purchases finished parts and components. The parts made by the production department are combined in assembly with the items bought by the purchasing department to make the company's final products.

The percentage of industrial components being purchased externally is constantly increasing compared with the percentage being manufactured internally.

The trend in manufacturing is toward the development of three distinct types of factories. The first type does not make finished end products; it is equipped with costly high-volume specialty machines and produces machined and fabricated parts in large quantities at low unit cost. These parts are sold to numerous factories of the second and third types. The second type of factory, like the first type, does not make finished end products; it makes subassemblies. The required parts for

the subassemblies come form factories of the first type, or from the parts it makes, or from a combination of both. The third type of factory makes finished end products. As economic circumstances dictate this type of factory assembles the finished product from a combination of the parts it makes (usually parts that are unique to its product) and the standard parts or subassemblies it buys from factories of the first and second types.

In the multiple-type factory system of today, any company generally uses two distinct sources of supply: inside manufacture and outside manufacture. The production department is responsible for inside manufacture, including the authority to schedule production in economical quantities, and to do so far enough in advance to have materials available when needed.

The purchasing department, on the other hand, has the responsibility and authority to schedule the delivery of outside production. Purchasing executives have the same managerial interests concerning their outside production as production executives have concerning their internal production. Both must schedule accurately. Production executives are interested in low unit costs and high quality. Purchasing executives are interested in keeping their suppliers' costs down. In addition, they are interested in maintaining scheduled deliveries and good quality control to assure that production schedules are met and to minimize the costs of inspection and unacceptable materials.

Ethical Principles for Purchasing

The following are the principals that frame all ethical standards and guidelines of purchasing and supply management.

Supply management professionals should:

1. Avoid the intent and appearance of unethical or compromising practice in relationships, actions and communications.
2. Demonstrate loyalty to the employer by diligently following the lawful instructions of the employer, using reasonable care and granted authority.
3. Avoid any personal business or professional activity that would create a conflict between personal interests and the interests of the employer.
4. Avoid soliciting or accepting money, loans, credits or preferential discounts and the acceptance of gifts, entertainment, favors or services from present or potential suppliers that might influence, or appear to influence, supply management decisions.
5. Handle confidential or proprietary information with due care and proper consideration of ethical and legal ramifications and governmental regulations.
6. Promote positive supplier relationships through courtesy and impartiality.
7. Avoid improper reciprocal agreements.

8. Know and obey the letter and spirit of laws applicable to supply management.
9. Encourage support for socially diverse practices.
10. Conduct supply management activities in accordance with national and international laws, customs and practices, your organization's policies and these ethical principles and standards of conduct.
11. Develop and maintain professional competence.
12. Enhance the stature of the supply management profession.

Questions

1. Comment: The word “purchasing” is not used interchangeably with the word “procurement”.
2. Write short notes in each of the following:
   a- Effective Purchasing Managers' needs.
   b- Outsourcing.
3. Compare between direct and indirect purchases.
4. List the principals that frame all ethical standards and guidelines of purchasing and supply management.

Chapter 2

Supply Chain Management

Introduction

Why Supply Chain Management

Supply chain management is a concept that focuses on the interconnectedness of independent organizations that add value to products and services to deliver them to consumers. Over the past three decades, business management has evolved significantly, with new approaches such as business process re-engineering, strategic management, lean thinking, agile manufacturing, balanced scorecard, and blue ocean strategy emerging. The term'supply chain management' first appeared in the 1980s, primarily focusing on purchasing and cost reduction activities. The concept gained prominence in the 1990s, with significant publications in supply chain integration and supplier-buyer relationships.

The business environment has changed significantly, with globalization, competition, customer expectations, technological impact, and geopolitical factors. Organization-focused management approaches are no longer sufficient to deliver competitiveness in this new environment. Managers must understand that their businesses are only part of the supply chains they participate in, and it is the supply chain that wins or loses the competition.

The competition is moving from 'organization against organization'

to'supply chain against supply chain', and the survival of any business today is no longer solely dependent on its ability to compete but on the ability to cooperate within the supply chain. The seemingly independent relationship between organizations within the supply chain becomes increasingly interdependent, making supply chain management essential for today's business success.

Supply chain management is also pervasive and ubiquitous. One can hardly find any aspect of business that has nothing to do with supply chain management. Take an example of quality management – a very important part of today's business management, and ask yourself a question: can you manage and improve the quality standard of your product or service measured by the end-consumer without managing the suppliers and buyers in the supply chain at all? Of course not. Business value creation is always a collective contribution from the whole involved supply chain.

Defining supply chains

Ploughing through the plethora of literatures, one will come to realise that there are as many different definitions as many of those who cared to write about it. However, a broad conceptual consensus on the notion of Supply Chain (SC) and Supply Chain Management (SCM) is beyond anybody's reasonable doubt. Based on that, the author would like to offer his definition of SC here and SCM in the

next section.

> *Supply chain is defined as a group of inter-connected participating companies that add value to a stream of transformed inputs from their source of origin to the end products or services that are demanded by the designated end-consumers.*

In this definition, there are a number of key characteristics that have been used to portrait a supply chain. First, a supply chain is formed and can only be formed if there are more than one participating companies. Second, the participating companies within a supply chain normally do not belong to the same business ownership, and hence there is a legal independence in between. Third, those companies are inter-connected on the common commitment to add value to the steam of material flow that run through the supply chain. This material flow, to each company, comes in as the transformed inputs and goes out as the value added outputs.

Intuitively, one can imagine a supply chain as something resembles a "chain", in which the "links" are the participating companies that are inter-connected in the value adding process (see figure 1). The link on the upstream side of the material flow is the supplier's supplier; and on the downstream side of the material flow is the customer. There is usually an OEM – **Original** Equipment Manufacturer in between. The OBM sometimes is represented by OBM – Original Brand Manufacturer, or sometimes simply the "focal

company.”

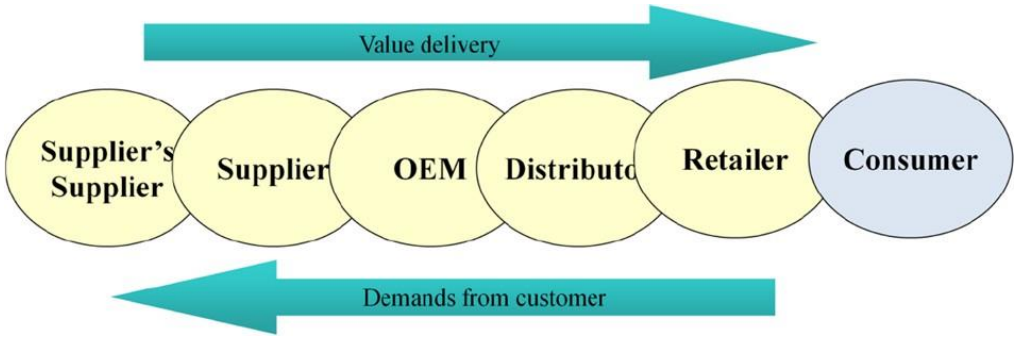


Figure 1. The basic Supply Chain model

At the end of a supply chain is the product and/or service that are created by the supply chain for the end consumer. Thus, the fundamental reason of a supply chain’s existence is hinged on to serving the end-consumer in the market place. The degree of how well a supply chain can serve their consumer ultimately defines its competitive edge in the market place.

It is understandable that in real-world a supply chain is much more complex than the one depicted in Figure1. It is not really a “chain”, rather it is more like a “network”, when you consider that there are usually multiple suppliers and multiple customers for each participating companies in the chain. There are also possible nested chains within the chains. For example an engine manufacturing supply chain is a nested supply chain within the connected automobile supply chain.

Depend on how would like to see the supply chain, there are similar but different names you may like to call the supply chain. If you view a supply chain as basically a chain of value adding activities, you may like to call it "Value Chain"; if you perceive a supply chain as continuous demands originated from the consumer and stretched to upstream suppliers, you may like to call the supply chain the "Demand Chain".

Since the business connections between organizations are pervasive, how could one draw a boundary of a supply chain? In order to answer this question, one needs to understand the four intrinsic flows of a supply chain.

Material Flow: All manufacturing supply chains have material flows from the raw materials at the beginning of the supply chain to the finished products at the end of the supply chain. A furniture-making supply chain will have the wood cut down from forest at the beginning of its supply chain and home furniture at the end of supply chain. The continuous flow of wood been transformed through the chain and end up to furniture ties the whole supply chain together and defines its clear boundary. A furniture supply chain can never be confused with a chocolate manufacturing supply chain because the material flows in between are clearly different and never will they cross with each other.

Information Flow: All supply chain s have and make use of

information flows. Throughout a supply chain there are multitude of information flows such as demand information flow, forecasting information flow, production and scheduling information flows, and design and NPI information flows. Unlike the material flow the information can run both directions, towards upstream and downstream alike. Interestingly most of them are unique to the specific supply chain. The information of woman's fashion clothing has no value to a motorbike supply chain. Any supply chain will have its own set of information flows that are vital to its existence which are often jealously protected against those of other supply chains.

Finance Flow: All supply chain have finance flow. It is basically the money flow or the blood stream of a supply chain. Without it, a supply chain will surely demise. However, for any supply chain, there is only one single source of such finance flow – the en-consumer. This understanding of single source of finance has led to a concept of "single entity" perspective of a supply chain, which is a very useful foundation for supply chain integration and collaboration. The distribution and sharing of this single financial resource fairly across a supply chain will allow for the better alignment between the contribution and reward for the participating companies.

Commercial flow: All supply chains represent a transactional commercial flow. This means that the material flow that run through the supply chain changes its ownership from one company to another,

from supplier to buyer. The transactional process of buying and selling shifts the material flow's ownership from the supplier to the buyer repeatedly until the end of the supply chain – the end-consumer. This transactional commercial flow will only take place in a supply chain where there are more than one companies. On the other hand, if it is with an organization there will be material flow, but no ownership change, and hence no commercial flow.

The four flows described above not only better explain the function of the supply chain, but also define it more rigorously. They represent four major areas of concerns and research activities in the supply chain management, which covers most of the known issues in the published literatures.

Customer Orientation

Having understood the supply chain model, one may ask "Is the end-consumer a part of the supply chain?" Most people will say "Yes", because consumer give the demand information; consumer provide the financial reward and so on. But the author will argue that strictly speaking the end-consumer is NOT part of the supply chain; the supply chain only extend from the very raw material suppliers to the retailer (if that's the last link in the supply chain before the end-consumer). There are number of fundamental reasons to support this argument.

1) First, all supply chain supplies, and every member of the supply chain supplies; but the consumer DON'T, it demands instead of supply. The fundamental function of a supply chain is to supply; and the consumer is the recipient of the supply, but not a part of the supply. Supply chain's existence is based on the existence of

   the demand from the consumer. Supply chain treats consumer as the object which it serves. If a supply chain contains the consumer within itself, then it will have no object to serve and no recipient to take the supply; and it will lose its purpose of existence.

   Second, a supply chain adds value to the product (or transformed inputs), but the consumer DON'T. Consumer *consumes* the product and depletes its market value. Used goods are always cheaper than the new ones. A supply chain and every member in it have the irrefutable duty to add values to the material flow, and they must learn how to improve the business and its management; but consumers will never need to do that. Their job is to use the money to vote which supply chain best satisfy their demand.

2) Third, a supply chain is always specialised and a consumer is always general. A computer manufacturing supply chain only produces computers, whilst a consumer will have to

> buy food, clothing, and automobile as well as computers. Due to the extremely divers nature of consumer's purchasing, to put the consumer as part of a supply chain will not be helpful in understanding the nature of a supply chain and may cause considerable confusion theoretically and logically.

Based on these three fundamental differences between the nature of supply chain and that of the consumer, it is more appropriate and less confusion if we separate the consumer away from the concept of the supply chain. This definition of supply chain without consumer will not deprive the immense benefits that consumer may contribute to the supply chain. How the end-consumer plays this pivotal role in the existence and the management of supply chain is the core notion of *supply chain management*.

The end-consumer to a supply chain is perhaps the most important factor of all as far as its management is concerned. Everything a supply chain does is driven by the needs and wants of the end-consumer. The contents of SCM are populated with the approaches, activities as well as the strategies that are aiming at delivering the products and services to satisfy the end-consumer. Therefore, it is safe to say that the SCM should be and has always been a customer centred management. This reflects the typical characteristic of supply chain's customer orientation.

Not only the end-consumer serves as the ultimate objective, it also provides vital information and practical assistance to the decision making in the process of supply chain management. The end-consumers needs and wants, where they are, how many they are and how much they can afford and etc. give the supply chain manager some very precise guidance as how to achieve market responsiveness.

It is therefore beyond the shadow of doubt that supply chain and its management have always been, still are, and will certainly continue to be customer oriented. This customer orientation gives the fundamental reason and purpose of its existence. It also ensures that supply chain management has to be a system perspective based management approach that engages every participating member of the supply chain to align to the customer orientation.

Defining Supply Chain Management

Defining the supply chain management can be both dead easy and extremely difficult. It is dead easy because it is so widely known and widely practiced in almost all businesses. There is hardly a need to teach the "A, B, C" again. It is also extremely difficult because the definition must capture all what supply chain management in practice has reached far and wide. As an attempt, the author proffers the following definition:

> Supply chain management is simply and ultimately the business management, whatever it may be in its specific context, which is perceived and enacted from the relevant supply chain perspective.

This definition squared out the nagging confusion between organizational business management and supply chain management. Rarely any aspect of organizational business management is not related to or influenced by the external firms in the supply chain. Thus the best way to manage the business is to take into consideration and engage with the external organizations in the decision making in order to achieve the ultimate business objectives – that means supply chain management.

In other words, trying to identify a set of supply chain management activities that is not or nothing to do with any known business management activities would futile. The inception of the supply chain management concept did not create a new set of functional activities that has never been carried out before. What it created is a new way of understanding on how the business activities might be better carried out.

The supply chain management defined as such has already elevated the modern business management concept from the organizational focused domain to the supply chain focused system giving rise to more

effectiveness in achieving the strategic objectives. Today's competition is no longer seen as the company against the company but the supply chain against the supply chain. Supply chain management is therefore a new perspective towards the old activities.

This definition effectively explains why supply chain management can be done in such vastly diverse ways; why apparently completely different management activities can often be called supply chain management; why the same traditional management function is now been entitled as supply chain management; and so on. The answer is simply that because we start view the management issues and taking actions from the supply chain perspective.

This definition certainly gives the supply chain management concept a ubiquitous and pervasive nature. But, that does not mean that there is nothing uniquely identifiable on its own. One can still identify some practically very useful conceptual components of the supply chain management. Any supply chain management practice and activities is captured by the three conceptual components: Supply Chain Configuration; Supply Chain Relationship; and Supply Chain Coordination.

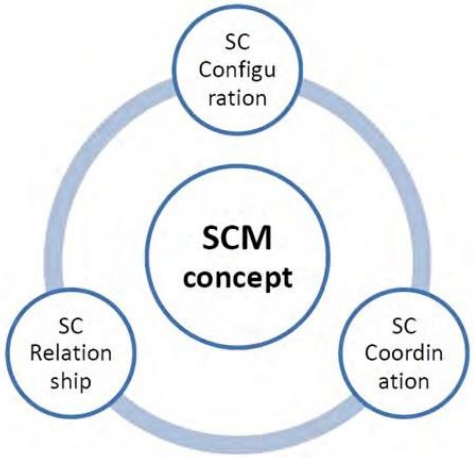


Figure 2. Supply Chain Management conceptual model

- **Supply Chain Configuration** is about how a supply chain is constructed from all its participating firms. This includes how big is the supply base for OEM (original equipment manufacturer); how wide or narrow is the extent of vertical integration (which is the single ownership of consecutive activities along the supply chain); how much of the OEM's operations are outsourced; how the downstream distribution channel is designed; and so on. It is also known as supply chain architecture. The decision on supply chain configuration is strategic and at a higher level.
- **Supply Chain Relationship** is about inter-firm relationships across the supply chain albeit the key focus of relationship is often around the OEM and its first tier suppliers and first tier

customers and the relationship in between. The type and level of the relationship is determined by the contents of inter-organizational exchanges. The relationship is likely to be "arm's length" if they only exchanged the volume and price of

the transaction; on the other hand, the relationship would be regarded as close partnership if the parties exchanged their vision, investment planning, NPI process and detailed financial information. The decision on supply chain relationship is both strategic and operational.

- **Supply Chain Coordination** refers mainly to the inter-firm operational coordination within a supply chain. It involves the coordination of continuous material flows from the suppliers to the buyers and through to the end-consumer in a preferably JIM manner. Inventory management throughout the supply chain could be a key focal point for the coordination. Production capacity, forecasting, manufacturing scheduling, even customer services will all constitute the main contents of the coordination activities in the supply chain. The decision on the supply chain coordination tends to be operational.

There is, however, one thing in common amongst the three key supply chain management focuses. That is they all deal with the external

organization in the same supply chain, which makes the concept more supply chain rather than organizationally internal. These concepts also tell us that supply chain management involves managerial decision making across strategic, tactic and operational levels – the pervasiveness. One may notice that all the major *Operations Management* text books will include a chapter or two on supply chain management, but that does not necessarily make the subject purely operational.

Development Trends

Another difficulty in understanding and defining supply chain and supply chain management is that it is never stand still and the subject has been continuously evolving since its inception in the early 1980s. The continuous development is partly propelled by the changes of overall business environment and heightened competitions in the global market place. But partly it is influenced by the new understanding of the supply chain that they participate. There are number of early development trends that can be observed evidently.

1) **From functional to process perspective**. Business management used to see and take action on the functional silos in the business. It was understandable that naturally the function is what seen to be the delivery part of the business. But, today with supply chain management

concept managers can see their problems more from the process perspective, understanding that functions can only make sense if it is perceived from a supply chain process perspective.

2) **From operational to strategic viewpoint**. At early years of applying supply chain management concept, managers tends to see it as another operational tactics that will help to reduce operational cost, such as purchasing function improvement and optimising the logistics operations. But, gradually more and more managers realised that the effective changes can only be achieved if the operational issues are addressed from the supply chain wide strategic viewpoint. Operational excellence can only be manifested through its *strategic fit*.

3) **From single enterprise to extended enterprise**. Enterprise management is now arguably displaced by the supply chain management, where the supply chain is by definition the extended enterprise. The long established enterprise centred management thinking was based on that the competition was raged between the organizations, thus it becomes obsolete as the competitions are now predominantly between the supply chains. Management thinking over the extended enterprise produces a great deal ideas that single enterprise alone cannot.

4) **From transactional to relationship based engagement**.

Business engagement between firms in the past was predominantly transaction based and cost driven. The merit of any purchasing and procurement of externally sourced materials and services was judged by the transactional measures such as price, volume and delivery terms. But what's now more of the practices in working with external organizations within the supply chain is so called relationship based engagement. This relationship approach does not abandon the transactional activities but put its decision baking on much wider consideration of knowledge exchange, long-term commitment, incentives and reward.

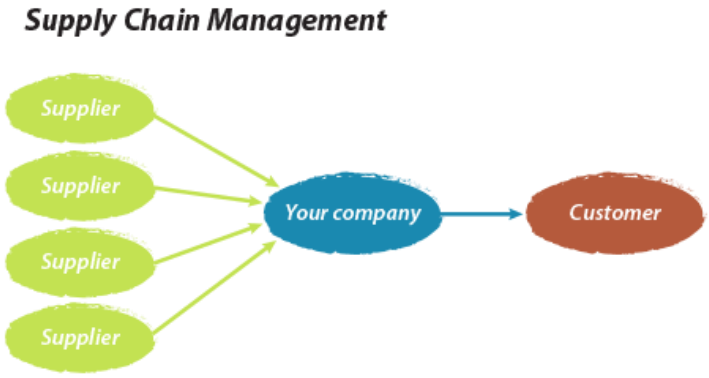
5) **From local to regional, and from regional to global**. Connections of supply network have over the last two decades grown from local to regional and to global. Hardly any major enterprise and supply chains is not connected to some part of the world. You need to get out before you can get up. This trend is spurred by the lower cost of labour and materials in many parts of the world, as well as first mover advantages in setting up global market presence.

The trends of supply chain development are not always positive and encouraging. There is now enough evidence to support that supply chain risks are now continuously growing to the level that is higher than ever before; and supply chain integration still remains as the

major management shortfall across all industrial sectors (PRTM Global supply chain trends report 2010-12). The task of managing and improving supply chain performances across all industrial sectors is only becoming tougher, not easier. This calls for deeper and more thorough understanding of the challenges supply chains are facing.

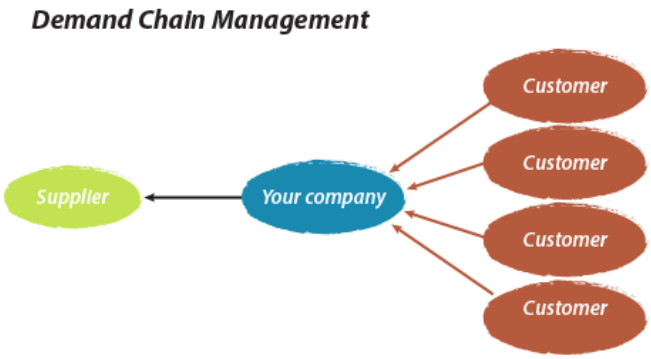
Supply chain , demand chain:

- The supply chain shows the direction of supply, from the source of raw materials to the final customer.
- As for the demand chain, it is represented in the demand that starts from the customer, through the retail and wholesale stores, to the manufacturing operations and suppliers of raw materials.



- Demand supply chain management refers to managing the up and down relationships between suppliers and customers to provide the customer with the optimum value at the lowest cost. **The term "chain or network**

oriented-by-demand" refers to that the flow of material managed by customer demand .



Customer demands control the main flow of the demand- network. Compared to the traditional supply chain, the demand network uses pull strategy. It provides the demand-chain with opportunities to share more information and collaborate with others in the chain.

The demand network uses the four-level model.

• The first level: is the response

• The second level expectation

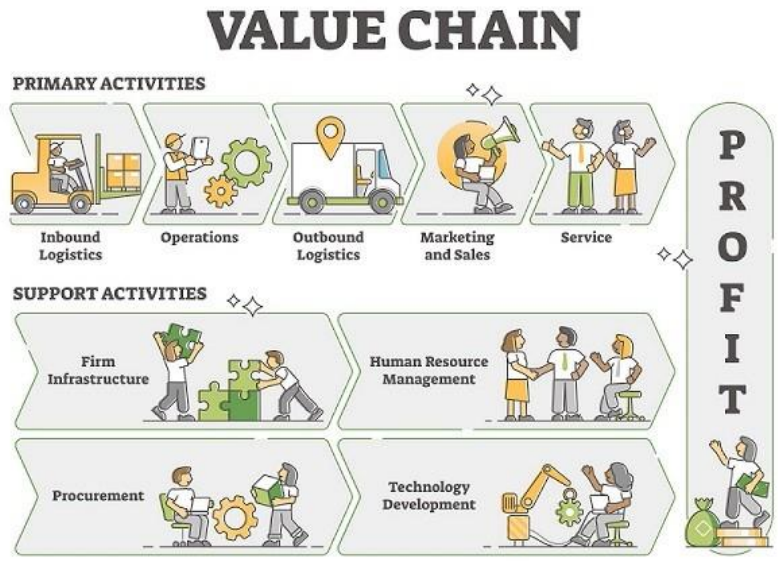
• The third level cooperation

• The last level is organized work.

The first two levels focus on the internal supply chain while the other two levels focus on external relations throughout the extended organization.

To generate sustainable competitive advantages with a demand network, companies must adhere to three conditions:

- Regularity (creating joint activities)
- Speed of reaction (responding quickly to short-term change)
- and adaptation (adjusting supply chain design)



Push vs. Pull Supply Chain Strategy

A company's supply chain stretches from the factory where its products are made to the point the products are in customer hands. Supply chain strategy determines when product should be fabricated, delivered to distribution centers, and made available in the retail channel. Under a pull supply chain, actual customer demand drives the process, while push strategies are driven by long-term projections of customer demand.

Push Supply Chain Strategies

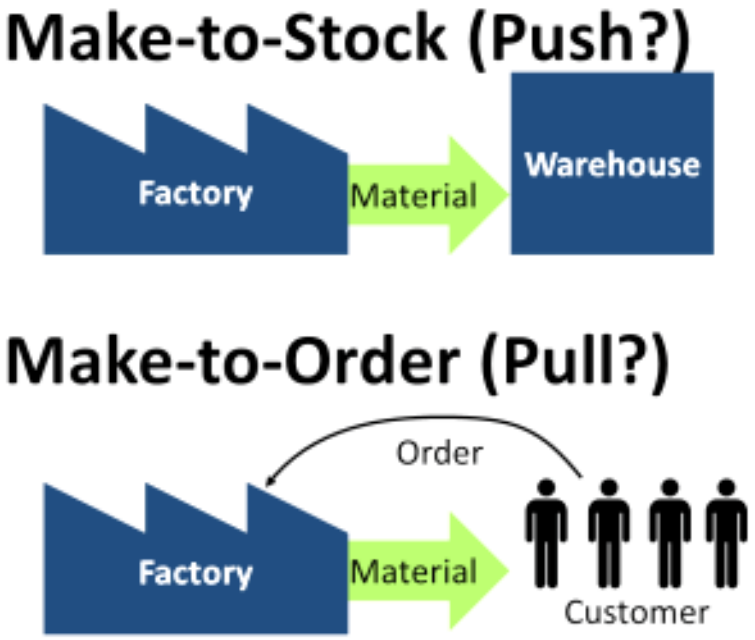
A push-model supply chain is one where projected demand determines what enters the process. For example, warm jackets get pushed to clothing retailers as summer ends and the fall and winter seasons start. Under a push system, companies have predictability in their supply chains since they know what will come? When? long before? it actually arrives. This also allows them to plan production to meet their needs and gives them time to prepare a place to store the stock they receive.

Pull Supply Chain Strategies

A pull strategy is related to the just-in-time school of inventory management that minimizes stock on hand, focusing on last-second deliveries. Under these strategies, products enter the supply chain when customer demand justifies it. One example of an industry that operates

under this strategy is a direct computer seller that waits until it receives an order to actually build a custom computer for the consumer.

With a pull strategy, companies avoid the cost of carrying inventory that may not sell. The risk is that they might not have enough inventory to meet demand if they cannot ramp up production quickly enough.



Importance and Benefits of Supply Chain Management:

Since World War II and with the solutions provided by management science and operations research, there has been an increase in the importance of supply chain planning and management, and by working as a team, supply chain planners and managers and all members at the beginning, middle and end of the chain have the ability to increase revenue and also control cost, in addition to better utilization for assets And finally, customer satisfaction.

The software needed for optimization is integrated at the chain level, in addition to proposing mathematical modeling solutions to supply chain problems. For example, the software package provides us with the optimal way of supplying from the supplier to the product and then to the customer. In sum, fulfilling the desires of customers and enjoying an increase in profitability is a natural result of achieving optimal efficiency through supply chain management.

Optimization allows to improve the performance of the company's supply chain in several diverse areas, namely:

- Reducing the cost of supply.
- Improving the marginal profit of the product.
- Increasing manufacturing efficiency (at all levels).
- Better return on assets (net profit after costs and interest).

Global Supply Chain Operations

Global Business Environment

To date, our world market is dominated mostly by many well established global brands. Over the last three decades, there have been a steady trend of global *market convergence – the tendency that indigenous markets start converge on a set of similar products or services across the world.* The end-result of the global market convergence is that companies have succeeded on their products or services now have the whole wide world to embrace for their marketing as well as sourcing.

The rationale of global market convergence lies partially in the irreversible growth of global mass media including Internet, TVs, radios, news papers and movies, through which our planet has become truly a small global village. Everybody knows what everybody else is doing, and everyone wants the same thing if it is perceived any good. It also lies in the rise of emerging economic powers led by BRICs (Brazil, Russia, India and China), which has significantly improved the living standard and the affordability of millions if not billions of people.

For organizations and their supply chains, the logic of going global is

also clearly recognizable from economic perspective. They are merely seeking growth opportunities by expanding their markets to wherever there are more potentials for profit- making; and to wherever resources are cheaper in order to reduce the overall supply chain costs. Inter-organizational collaborations in technological frontier and market presences in the predominantly non-homogeneous markets can also be the strong drivers behind the scene.

One can also observe from a more theoretical perspective that the trends of globalization from Adam Smith's law of "division of labour". A global supply chain is destined to be stronger than a local supply chain because it takes the advantage of the *International Division of Labour*. Surely, the specialization and cooperation in the global scenario yields higher level of *economy* than that of any local supply chains. Thus the growth of global supply chain tends to give rise to the need for more coordination between the specialized activities along the supply chain in the global scale.

As the newly appointed Harvard Business School dean professor Nitin Nohria said "If the 20th century is American's century, then the 21st century is definitely going to be the global century." The shift of economic and political powers around world is all too visible and has become much more dynamic and complex. But, one thing is certain that there will be significantly and increasingly more participation of diverse industries from all around the world into the

global supply chain network; hence bringing in the influences from many emerging economies around the world. Their roles in the globally stretched network of multinational supply chains are going to be pivotal and will lead towards a profoundly changed competitive landscape.

In such a global stage there are a number of key characteristics that global supply chains must recognize before they can steer through:

- **Borderless**: National borders are no longer the limits for supply chain development in terms of sourcing, marketing, manufacturing and delivering. This borderless phenomenon is much beyond the visible material flows of the globalised supply chain. It is equally strongly manifested in terms of invisible dimensions
  of global development such as brands, services, technological collaboration and financing. Evidently, the national borders are far less constrictive than they used to be. Arguable this is perhaps the result of
  technology development, regional and bilateral trade agreements, and the facilitation or world organizations such as WTO, WB, GATT, OECD, OPEC and so on.

- **Cyber-connected**: The global business environment is no longer a cluster of many indigenous independent local markets, but rather it emerged as an inter-connected single market through predominantly and growingly important cyber connections. For this reason, the inter-connection of our global business environment is almost “invisible”, spontaneous and less controllable and surely irreversible. Globally stretched multinational supply chains would not be

possible or even comprehensible without cyber- technology allowing large amounts of data to be transferred incredibly quickly and reliably.

- **Deregulated**: Trade barriers around the world has been demolished or at least significantly lowered. Economic and free-trade zones around the world have promoted open and fair competition and created, albeit never perfect, a level playing field on the global stage. Deregulation simplifies and removes the rules and regulations that constrain the operation of market forces. It has targeted more at the international trading and aiming for stimulating global economic growth. The typical deregulated regions are European Union, North America Free Trade Agreement zone; Associations of Southeast Asian Nations group and so on. Deregulation reduces government control over how business is done thus moving towards laissez-fair and free market system.

- **Environmental Consciousness**: Last decade has witnessed the growing concerns on the negative impact of business and economic development on the natural environment. The global movement towards green and more eco sustainable business strategies plays an important role in today's global supply chain development. This is also driven by the actions of lawmakers and regulatory agencies, such as the

Environmental Protection Agency (EPA). Governments of leading economies are increasingly involved in promoting greening activities in business, and formalize more legislation and regulation to place upon firms in the future. Carbon footprint is now a key performance measure of the sustainability for many global supply chains.

- **Social Responsibility**: Along with that is a wider socio-economic impact. Fair trade and business ethics become increasingly the key measures on business's social responsibility, and the key factors for business decision making. Social pressure strikes at the heart of a company's brand in the mind of the consumer. A significant group of consumers have begun making their purchasing decisions based on the supply chain's ethical standard and social responsibility. Global corporate citizenship and social responsibility forms yet another important business environmental factor that can make or break a business.

Strategic Challenges

Under such a changing global business environment, what are the new strategic and operational challenges? At a macro level, there are at least five key strategic challenges that will have the long term and overall impact on the architecture as well the management process of the global supply chains. Those strategic challenges tend to be interrelated intricately and dynamically with one another. The magnitude of those challenges varies from industry to industry; and from time to time.

Market dimension

Continuing demand volatility across the world market has hampered many supply chains' ability to manage the responsiveness effectively. Demand fluctuation at the consumer market level poses a serious challenge to the assets configuration of supply chain, capacity synchronisation, and lead-time management. More often than not it triggers the 'bullwhip effect' throughout the supply chain resulting in higher operating cost and unsatisfactory delivery of products and services.

The root causes of the demand volatility in the global market are usually unpredictable and even less controllable. Economic climate plays a key role in overall consumer demand. The recent worldwide economic downturn has made many global supply chains over-

capacitated, at least for a considerable period of time. Geo-political instability around the world has also contributed to the market volatility to certain industries. Technology development and product innovation constantly creates as well as destroys the markets often in a speed much faster than the supply chain can possibly adapt. Emerging economies around the world are aggressively churning out products and services that rival the incumbent supply chains in terms of quality and price, which lead to huge swings of market sentiment.

Recent research shows that customer loyalty has significantly decreased over the last decade, adding to the concerns of market volatility. The development of internet based distribution channels and other mobile marketing medias has made it incredibly easier for consumers to switch their usual brands. Many products are becoming more and more commoditized, with multiple competitors offering very similar features. With increased market transparency, many B2B and end customers simply shop for the lowest price, overlooking their loyalty to particular suppliers or products. A lack of robust forecasting and planning tools may have contributed to the problem, as companies and their suppliers frequently find themselves scrambling to meet unexpected changes in demand.

Technology dimension

Technology and the level of the sophistication in applying the technology for competitive advantages have long been recognised as the key strategic challenges in supply chain management. This is even

more so, when we are now talking about the supply chain development in a global stage. The key strategic challenges in the technological dimension are threefold.

The first is the development lead-time challenge. The lead-time from innovative ideas to testing, prototyping, manufacturing, and marketing has been significantly shortened. This is partially due to the much widened global collaboration on technological development and subsequent commercialisation and dissemination. The globally evolved technology development systems have created a new breed of elite group as the world technology leaders across different industries. They capture the first mover advantages and made the entry barriers for new comers almost impossible to overtake. No doubt, there is a strategic challenge that global supply chain must create an ever ready architecture that can quickly embrace the new ideas and capitalise it in the market place.

The second challenge comes from its disruptive power. Harvard Business School professor Clayton Christensen published his book *The Innovator's Dilemma* in May 1997, in which he expounded on what he defined as the *disruptive technology*. The basic message he tried to put across was that when new technologies causes great firms to fail, managers face the dilemma. Evidently, not all new technologies are sustaining to business, often they are competency-destroying. The product or service developed through applying new

innovative technologies may not be so much appreciated by the consumers. Consumers often are often not so eager to buy the ideas. They may not be so convinced that the value the technology created or the costs it added in. If you wait for other companies to test the market first, then you run a high risk of losing the first mover advantage and losing the market leadership. That's the dilemma and that's the challenge.

The third challenge lies in the supply chain network. The innovative ideas and new technologies usually emerge from a supplier or a contractor in the supply chain network. To convince the whole supply chain of the value adding or cost reduction is not guaranteed. Each supplier and contractor will have its own value stream and will make technology adoption decisions based on the needs of its own customers. Innovative ideas that come up from subcontractors may be stifled due to the supply chain's inability to coordinate value contribution between individual members and the whole supply chain. The cost and profit structures in the value network can also limit the attractiveness of an innovation. If profit margins are low, the emphasis will be on cost cutting across proven technologies, rather than taking the risk of the new technologies.

Finally from the technology evolution perspective, technology destroys as readily as it creates. The development of digital photography has literally destroyed the photo film manufacturing

industries including many well known brands; LCD and Plasma technology also smashed the TV Tube (traditional screen component) manufacturing industry overnight. This increased risk of technology disruption at the industrial scale is lot more formidable than the innovative dilemma Prof Christenson was talking about in his book. Nevertheless, there are some helpful supply chain strategies that can better prepare them for the eventuality.

Resource dimension

From resource based perspective, global supply chain development is both motivated by dinging new resources around world and by make better use of its own already acquired resources to yield economic outputs. It comes as no surprises that one of the key strategic challenges in global supply chain development is about resource deployment. The term resource in this context means any strategically important resources, including financial resource, workforce resource, intellectual resource, natural material resources, infrastructure and asset related resources, and so forth.

Stretching supply chains' downstream tentacles around the world opens the door for making good (more efficient) use of internal resources, i.e. the same level of resources can now be used to satisfy much wider and bigger market in terms of volume, variety, quality and functions. However the internal resource or competence based

strategy will also face more severe challenges on the global stage than in its own local or regional market. The challenges are not necessarily just from the indigenous market, but more likely they come from equally competitive incumbent multinationals and possible emerging ones alike. Also more menacingly the internal based advantages can evaporate anytime when global business environment subjects fundamental changes.

Stretching the sourcing-end (supply side) of supply chain to the global market is a great strategy to acquire scarce resources, or any resources at a much lowered cost. The productivity and operational efficiency oriented strategy is often no match to the procurement focused strategy in measures of reducing the total supply chain cost. No wonder many multinationals are actively debating on sourcing their workforce, materials and energy from overseas locations in order to significantly reduce the operation cost, which will then lead to more competitive market offerings. This resource sourcing strategy has been the prime drive for the surge of off-shoring and outsourcing activities all over the world. However many long- term and short-term impacts of outsourcing and off-shoring are difficult to be fully understood from the outset, if at all possible. Thus it forms a key strategic challenge in global supply chain development.

Time dimension

Most of the key global supply chain challenges are time related, and it appears to be that they are becoming even more time related than ever before. Given that everything else is equal; the differences on time could make or break a supply chain. When the new market opportunity emerges it is usually the one who gets into the market first reaps the biggest advantages. Competitions on many new electronic consumer products is largely about who developed it first and become the industry leader. From the internal supply chain perspective, the cost and core competences are all largely measured against time. Inventory cost increase, if the materials do not move on quick enough; supply chain responsiveness is can be significantly influenced by the lead-time and throughput time.

Indeed, one of the key supply chain management subject areas is about agility and responsiveness. That is basically defined as how fast the supply chain can respond to the unexpected and often quite sudden changes in market demand. Understandably, in the increasingly fast moving global market place, developing and implementing an agile supply chain strategy makes sense. However, the tough challenges are usually not on making the decisions as to whether should the supply chain be agile or not. They are more on balancing the 'cost to serve'. In order to maintain a nimble footed business model, the supply chain may have to upgrade its facilities with investment, having higher than usual production and service capacities, or having high level of inventories. Then the question is

would the resultant agility pay for the heightened supply chain costs. There is no fixed answer to this question, and it remains as a key challenge to supply chain managers.

The time measures on many operational issues have also been the major challenges for supply chain managers. Customer lead-time, i.e. from customer order to product delivery, is one of those challenges. Toyota claims that they can produce a customer specified vehicle with a fortnight – the shortest lead-time in the auto industry. This adds huge value to the supply chain in terms of customer satisfaction, cost reduction, efficiency and productivity. But it could be a huge challenge, when the customers are all over the world and the productions sites and distribution logistics facilities are not well established.

All the challenges in the three dimensions are, of course, interrelated and even interdependent with each other. A supply chain strategist must have a sound system view to understand the intricate relations of all factors in the whole supply chain and over the projection of long-term. Those strategic challenges have undoubtedly given rise to the risk level of global supply chain development. It came as little surprise that the supply chain risk management, which will be discussed later in this book, is now one of the hot topics discussed in the academia and business circle alike.

How Global Supply Chains Responded

Knowing the challenges is one thing perhaps to begin with, but learning about how to face up to the challenges is quite another. Despite the plethora of literatures on supply chain management, there are still no universally agreed "one size fit all" recipes for managers to prescribe in order to survive the challenges. Academic and empirical studies show there are at least five common approaches that supply chains have survived the global challenges.

Collaboration

"If you cannot beat them, you better join them." A great deal of global supply chain management activities are not necessarily about competing against one another, rather it is more about collaboration and partnering. Inter-firm collaboration in supply chain management context is simply defined as working together to achieve a common goal. The content of collaboration varies from project to project and from business to business. It may be a research and development collaboration which is aiming perhaps for a technological advancement or a new product design; or it could be a logistics operational collaboration where the aim is to reduce logistics lead-time and cost; it could also be marketing collaboration where the aim is to penetrate the market and increase sales. So, the collaboration is usually mentioned when there is an area or a project the activities of the collaboration can be associated with. The parties that involved in

the collaboration are often referred to as the *partners* or *collaborative partners*. There are a number of obvious reasons why collaboration is one of the most favorite supply chain management approaches.

- **Sharing resources**: collaboration between two firms helps to share the complementary resources between them, thus avoiding unnecessary duplication of the costly resources such as capital-intensive equipment, service and maintenance facilities, and distribution networks and so on. Information, knowledge and intellectual resources are also very common resources that are shared during the collaboration.
- **Achieve synergy**: collaboration of the two partnering firms will usually result in what is called 'synergy.' Synergy, in general, may be defined as two or more things functioning together to produce a result not independently obtainable. That is, if elements A and B are combined, the result is greater than the expected arithmetic sum A+B. In the context business collaboration or partnering, synergy is about creating additional business value that neither can achieve individually.
- **Risk sharing**: a properly constructed collaboration can help to mitigate the company's market and supply risk significantly for both parties. Risk is the negative but uncertain impact on

business, which is normally beyond control. By collaborating on investment and marketing, the negative impact of the supply chain risks can be borne by both parties and thus shared and halved.

- **Innovation**: collaboration in technology development and R&D partnering is particularly effective way to advance their competitive advantages through innovation in the technological frontier. The logic behind is perhaps that when people from different business working to gather, they start blend their knowhow and experience together, sparkling new innovative ideas. In most of innovation training programmes one can always recognise one of steps of generating innovative ideas is to have brain storming across a multi- functional team.

Supply chain integration

The nature of a supply chain is that it is usually a network which consists of a number of participating firms as its member. For a global supply chain the network stretches many parts of the world, and the participating member firms of the network can be an independent company in any country around the world. Supply chains are therefore voluntarily formed 'organizations' with fickle loyalties and often antagonistic relations in between the member firms. Communication and visibility along the supply chain are usually

poor. In other words, supply chains are not born integrated.

Supply chain integration therefore can be defined as the close internal and external coordination across the supply chain operations and processes under the shared vision and value amongst the participating members. Usually, a well integrated supply chain will exhibit high visibility, lower inventory, high capacity utilisation, short lead-time, and high product quality (low defect rate). Therefore, managing supply chain integration has become one of the most common supply chain management approaches that can stand up to the global challenges.

However, there is no supply chain that is strictly 100% integrated, nor any one that is strictly 0% integrated. It is about how much the supply chain is integrated from a focal company's point of view. To illustrate this degree of difference in supply chain integration, Frohlich and Westbrook (2001) suggested a concept of 'Arc of Integration' (Figure 3). A wider arc represents a higher degree of integration which covers larger extent of the supply chain, and a narrow one for a smaller extent. The issue about supply integration is particularly important when the supply chain is formed by the members around the globe.

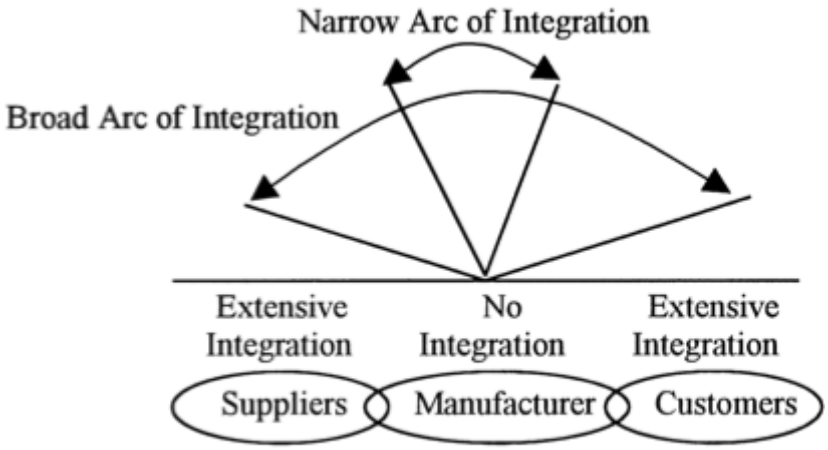


Fig. 2. Arcs of integration.

Figure 3. Arc of integration (Source: Frohlich and Westbrook, 2001)

Divergent product portfolio

A conventional wisdom says that 'don't put all your eggs in one basket.' It also makes sense in formulating a global supply chain development strategy. Translated into business management terminology, the wisdom is very similar to the 'divergent product portfolio' strategy. Then it may make even more sense when the global market becomes the stage for the supply chain. Two key characteristics of global market are volatility and diversity.

Develop divergent product portfolio will make the supply chain more capable of satisfying the divergent demand of the world market.

Many leading multinational organizations have already been the firm believer of this strategy. They have developed a wide range of product or even business sector portfolio to cater for the market needs. Virgin Group, General Electric, British Aerospace are just some well know examples.

The divergent product portfolio strategy can also significantly mitigate the market risks that brought forth by the nature of global market volatility. If one product is not doing well, the supply chain can still be stabilised by others that do well. The shock of one single market at a particular time will not derail the overall business. In a long run, occasional market instabilities will ease off with each other. So, the divergent portfolio works like a shock absorber and risk mitigating tool.

Develop the "blue ocean strategy"

Instead of going for the 'head-on' competition in the already contested 'red sea' a much more effective approach is to create a new market place in the 'blue ocean', which makes the competition irrelevant. This is an innovative strategic approach developed by Prof. Cham Kim and Renee Mauborgne in 2005, and published in their joint authored book "Blue Ocean Strategy". In the book, the authors contend that while most companies compete within such red oceans, this strategy is increasingly unlikely to create profitable growth in the future.

Based on a study of 150 strategic moves in many globally active supply chains over the last thirty years, Kim and Mauborgne argue that developing the 'blue ocean strategy' (as they coined it) has already been proven an effective response to the global challenges for many supply chains. Tomorrow's leading supply chains will succeed not by battling competitors, but by creating 'blue ocean' of uncontested market space that is ripe for growth. They have proved that one can face up to the challenges most effectively without actually doing so. Creating new market space is actually a lot easier than you think if you know how.

Pursuing world class excellence:

To weather the global challenges and to achieve long lasting business success often calls for one fundamental feat and that feat is world class excellence. Almost all known world leading supply chains in all industrial sectors have somehow demonstrated that they have just been *excellent* in a multitude of performance measures. The *world class excellence* defines the highest business performance at a global level that stand the test of time. Only the very few leading edge organizations around the world truly deserve this title. But the title is not just a title. It is the fitness status that ultimately separates the business winners from losers.

In other words, what you can excel you can prevail, and the secret of success is doing the common things uncommonly well! That's the excellence.

To become a world class supply chain one need to excel in four dimensions. The first dimension is the operational excellence. All world class supply chain must have optimised operations measured in productivity, efficiency, cost effectiveness, quality, high standard of customer service and customer satisfaction. The second dimension is the strategic fit. All world class supply chains must also ensure that excellent operations fit to the supply chain's strategic objective and stakeholder's interests; and the internal resources fit to the external market needs. The third dimension is the capability to adapt. Would class supply chains must be dynamic and able to adapt into to new business environment in order to sustain the success. The fourth dimension is the unique voice. All world class supply chains needs to develop its own unique signature practices that render positive market results. Such internally unique practice coupled with positive market result is called unique voice. This dimension goes beyond benchmarking on best-practices; it creates best-practices (Lu 2011).

Current Trends in Global SCM

Many reliable management researches and surveys conducted in recent years have come to a broad consensus that some significant

development trends are shaping and moving today's global supply chains. The following trends are mainly based on and adapted from the PRTM 2010 Survey results with the author's own interpretation and analysis to facilitate student learning.

***Trend 1**: Supply chain volatility and market uncertainty is on the rise.*

Research survey shows that continued demand volatility in most of global markets is a major concern to the executives of supply chains. Significantly more than any other challenges to supply chain flexibility, more than 74% of the surveyed respondents ticked the demand volatility and poor forecasting accuracy as the increasing major challenges to supply chain flexibility. Apparently, few companies have strategies in place for managing volatility in the years ahead let along implementing it. The lack of flexibility to cope with the demand change is increasingly a management shortfall. In the path of economic recovery, this shortfall could well be the trigger for bullwhip effect.

The fast development of cyber market and mobile media has given rise to the market visibility leading to high level of market transparency. B2B customers and consumers have found it a lot easier to shop for alternative lower price or better value. The switching cost is evaporated rapidly, and so is the customer loyalty, which adds salt to the injury. The only known approaches to deal with the trend of

increased volatility are improving forecasting accuracy and planning for flexible capacity throughout the supply chain. Best performing companies tends to improve supply chain responsiveness through improving visibilities across all supply chain partners. On the downstream side, companies are now focusing more on deepening collaboration with key customers to reduce unanticipated changes.

Trend 2: Market growth depends increasingly on global customers and supplier networks

The research survey has shown a positive growing trend in international customers and international suppliers in more international locations. As a result, more than 85% of companies expect the complexity of their supply chains to grow significantly at least for the coming year. The immediate implication of this trend is that the supply chain will have to produce higher number of products or variants to fulfil the customer expectations, albeit this may vary slightly for different geographical regions. In the main, the pattern of global supply chain is going to be more complex in terms of new customer locations, market diversity, product variants, and demand volatility.

On the supply side, the trends indicated that a more dynamic supply networks stretching far and wide globally. Managing those suppliers, developing them and integrating them become more a critical

challenge than ever before. Nearly 30% of respondents expect the in-house manufacturing facilities will decline and to be replaced by outsourced and off-shored international contractors. Similarly nearly 30% of respondents expected a decline in the number of strategic suppliers to the OEM (original equipment manufacturer) in order to achieve more closely integrate the supply chain for higher collaborated value adding. This will result in more consolidated supply base. This is more evident in North America and Europe, but significantly less so in Asia where expansion of supply network is more of the case.

Trend 3: Towards more cost-optimised supply chain configurations

Survey respondents seemed confident that they will be able to deliver substantial gross margin improvements over the next couple of years. However, the gains will not come from price increases, but from reductions of end-to-end supply chain costs. Globalising supply chain operations and outsourcing specific functions are viewed as critical for controlling costs. It came as no surprise that outsourcing is on the rise across many industrial sectors around the world. Companies are taking advantages of lower costs in emerging markets and increasing their flexibility of their own supply chain. The functions that will see the greatest increase in outsourcing are product development, supply chain planning and shared services.

However, globalisation does not seem to have reduced process and management costs. In fact those hidden costs could be on the rise when supply chain becomes more global if not careful. Leading companies understand the impact of those hidden costs and are taking aggressive steps to identify and manage them. Many are embracing new concepts like Total Supply Chain Cost Engineering, an integral approach to calculating and managing total cost across all supply chain functions and interfaces. Rigorous cost optimisation across the end-to-end supply chain – from order management, sourcing, and manufacturing to logistics and transportation – are critical for success.

Trend 4: Risk management involves end-to-end supply chain

To date, risk has become an increasingly critical management challenge across the global supply chains. According to the research survey participants, new demands from their customers have played a key role in this development. Dealing with cost pressures of their own, many customers have increased their efforts in asset management and have started shifting supply chain risks, such as inventory holding risks, upstream to their suppliers. This approach, however, merely shifts risks from one part of the supply chain to another but not reduces it for the whole supply chain. In fact, between 65% and 75% respondents believe that supply chain risks can only be most effectively mitigated by the end-to-end supply chain

approaches. These end-to-end supply chain practices include advanced inventory management, joint production and material resource planning, improved delivery to customers and so forth.

Leading companies are taking an end-to-end approach in managing risk at each node of the supply chain. To keep the supply chain as lean as possible, they are taking a more active role in demand planning, which ensures they order only the amount of material needed to fill firm orders. Firms are also limiting the complexity of products that receive late-stage customisation. Leading companies mitigate inventory-related risks by shifting the responsibility for holding inventory to their suppliers and, furthermore, by making sure finished product is shipped immediately to customers after production.

Trend 5: More emphasis on supply chain integration and empowerment

Little can be achieved without appropriate management approaches that truly integrated across all functions throughout the supply chain and empowered them to take bold action. However, approximately 30% mention the lack of integration between supply chain functions like product development and manufacturing. Integrated supply chain management across all key functions still seen to be a myth, with many procurement and manufacturing executives making silo optimisation decisions. Nearly one-fourth of survey respondents

point to their organizations' inability to make concerted actions and coordinated planning to respond to the external challenges. This could be a surprise to many that would believe after so much has been talked by so many for so long on the supply chain integration, little has been achieved in practice.

Whilst almost all the survey participating companies have supply chain department, many of them failed to empower their supply chain managers to take leading roles in business transformation. Leading companies understand that breakthrough improvements are not possible unless the decisions made are optimal for all supply chain functions. For this reason, they have already taken steps to integrate and empower their supply chain as a single resource under one joint responsibility. These firms are making sure the organization has a strong end-to-end optimization, and are integrating supply chain partners up and downstream.

Portfolio of relationships between the organization and suppliers:

suggest(Bensaou 1999) A portfolio of relationships between the organization and suppliers depends on the interaction of two factors: Buyer's Specific Investments : Buyer's Specific Investment represented by the vertical axis and includes:

Tangible investments: buildings, tools, equipment or products.

Intangible investments: such as individuals, time and efforts made to

educate and raise the performance of the supplier or exchange information, training and knowledge necessary to develop the form of the relationship between them.

2- Fixed investments of the supplier: Supplier's Specific Investment

It is represented by the horizontal axis and includes:

Tangible investments: such as a factory or a distribution site (wholesaler).

Intangible investments: such as sending engineers to develop information systems to be compatible with buyer’s databasesDSS, or data exchange protocol electronicallyEDI.

This interaction created four types of relationships, which are illustrated in the following figure:

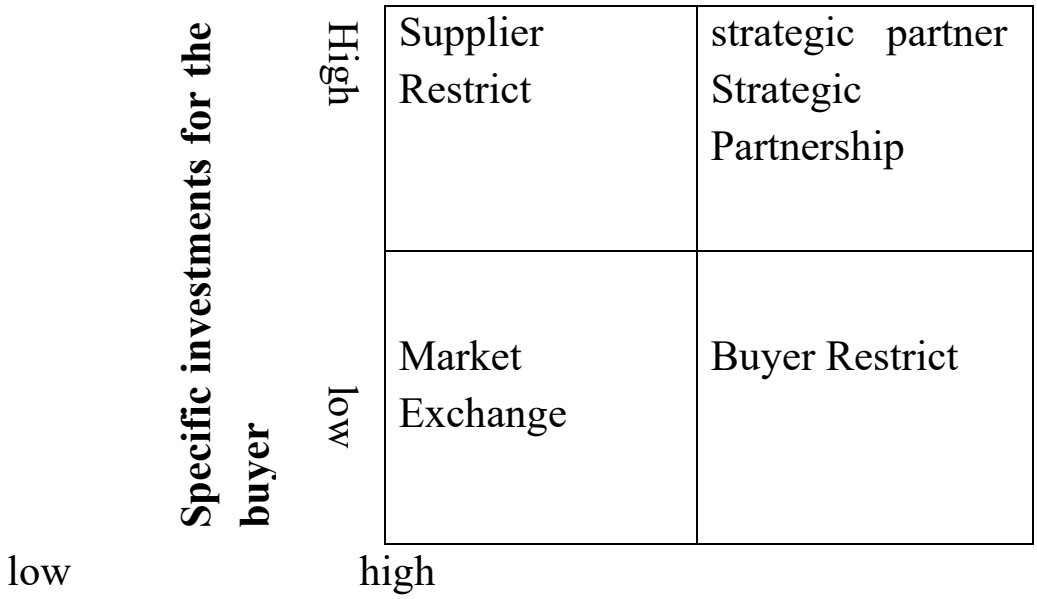


Figure (1) Portfolio of relations between the organization and suppliers

1- Strategic partner: in which both partners provide specific and high-value assets to the relationship, They are considered as real commitments to the force Relationship.

2- Restrict the supplier : Asymmetry in the relationship, the supplier is held hostage by Buyer, while the buyer can switch from a customer to another freely.

3- Marketing exchange: in which each development partner offers assets to work with other ways, and each partner in this situation can Entering the market and switching to another partner at the lowest cost A possible loss.

4- Buyer restriction: asymmetry in the relationship, the buyer is considered a hostage to the supplier, while the supplier can freely switch from one customer to another.

The type of appropriate relationship is determined according to the type of product offered, the current market and the conditions of the supplier.

Chapter 3

Organization and Process of Purchasing Management

Introduction:

The purchasing function has changed dramatically over the last several years. And it continues to change and evolve almost daily. This chapter addresses the following subjects:

1. The role and objectives of purchasing department.
2. Modern Purchasing Department.
3. Centralization and Decentralization of Purchasing.
4. How to design a Purchasing Process.
5. Organization's Purchasing Process

The Role and Objective of Purchasing in Organizations

The ability to source adequate supplies from reliable companies in the timeframe required is only one definition of good purchasing. The purchasing function has to also ensure that everything is available at the right price but also the right quality.

Managing purchasing effectively well will ensure that it continues to perform as desired by the organization. A key competence for any organization is the ability to always make the right "make or buy" decisions, or "do or buy" for service organizations.

Essentially the role of purchasing is to support the organization's corporate strategy in three key ways:

- Minimizing the organization's expenditure to improve profit and/or contribute to growth and success by getting better value for money, reducing costs or both as appropriate. This also includes implementing processes that are cost effective so that time and other resources are not spent on activities which add little value.
- Minimizing commercial exposure by managing supply chains to ensure confidence; apportioning risk appropriately; ensuring compliance with relevant legislation etc.
- Bringing knowledge of the supply market and opportunities that the company can exploit for profit.

There are many different purchasing **strategies**, but all need to respond to the basic objectives of serving the markets in which the organization operates. For instance, one organization might benefit from a supplier rationalization program i.e. dramatically reducing the number of suppliers to give more business to fewer suppliers in exchange for lower costs and improved terms and conditions and service. This would then deliver a more cost competitive product where price is the key order winner. Another might benefit from standardization of products in order to generate leverage i.e. more business of the same type to offer the market place. Purchasing and supply management professionals must have a wide range of solutions that need to be carefully selected to support an organization's corporate objectives.

The **objectives** of a world-class procurement organization move far beyond the traditional belief that procurement's primary role is to obtain goods and services in response to internal needs. To understand how this role is changing, we must understand what purchasing is all about, starting with the primary objectives of a world-class purchasing organization.

Support Operational Requirements:

This requires purchasing to:

- Understand business requirements
- Buy products and services
    - At the right price
    - From the right source
    - At the right specification that meets users needs
    - In the right quantity
    - For delivery at the right time
    - To the right internal customer

Manage the Procurement Process and the Supply Base Efficiently and Effectively:

To manage the procurement process and supply base efficiently and effectively procurement must follow the following key steps:

- Identify opportunities
- Manage internal operations

    - Achieve objectives
- Identify opportunities where the procurement team adds true value:
    - Evaluation and selection of suppliers
        - All purchases should go through the approved procurement processes
        - Engineering and other functional inputs are part of this process
        - Sales personnel should not be allowed to enter contractual agreements without procurement's involvement
        - Increasing use of sourcing teams
    - Review of specifications or statement of work
        - Review the requirements for the material or service being provided
        - May be able to suggest alternative standardized materials that can save the organization money
        - Periodic review of requisitions can allow greater leveraging of requirements
    - Acting as the primary contact with supplier
    - Determining the method of awarding contracts
    - Managing the supply base
        - Current suppliers are competitive

    - Identification of new potential suppliers and develop relationships
    - Improvement and development of non-competitive existing suppliers
- Manage its internal operations efficiently and effectively, including:
    - Management of procurement staff
    - Developing and maintenance of policies and processes
    - Introducing and leveraging appropriate technology and systems
    - Defining procurement strategy and structure
    - Developing plans and measures
    - Providing procurement leadership to the organization
    - Providing professional training and growth opportunities for employees
- Achieve this objective through :
    - Leadership of procurement for the organization
    - Sourcing management
    - Ownership and accountability for sourcing processes
    - Communication of purpose, process and pay off
    - Collaboration, partnering and teamwork.

Develop Strong Relationships with Other Functional Groups

Internal customers of purchasing include:

- Marketing
- Manufacturing
- Physical distribution centers
- Engineering and technical groups
- Research and development
- Information technology
- Transportation and other services

1- Support Organizational Goals and Objectives:

Develop integrated purchasing strategies that support organizational strategies. Effective purchasing strategies involve:

- Monitoring supply markets and trends (e.g., material price increases, shortages, changes in suppliers) and interpreting the impact of these trends on company strategies
- Identifying the critical materials and services required to support company strategies in key performance areas, particularly during new product development
- Developing supply options and contingency plans that support company plans
- Supporting the organization's need for a diverse and globally competitive supply base.

Modern Purchasing Department

Here are 10 signs of a modern purchasing department:

1. The head of purchasing reports directly to the CEO of your company
2. Your department is responsible for procurement in “non-traditional” spend areas such as healthcare benefits, fleet management, facilities and construction, temporary labor, and travel
3. Purchasing is actively involved in senior management level, long-term strategic planning.
4. The purchasing staff is responsible for manually placing only a small percentage of your organization’s purchase orders
5. Logistics and inventory functions either fall under purchasing on the organizational chart or are integrated into the work of purchasing staff
6. Maverick buying is a thing of the past
7. When dealing with large, frequently used suppliers, no paper is exchanged between the time that a need for a product or service is defined until the time that the supplier receives payment.
8. No major sourcing process is conducted without the use of a cross-functional team
9. You are buying from global sources and measuring non-domestic spend as a percentage of total spend.

10. Your department has social responsibility goals and measurements in place.

Centralization or Decentralization of Purchasing

A centralized purchasing function and a decentralized one each confer their own advantages. In a company with a centralized purchasing function, a corporate-level purchasing department makes decisions and exercises control over purchasing throughout the organization.

In a company with a decentralized purchasing structure, business units or departments purchase their own materials and supplies with no oversight from corporate headquarters. Some companies adopt a hybrid structure, in which some classes of items are purchased centrally and some are purchased locally; or a spending limit is given, with local managers responsible for purchasing goods up to a certain monetary limit.

Should you consider centralizing or decentralizing your operational activities? The answer lies in understanding the costs and benefits of both options in terms if the impact to purchase cost and customer service. There are some criteria that should be evaluated to make an informed decision.

Is the purchase strategic?

Strategic purchases are linked to your organization's value proposition. For example, special ink that is specified for use with high capital-cost printing equipment is a strategic purchase for a printing firm as the

results will have a direct impact on the quality of the work. Buying office supplies for the organization to support its operations is not strategic. To ensure your organization has a competitive advantage it's sensible to source strategic purchases centrally. This will also ensure high visibility and control of purchasing dollars.

What is the cost impact?

Future trends in purchasing are elevating it from a purely transactional activity to one of strategic importance. This translates to organizations partnering with fewer suppliers in an effort to cut costs and improve quality. Whether the reason for the proliferation of suppliers in your organization is multiple service locations, corporate acquisitions or simply 'that's how we have always done it', evaluating the benefits of centralization is a worthwhile exercise. Typically, organizations are able to achieve cost savings of 10% - 15% just by consolidating requirements with a single supplier. Some examples of areas to consider include office supplies, travel, janitorial services and equipment maintenance.

What is the service impact?

The decision should also consider the impact on service levels. For example, if your organization has three warehouse locations in North Africa and you are looking to centralize fork lift maintenance services, will the supplier be able to service all locations (i.e. do they have North Africa coverage)? What will the response time be for a rush service call? In some situations, a local supplier may have a faster speed of response than a national supplier. If a delayed service response time for

maintenance means you are not able to load trucks to ship product to your customer, the costs savings for centralization are lost and this creates a negative impact to your customer.

Where is the expertise located?

It is important to take into account where the purchasing talent is located. If each location has local expertise to source for their needs, it may make sense to keep the structure decentralized rather than have someone from 'head office' make decisions for materials that they are not familiar with. On the other hand, if the resident expert is at head office, this individual may be able to help other locations by using this knowledge to make better decisions for the whole organization.

While the best solution may sometimes not be clear, it makes sense to at least investigate alternatives for your organization. It need not be one way or the other; most organizations have a 'hybrid' structure where they gain from the benefits of both centralization and decentralization.

Advantages of centralized and decentralized purchasing functions[1]

A company's ideal position along a continuum from a decentralized purchasing organization to a centralized one depends on its overall organization, its products, and the degree of commonality among the items and services it buys.

Centralized	Decentralized
Reports to a higher level, giving purchasing greater muscle within organization	Broadens job definition for purchasing professionals, leading to greater job satisfaction
Consolidates buying volume for greater negotiating power and lower costs	Enables access to local and more specialized sources
Enables a reduction in supplier base	Finds specialty suppliers for products with a competitive edge
Focuses on overall corporate strategy	Focuses on customers and end users, recognizing their particular needs
Leverages the company brand and stature	Responds more quickly to extraordinary situations
Enables tighter control of purchasing policies and procedures	Empowers the business unit
Allows business units to focus on their core competencies	Communicates more readily with operations departments

A company whose business units all use the same types of parts, if not interchangeable parts, gains most from centralizing its purchasing.

This centralized procurement function consolidates the purchasing of similar items in all its business units and leverages that combined volume, producing lower costs, improved quality, and better service. On the other hand, a company whose business units each have unique requirements for parts and materials benefits more from a purchasing structure that puts buyers closer to end users.

Nonetheless, all companies benefit from a central purchasing administration--common processes, procedures, forms, and systems. Companies use data from a central administration, such as an enterprise resource planning (ERP) system, to evaluate the effectiveness of the purchasing function. Such a system provides information from across the entire organization, which is essential for making intelligent decisions about the company's position along the centralization/decentralization continuum. A company's optimum balance between centralization and decentralization is dynamic, requiring continuing review and adjustment.

Improving the company's process

1. Centralize for greater cost control and corporate leverage.

Leading companies consider the benefits of centralizing purchasing. A central purchasing function sees the company's entire spending pattern and analyzes it to find opportunities for cost savings and efficiency. Because the central purchasing department buys in greater volume than a local business unit, it negotiates lower prices with suppliers. Furthermore, a central purchasing department helps in inventory

control. The need for some materials may vary within an individual business unit but become fairly constant when spread across the entire company. Thus, deliveries can be routed to the department needing the supplies next.

2. Decentralize for quicker procurement responsiveness.

Companies in fast-changing industries that need lightning-fast product introduction cycles benefit from decentralized purchasing. They avoid a heavy-handed corporate control that stifles entrepreneurial spirit by bringing purchasing decisions close to the end user of the materials.

A decentralized purchasing structure develops faster communication between purchaser and end user so that purchasing understands the end user's needs. Purchased materials meet user requirements and buying decisions are not inhibited by bureaucratic restraints. The effect is to push decision making down to a lower level, empowering business units to innovate and experiment.

3. Centralize procurement of common products.

The need for certain products, such as those used in maintenance, repair, and operations (MRO), varies little from location to location. If local business units purchase these items separately, the company may find that one unit is paying more than another for the same item. To eliminate such discrepancies, effective companies manage purchasing of these items centrally.

Centralizing purchasing of commonly used items also consolidates information about their use. By centralizing, companies gain access to

spending and inventory data that would otherwise be fragmented among the business units.

4. Decentralize procurement of specialized products.

Although hammers and pencils can be purchased in volume for an entire organization, and the same knobs and handles can fit on many of a company's product models, many situations require unique or specialized supplies. A single chemical process, for example, may need a particular solvent. Or a specialty medical device may include a component manufactured by few suppliers. In such cases the engineers involved will be more knowledgeable about prospective suppliers than a central purchasing department at corporate headquarters. In addition, distant business units may have different needs and want specialized products to address those needs. Leading companies decentralize purchasing in such cases to preserve the benefits of specialization.

5. Align purchasing structure with corporate structure and strategy.

Because of purchasing direct effect on a company's bottom line, smart companies ensure that the structure of the purchasing function enhances the company's strategy. Company acquisitions or changes in product strategy cause a company to realign its purchasing structure. In addition to these internal situations, external challenges such as competition and environmental issues can force a company to centralize or decentralize its purchasing structure.

6. **Vary the centralization approach depending on the class of goods and services procured.**

Whether a company takes a centralized approach to procurement may depend upon the company's product and the nature of its materials. A large consumer packaged goods company like Cincinnati, Ohio-based **Procter & Gamble** (P&G), with a variety of products, can use different approaches. One of P&G's major products is coffee. Successful coffee bean procurement requires that three disparate activities be connected: sourcing and commodity training, coffee tasting and quality management, and logistics. To meld these activities successfully, the purchasing organization for coffee needed people and tasks from both manufacturing and product development in a centralized and integrated function.

On the other hand, when P&G acquired Giorgio Beverly Hills fragrances, management discovered that Giorgio's procurement team focused less on fragrance sourcing and more on the logistics of day-to-day supply replenishment. To relieve the sourcing team of the complexities of logistics, P&G divided the procurement function between a small group working on strategic sourcing and a very large group dedicated to the logistics flow. In this case the purchasing function was split into smaller, more focused groups.

7. **Adopt a procurement organization structure appropriate for the company’s size.**

The level of a company's total expenditure frequently dictates certain challenges in procurement. A small company lacks the purchasing volume to negotiate more advantageous prices from suppliers. But large companies often become fractured and fail to amalgamate their expenditures to take advantage of the greater volume.

Organization's Purchasing Process

The purchasing process for companies breaks down into eight clear steps. In the first step the company identifies a need, for which the answer is the purchase of a product. The final step is the execution of a purchase contract. The steps in between build an organized, informed process that results in the company purchasing the right product for the need from a qualified supplier whose product is the most durable for the price.

With the introduction of modern technology, purchasing processes have been able to change dramatically. Improved methods of communication have meant that order requests can be transferred electronically, notification of delivery emailed, supplier payments automated.

While many businesses may find the utopia of fully automated procurement a strategy rather than reality, purchasing departments often find themselves in a hybrid where a mixture of technology, partners and culture may be unable to accept a fully automated approach and traditional and contemporary processes co-exist.

In designing purchasing processes, it is important to take into account both how information systems can be leveraged and where business

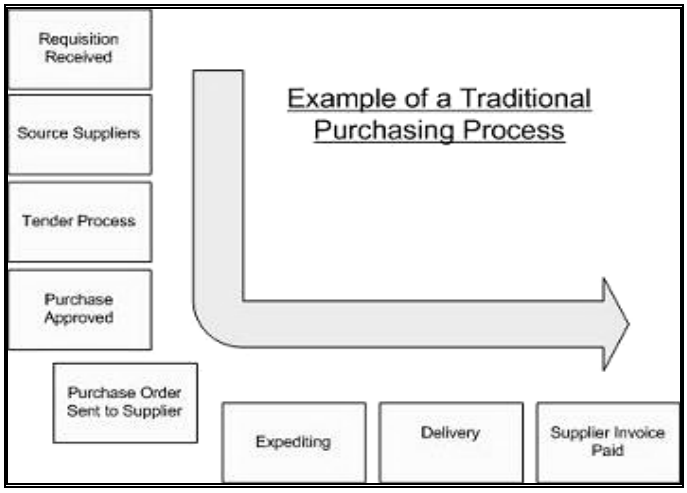
constraints and governance exist. Whilst some fundamentals e.g. originating need – communicating the need to the supplier – delivery – the payment of the supplier - may exist in most processes – how they are deployed can vary depending on the overall strategy of the business and the prevalence of, and confidence in, Information Systems.

When designing purchasing processes it is helpful to understand both the traditional and contemporary methods in order to select the appropriate element that applies (or can apply) to your organization.

Traditional Purchasing Process

Where information technology is not heavily ingrained - Traditional Purchasing processes tend to be characterized by high levels of bureaucracy, encumbered with manual authorization (often requiring multiple signatures independent of the order value.), slow communications and a focus on unit price rather than long term commodity arrangements. Due in part to the lack of readily available Management Information.

The diagram below provides an example of a traditional purchasing process.



Traditional Purchasing Process

- The process may require authorization at various intervals – including at the requisition, Purchase Order, supplier payment process – this may be multiple authorizations at each stage e.g. the operator and his/her supervisor.
- Sourcing and tendering may focus on obtaining multiple cost/availability options from various suppliers rather than leveraging formal long term contracts. There may be little to no pressure on limiting the number of suppliers used.
- Manual Purchase Orders are raised and sent to suppliers – manual acknowledgements are also requested. Communication is slow and paper based.
- Periodic expediting activity takes place to ensure delivery schedules are adhered to.
- Items are delivered and forms/documents are transferred within the business to close down orders.

- Manual invoices are submitted and subject to authorization procedures often requiring signatures to indicate that the Purchasing process has completed satisfactory (and that the order has been met).

Contemporary Purchasing Process

Where information systems are prevalent much of the authorization and communication methods that are present in the traditional process can be automated or eliminated. Management Information is also more widely available (and of better quality) and enables the organization to move towards automated processes which rely more on exception management rather than transaction management.

The resultant culture is therefore one that focuses more on Supplier Relationship Management and a long term approach that one that focuses purely on Transactions.

- Modern ERP systems monitor inventory and trends and automate requisitions based on forecast need.
- Automated workflow and approvals engine route requirement to be authorized (where applicable)
- Where formal orders are required suppliers informed electronically either as part of established B2B network or via electronic message. Supplier acknowledgement and changes to terms updated in real time.
- For low value or less complex supplies – a mixture of Procurement Cards and online catalogues can be used negating

the need for formal orders whilst ensuring that robust controls are still in place.

- Use of barcodes/RFID speed up the delivery process, electronic messages covering proof of dispatch and delivery are transmitted by the ERP and stakeholders are advised in real time.
- Electronic Invoices are submitted and are matched by the ERP against the Purchase order and delivery and then routed for payment negating the need for human intervention. Where Procurement Cards are used – Transaction Management systems route and aide process activity.

Systems can dramatically reduce the amount of paper documents within a purchasing environment while streamlining the process via use of workflow systems.

Questions

1. Discuss the role and function of purchasing management in organizations.
2. Compare between traditional and contemporary purchasing process.
3. Issues to be considered when designing purchasing processes.
4. List 10 signs of a modern purchasing department.

Chapter 4

Strategic Sourcing Process

Introduction:

Traditional price-based relationships among customers and suppliers are changing. Long-term relationships are now built on total cost, trust, innovation, quality, and flexibility. Development of a strategic sourcing plan is driven by the recognition that tactical sourcing will not succeed in yielding a supply base that results in the benefits of collaborative relationships and strategic alliances.

This chapter will address the criteria of selecting the best suppliers, ways of improving customer supplier relationship and how to evaluate suppliers. The subjects will be addressed are:

1. Criteria of Selecting the best suppliers
2. Improving Supplier Relationships
3. Suppler Selection and Evaluation Process

Criteria of Selecting the Best Suppliers

Quite often, organizations use price as the determining factor when considering which supplier to select. While price is an important determining factor, other dimensions such as quality, lead time and payment terms must not be overlooked. There are some criteria that may be used to select the best supplier and improve the relationship with them.

- Quality

The cost of poor quality extends much further than the carrying cost of safety stock to ensure supply can meet demand. If a component of your product has been outsourced and that part is defective, your customer will associate the poor quality with your product. Not only will your organization have to pay to replace or repair the item, but it will also affect the perceived quality of your brand, further reducing future sales opportunities.

- Lead Time

Lead time is the time between placing an order and delivery of the product. The longer the lead time, the higher the cycle inventory and safety stock must be to meet demand. This higher inventory translates to higher costs to maintain these inventories and must be taken into account when evaluating the “best price” from each supplier.

- Delivery Reliability

While this may be difficult to evaluate, especially for a new supplier, it is worth investigating from past or current customers. For example, a large supplier may place your order on a lower priority when they are

busy if you are one of their smaller customers. This means you will receive your order late, which again may mean having to carry extra stock. It is much better to have a reliable delivery at the expense of a longer lead time as other operational activities may be planned in advance to reduce costs.

- ***Flexibility***

Since forecasts are almost always wrong, a flexible supplier should be able to quickly respond to changing market needs. For example, what mechanisms exist for a rush delivery? What costs are involved? Will the lead time be the same as for a regular delivery, or will it be shorter?

- ***Transportation Costs***

The transportation costs associated with delivering the product to your location is part of the total purchase cost. In some cases this cost is buried in the product's unit cost, while in others it is shown as a separate line item. For local suppliers, it may be possible to arrange a pick-up using your own trucks, reducing transportation costs further. Distance and mode of transportation (truck, rail, and air) are key drivers that affect transportation costs.

- ***Pricing Terms***

Suppliers typically offer quantity discounts for larger batch sizes, however extra holding costs for inventory should be factored in if the batch size is significantly larger than what your requirements are. Some supplier offer additional discounts for early payment. For example, a two percent discount may be applied if payment is made within 10

days. This may be beneficial for your organization depending on what other options it has to utilize its working capital.

- Technological Capability

Although this is more qualitative, the ability of your supplier to provide you with accurate, timely information will help with planning and increase customer service in the event of a stock-out situation. Web-enabled suppliers that track your order status enable you to make adjustments as well as to inform your customers of changes to their order. Using the phone to track down the supplier and wait for an answer may not be good enough for some of your customers who demand instant updates for their order status.

Improving Supplier Relationship

Effective purchasing management and professional buying works better when a good strategic framework exists. Commonly, relationships between suppliers and customers are driven by personalities, or the needs of the moment, whereas relationships and purchasing strategy should ideally be based on a combination of factors reflecting the nature of each purchasing area, including: risk, complexity, value, the market and basic matters of supply and demand.

In the business world, our organizations are both customers and suppliers. The emphasis in day-to-day transactions is on customer satisfaction and much improvement has resulted from this focus. In many cases, suppliers automatically are blamed for problems that occur with products and services. The customer talks, the supplier listens, the

customer gets upset, and the supplier changes in response to the customer's reaction. The changes may or may not be in the best interest of the ultimate end user, but they appease the customer and preserve the business relationship.

In a typical customer-supplier relationship, the supplier is expected to meet the customer's standards. If problems occur, the customer rushes in to fix the supplier. In a true customer-supplier relationship, however, there is much to be gained from adopting a more two-sided approach. The purpose of these relationships is to share ideas, to listen to each other, and be willing to take steps together to create mutual benefit-while maintaining end user satisfaction. Because customers have the ultimate power in these relationships, they must create an atmosphere that makes it easy for the supplier to speak candidly.

Profitability and efficiency in purchasing and supply management is increasingly being driven by good relationship management – working closely with suppliers and internal clients to achieve the best end result.

Managing strategic relationships and ensuring suppliers are handled with respect and in an ethical manner is a specific skill set that increasingly the purchasing profession is demanding from individuals. Strong relationships can help drive innovation as it is often the supplier that can identify opportunities for improving processes or providing new materials.

Increasingly, relationship management is being seen as a softer skill, however, it must not be over-looked and that in a purchasing context it

is much more than this; the softer 'relationship' aspect of this skill is key, but so is the management of it and that is where perhaps the more strategic approaches are needed.

As a buyer, the purpose of investing time in a relationship with a supplier is to ensure the performance of that supplier always operates to the best of its ability, or perhaps if it hasn't been performing as desired, to try and improve the performance.

Just like any relationship, supplier relationships will vary in intimacy, all depending on what is deemed necessary for the relationship to work, the people involved and perhaps even the history of the relationship.

A relationship for example could be deliberately kept at arms- length but still remain very cordial – this could be because it is deemed that there will be no immediate business benefit for it to be any different. This may be the case when the items being supplied are relatively low value, infrequently required and pose very little risk to the organization should the security of that supply ever break down.

Moving to the other extreme is the long-term close relationships that may be operated as a partnership. This will often be the case when items are high risk, high value and integral to organizational operation.

However, there is word of caution here for some sectors. Scarcity of some raw materials such as steel, which is currently a situation faced by many manufacturers, can potentially change the dynamics of a relationship and put the suppliers in the driving seat - another element

of relationship management that the professional purchaser must consider.

This is a situation Japanese car manufacturer Nissan found themselves in 2004 year, when it had to close three of its Japanese car plants for five days because it ran out of steel. This meant Nissan, Japan's second largest car manufacturer, lost production of 25,000 cars.

Although this may be an extreme case, steel is a major commodity and it does highlight the need for purchasers to keep such issues at the forefront of their minds when working with suppliers – especially for high-risk items. It also highlights the need for flexibility within supplier relationships. The key issue for purchasers is to try and ensure that key suppliers don't go elsewhere.

One factor for the purchaser to consider is how much knowledge they have of the market place within which the organization operates. Purchasers must be aware of issues that may affect their global supply chain, both on a political and an economic front.

Well managed global sourcing, outsourcing, risk management and supplier relationship management are just some of the core components that will help organizations achieve success in years to come.

Suppler Selection and Evaluation Process

Every organization knows it should be assessing supplier performance. Most are deploying some sort of supplier performance measurement, whether it is a couple of rudimentary key performance indicators or

more sophisticated data gathering and on-site assessment programs. But few purchasing and quality professionals are likely to answer "yes" when asked whether they are satisfied with their supplier assessment capabilities and results.

With increased reliance on suppliers for one's own ability to meet customer requirements and expectations, and even, in some cases, to comply with legal and regulatory requirements, organizations arc under increasing pressure to avoid supplier problems and to attract and retain the high performers, particularly among their strategic suppliers or long-term partners.

How can an organization turn thought into action and effectively use internal resources to improve the performance of these key suppliers and, at the same time, produce results and a return on investment? In the following ***the seven steps of Measuring Supplier Performance***:

1. Align supplier performance goals with organizational goals and objectives.

2. Determine an evaluation approach.

3. Develop a method to collect information about suppliers.

4. Design and develop a robust assessment system.

5. Deploy a supplier performance assessment system.

6. Give feedback to suppliers on their performance.

7. Produce results from measuring supplier performance

1. Align performance goals

Determining what performance your organization wants from its supply chain cannot be done in a vacuum. You must first have in place a supplier strategy that relates to overall organizational goals and objectives.

Many organizations are pursuing continuous improvement programs and methodologies such as Six Sigma, lean enterprise, lean sigma, continuous improvement, operational excellence and total quality management. Typically, organizations trying to get to the next level of excellence need to have key suppliers aligned with their own organizational direction.

If a company is pursuing lean and just-in-time deliveries, key suppliers need to be on a lean journey themselves, because the lack of synchronization can adversely impact cost, quality and delivery. If a company is committed to Six Sigma and has developed a fact-based culture, then the company will require a similar approach to performance improvement from its important suppliers.

Alternatively, if a company has not articulated an enterprise improvement strategy, the drive to allocate the resources to measure and improve supplier performance will be less strong. It is difficult to ask suppliers to "do what I say and not what I do." Additionally, commitment of resources from upper management to such a program may be difficult if continuous improvement is not valued within the culture.

2. Choose evaluation approach

The aspects of supplier performance that companies may wish to evaluate include:

* Financial health;

* Operational performance metrics;

* Enabling behaviors or cultural factors; and

* Risk factors.

- Financial health

Financial health is most important for key suppliers or long-term partners. Typical indicators of financial strength include factors such as sales, profitability and liquidity. Financial data can be obtained via Dun & Bradstreet or other credit reports, banks and trade references. Data are, of course, more accessible for publicly traded companies than for privately held ones. So, sometimes the best way to get financial information is to ask suppliers directly.

- **Operational performance metrics**

Operational performance metrics can cover many areas, such as on-time delivery, quality, lead times, responsiveness (rescheduling, order status), inventory turns and customer service call response time.

There are several ways to obtain these metrics: extract them from your own enterprise system, get reports from the supplier or conduct internal supplier satisfaction surveys of the end user at the customer.

Business processes and practices can be reviewed to see how a supplier runs its business and provides a product or service at the best value, on time and exactly as required for its customers. This information is typically best practice based and qualitative, focused on processes and inherently independent of any vertical business sector bias. Business processes and practices information can be obtained through questionnaires or surveys or during site visits to suppliers. Evaluating business processes and practices can help get at the root causes of supplier problems. Traditional quantitative metrics can highlight a problem or negative trend but cannot get at the root cause.

- **Enabling behaviors or cultural factors**

At the heart of high performance business models such as Six Sigma, the Malcolm Baldrige National Quality Award criteria and lean are enabling behaviors, such as customer focus, agility, continuous improvement and teamwork. If, for example, a supplier does not have a continuous improvement culture, it is unlikely that supplier will be in sync with the demands of a customer that values continuous improvement methodologies and expects the same drive to improve in its supply base.

- **Risk factors.**

An important aspect of evaluating suppliers is to understand and then mitigate risk. You can uncover risk factors in financial health, operational performance environment, business processes and

practices, and enabling behaviors or cultural factors. Risk cannot be determined solely by using past performance to predict the future.

Financial risk factors may be the most obvious area many companies focus on. The operational performance environment includes risk from dealing with foreign suppliers, such as trade relations, shipping and currency exchange. The business processes and practices a supplier has in place are also critical. Another risk factor is the leadership in place at a supplier. A leadership committed to investing in the workforce and enabling employee empowerment and input has a greater chance of success and overcoming business adversity as it arises. A culture lacking teamwork and continuous improvement indicates higher risk to the customer, as the chances of a supplier being responsive to systemic problems and getting to root causes of problems and correcting them are slimmer.

3. Develop information collection method

The challenge is the coverage problem how to collect any of the above information for a large portion of your supply base using current resources. Methods include paper questionnaires, web-based questionnaires, extracts from current systems, site visits and third-party standard certification.

Outputs of the various can include:

- Reporting on survey results.

- Supplier performance metrics such as KPIs derived from internal surveys or internal management systems.
- Supplier assessment reporting, which can be qualitative and quantitative.
- Ultimately, and ideally, supplier performance scorecards containing a rollup or summary view of all results.

4. Design a robust assessment system

Organizations need to choose an approach to evaluating suppliers. Approaches may include:

- Accepting a third-party standard, such as ISO 9001 and its sector specific derivatives or good manufacturing practices.
- Benchmarking performance against industry leaders.
- Measuring performance against best practices, such as the Malcolm Baldrige National Quality Award criteria.
- Developing KPIs and scorecards based on system data or internal customer feedback.
- Developing your own certification or evaluation and measuring performance against it.

5. Deploy the system

One of the biggest difficulties in assessment systems is deployment. For systems that require data extraction and massage, IT may need to develop and then link information from disparate systems. For

questionnaire-based systems, the questionnaires themselves can become unwieldy and difficult for both internal and supplier participants to respond to. As for on-site evaluations or audits, they require training of personnel, preferably a crossfunctional team, and are resource intensive to properly deploy. Subject matter expertise, survey instrument development expertise and knowledge of IT are needed to avoid the pitfalls in deploying all these approaches.

6. Give actionable feedback

Many organizations send performance report cards to their suppliers. Suppliers often bristle at the term "supplier management" because it implies one organization managing another. Customer companies need to have a real dialogue with their important suppliers on performance and work on the critical issues of the relationship. This requires a two-way flow of information.

If the results of performance measurement and supplier assessment are not actionable or expectations of actions are not communicated, those actions will not occur. This is a difficult piece of the supplier performance puzzle because many supplier organizations may have competencies in some areas that exceed those of their customers.

7. Produce results

Measuring supplier performance is about understanding, communicating and then improving supplier performance. If all the important components of a good supplier assessment system are in

place and you and your supplier are getting relevant, actionable results, then the suppliers can take the next step of improving their performance.

Supplier performance measurement can lead to supplier development, and supplier performance improvement has the potential to impact the customer financially and competitively.

Companies need to work with suppliers to develop action plans as a result of assessments. They should then track performance to these plans to close the loop and realize the full benefits from the supplier performance measurement process.

Questions

1. Discuss the criteria that may be used to select the best supplier and improve the relationship with them.
2. Discuss the steps comprise a process for developing and deploying supplier assessment.
3. Write short notes in each of the following:
    a. Pricing as one of the criteria of selecting the best supplier.
    b. Lead time as one of the criteria of selecting the best supplier.
    c. Financial health as the most important for key suppliers or long-term partners.
    d. The importance of sending performance report cards to suppliers.
4. Summarize the aspects of supplier performance that company may wish to evaluate.
5. Write briefly about risks related to suppliers' performance

Chapter 5

Inventory Management

Introduction

An inventory is a stock or store of goods. A typical firm has about 30 percent of its current assets and as much as 90 percent of its working capital invested in inventory. Because inventories may represent a significant portion of total assets, a reduction of inventories can result in a significant increase in return on investment (ROI), a ratio of profit after taxes to total assets.

Inventory in the supply chain is critical to ensure high customer service levels. However, it is also a very costly asset to maintain. Having the right amount of inventory to meet customer requirements is critical.

The task of inventory planning can be highly complex in manufacturing environments. At the same time, it rests on fundamental principles. The system used for inventory must tie into the operations of the firm. Inventory planning and management must be responsive to the needs of the firm. The firm should design systems, including reports that allow it to make proper business decisions.

The focus of this chapter is how inventory policy can be used to aid in establishing a competitive advantage. Hence it addresses the following subjects:

1. What is inventory?
2. Purpose of inventory.
3. Effect of Inventory Size on Cost of Operation.
4. Types of Inventory.

5. Role of Inventory Management in Working Capital.
6. The Business cycle.
7. The need for Inventory Management:
8. Inventory Management.
9. Reduce Inventory with Supplier Partnership Strategies.
10. Cost Components of Inventory.

What is Inventory?

Inventory is defined as a stock or store of goods. These goods are maintained on hand at or near a business's location so that the firm may meet demand and fulfill its reason for existence. If the firm is a retail establishment, a customer may look elsewhere to have his or her needs satisfied if the firm does not have the required item in stock when the customer arrives. If the firm is a manufacturer, it must maintain some inventory of raw materials and work-in-process in order to keep the factory running. In addition, it must maintain some supply of finished goods in order to meet demand.

Sometimes, a firm may keep larger inventory than is necessary to meet demand and keep the factory running under current conditions of demand. If the firm exists in a volatile environment where demand is dynamic (i.e., rises and falls quickly), an on-hand inventory could be maintained as a buffer against unexpected changes in demand.

Purpose of Inventory

The purpose of holding inventories is to allow the firm to separate the processes of purchasing, manufacturing, and marketing of its primary products. The goal is to achieve efficiencies in areas where costs are involved and to achieve sales at competitive prices in the marketplace. Within this broad statement of purpose, we can identify specific benefits that accrue from holding inventories.

1. **To meet anticipated demand**. These inventories are referred to as anticipation stocks because they are held to satisfy expected demand. Examples of this type of demand are stereo systems, tools, or clothing.
2. **Provide the desired level of customer service.** Customer service refers to a company's ability to satisfy the needs of its customers. There are several ways to measure the level of customer service, such as: (1) percentage of orders that are shipped on schedule, (2) the percentage of line items that are shipped on schedule, (3) the percentage of dollar volume that is shipped on schedule, and (4) idle time due to material and component shortage. The first three measures focus on service to external customers, while the fourth applies to internal customer service.
3. **Avoiding Lost Sales:** Without goods on hand, which are ready to be sold, most firms would lose business. Some customers are willing to wait particularly when an item must be made to order or is not widely available from competitors. In most cases, however, a firm must be prepared to deliver goods on demand. Shelf stock refers to

items that are stored by the firm and sold with little or no modification to customers. An automobile is an item of shelf stock. Even though customers may specify minor variations, the basic item leaves a factory and is sold as a standard item. The same situation exists for many items of heavy machinery, consumer products, and light industrial goods.

4. **Reducing Risk of Production Shortages:** Manufacturing firms frequently produce goods with hundreds or even thousands of components. If any of these are missing, the entire production operation can be halted, with consequent heavy expenses. To avoid starting a production run and then discovering the shortage of a vital raw material or other component, the firm can maintain larger than needed inventories.
5. **Reducing Order Costs:** Each time a firm places an order, it incurs certain expenses. Forms have to be completed, approvals have to be obtained, and goods that arrive must be accepted, inspected, and counted. Later, an invoice must be processed and payment made. Each of these costs will vary with the number of orders placed. By placing fewer orders, the firm will pay less to process each order.
6. **Minimize inventory investment.** As a company achieves lower amounts of money tied up in inventory, that company's overall cost structure will improve, as will its profitability. A common measure used to determine how well a company is managing its inventory investment (i.e., how quickly it is getting its inventories out of the

system and into the hands of the customers) is inventory turnover ratio, which is a ratio of the annual cost of goods sold to the average inventory level in dollars.

7. **To smooth production requirements.** Firms that experience seasonal patterns in demand often build up inventories during off-season periods to meet overly high requirements during certain seasonal periods. These inventories are aptly named seasonal inventories. Companies that process fresh fruits and vegetables deal with seasonal inventories. So do stores that sell greeting cards, skis, snowmobiles, or Christmas trees. Inventories can facility cost-efficient operations in several ways. Inventories can provide a buffer between operations so that each phase of the transformation process can continue to operate even when output rates differ.
8. **Inventories also allow a company to maintain a level workforce throughout the year** even when there is seasonal demand for the company's output. By building large production lots of items, companies are able to spread some fixed costs over a larger number of units, thereby decreasing the unit cost of each item.
9. **Gaining Quantity discounts**: Large purchases of inventory might qualify for quantity discounts, which will also reduce the unit cost of each item. These discounts will reduce the cost of goods sold and increase the profits earned on a sale. These benefits arise because inventories provide a "buffer" between purchasing, producing, and marketing goods. Raw materials and other inventory items can be

purchased at appropriate times and in proper amounts to take advantage of economic conditions and price incentives. The manufacturing process can occur in sufficiently long production runs and with pre-planned schedules to achieve efficiency and economies. The sales force can respond to customer needs and demands based on existing finished products. To allow each area to function effectively, inventory separates the three functional areas and facilitates the interaction among them.

10. **To decouple components of the production-distribution system.** The inventory buffers permit other operations to continue temporarily while machine breakdowns are resolved. Similarly, buffers of raw materials are used to insulate production from disruptions in deliveries from suppliers. Finished goods inventories are used to buffer sales operations from manufacturing disruptions. By recognizing the cost and space needed, companies start to realize the elimination of disruptions can greatly decrease the need for the inventory buffers decoupling operations.

11. **To protect against stockouts.** Delayed deliveries and unexpected increases in demand increase the risk of shortages. Delay can occur because of weather conditions, supplier stockouts, deliveries of wrong materials, quality problems, and so on. The risk of shortage can be reduced by holding safety stock, which are stocks in excess of average demand to compensate for variability in demand and lead time.

12. To take advantage of order cycles. Inventory storage enables a firm to buy and produce in economic lot size in order to minimize purchasing and inventory costs without having to try to match purchase or production with demand requirements in the short run. This results in periodic orders, or order cycles. The resulting stock is known as cycle stock. In some cases, it is also practical or economical to group orders and/or to order at fixed intervals.

Effect of Inventory Size on Cost of Operation

The cost of operation is greatly affected by both excessive and insufficient inventories, as summarized in next table.

Area of Cost	Excessive Inventory	Insufficient Inventory
1.Material Cost	Greater risk of loss because of: a. Devaluation of inventory on hand due to reduction in supplier's prices. b. Inventory becomes obsolete. c. Inventory deterioration due to decrease or no usage. d. More pilferage	Higher cost for materials and higher manufacturing costs due to increase of "small quantity" rush orders needed to maintain continuous operation.
2.Factory Cost	Increased cost due to the need for additional storage space, results in overcrowding in storage area causing inefficient working conditions	Increased cost due to: a. Work stoppage b. Temporary layoffs and rehiring c. Training new employees d. Additional machine set-ups e. Emergency (overtime) operation
3.Overhead Cost	Increased cost due to:	Increased cost due to added clerical cost for

	a. Additional carrying cost b. Increase cost for borrowing needed money c. Outside rental of space as needed	extra help or overtime in purchasing, receiving, inspection, etc., as result of additional "rush orders".

Types of Inventory

Four kinds of inventories may be identified:

1. **Raw materials Inventory**: This consists of basic materials that have not yet been committed to production in a manufacturing firm. Raw materials that are purchased from firms to be used in the firm's production operations range from iron or awaiting processing into steel to electronic components to be incorporated into stereo amplifiers. The purpose of maintaining raw material inventory is to uncouple the production function from the purchasing function so that delays in shipment of raw materials do not cause production delays.
2. **Stores and Spares:** This category includes those products, which are accessories to the main products produced for the purpose of sale. Examples of stores and spares items are bolts, nuts, clamps, screws etc. These spare parts are usually bought from outside or some times they are manufactured in the company also.
3. **Work-in-Process Inventory**: This category includes those materials that have been committed to the production process but have not been completed. The more complex and lengthy the production process, the larger will be the investment in work-in-process inventory. Its purpose is to uncouple the various operations in the production process so that machine failures and work stoppages in one operation will not affect the other operations.

4. **Finished Goods Inventory**: These are completed products awaiting sale. The purpose of finished goods inventory is to uncouple the productions and sales functions so that it no longer is necessary to produce the goods before a sale can occur.

Inventory management performance measures

1. Customer satisfaction. Measured by the number and quantity of backorders and/or customer complaints.
2. Inventory turnover. The ratio of annual cost of goods sold to average inventory investment. It is a widely used measure. The turnover ratio indicates how many times a year the inventory is sold. The higher the ratio, the better, because that implies more efficient use of inventory. It can be used to compare companies in the same industry.
3. Days of inventory on hand. The expected number of days of sales that can be supplied from existing inventory. A balance is desirable: a higher number of days might imply excess inventory, while a low number might imply a risk of running out of stock.

Effective Inventory Management

The requirements of effective inventory management are:

1. A system to keep track of the inventory on hand and on order.
2. A reliable forecast of demand that includes an indication of possible forecast error.
3. Knowledge of lead times and lead time variability.

4. Reasonable estimates of inventory holding costs, ordering costs, and shortage costs.
5. A classification system for inventory items.

Functions of Inventory Management

Inventory management has two broad function; (1) inventory accounting and (2) inventory control.

Inventory accounting is concerned with the book keeping aspect of inventory management. This function deals with the entry, processing, and distribution of inventory stock, which, in turn, provides a history for all inventory transactions. This accounting will also provide information for the comparison of "book" inventory to the actual physical count of inventory stocked. Inaccurate, incomplete, or delayed inventory transaction reporting cannot be the basis for correct inventory planning or order release. Unless strict control is established and maintained, the entire inventory management system will be of no value.

Inventory control consists of planning, ordering, and scheduling the release of materials used in the manufacturing process. The inventory control manager is concerned with all types of inventory in the company, while the purchasing manager is concerned with the acquisition of materials.

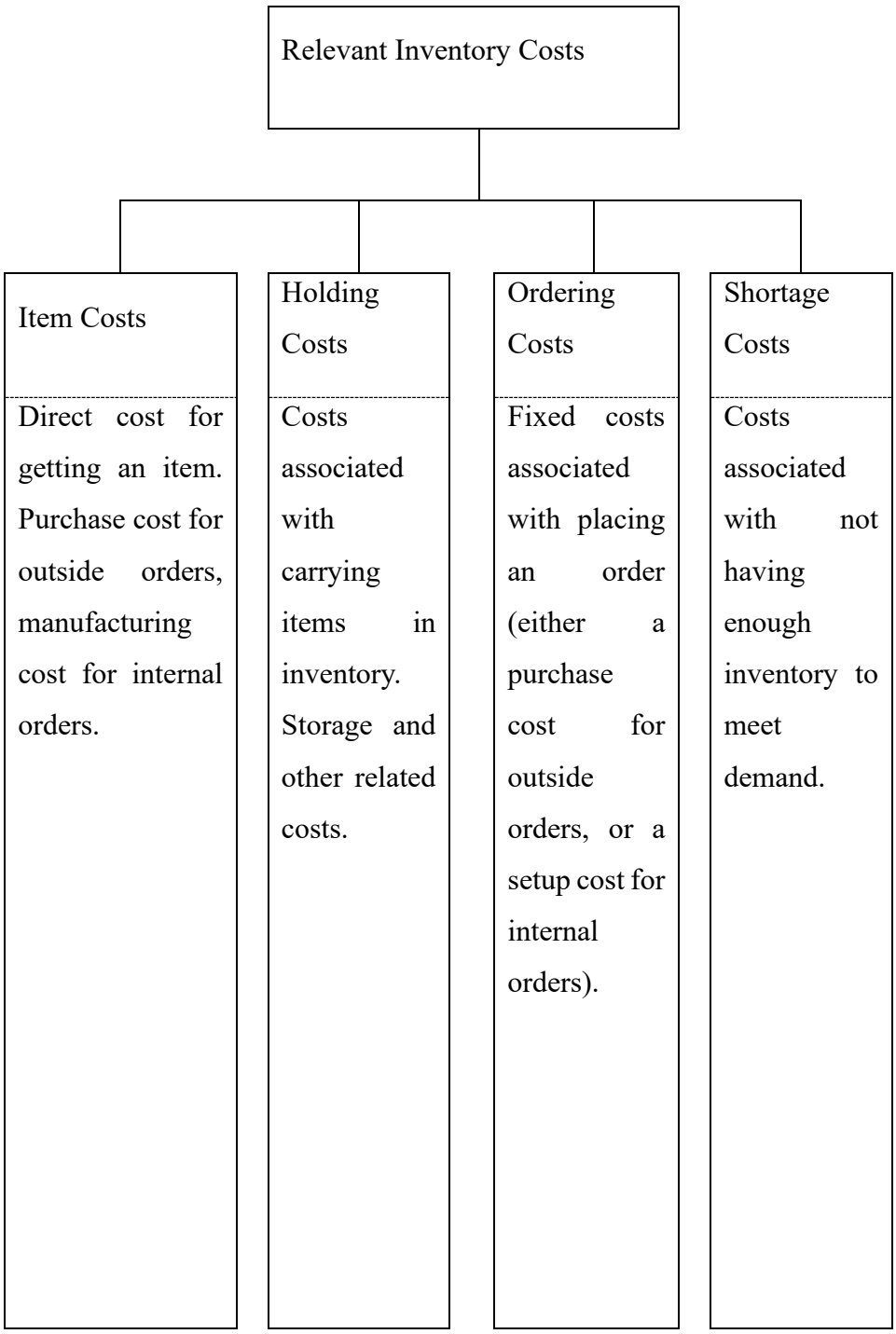
Cost Components of Inventory

When assessing the cost effectiveness of an inventory policy, it is helpful to measure the total inventory costs that will be incurred during some reference period of time.

Most frequently, that time interval used for comparing costs is one year. Over that span of time, there will be a certain need, or demand, or requirement for each inventory item which is simply the forecasted annual usage.

The following graph describes how the annual costs in each of the four categories will vary with changes in the inventory lot sizing decision.

Relevant inventory costs



Item costs:

How the per unit item cost is measured depends upon whether the item is one that is obtained from an external source of supply, or is one that is manufactured internally. For items that are ordered from external

sources, the per unit item cost is predominantly the purchase price paid for the item. On some occasions this cost may also include some additional charges, like inbound transportation cost, duties, or insurance. For items that are obtained from internal sources, the per unit item cost is composed of the labor and material costs that went into its production, and any factory overhead that might be allocated to the item. In many instances the item cost is a constant, and is not affected by the lot sizing decision. In those cases, the total annual item cost will be unaffected by the order size. Regardless of the order size (which impacts how many times we choose to order that item over the course of the year), our total annual acquisitions will equal the total annual need. Acquiring that total number of units at the constant cost per unit will yield the same total annual cost. (This situation would be somewhat different if we introduced the possibility of quantity discounts.)

Ordering costs:

Any time inventory items are ordered, there is a fixed cost associated with placing that order. When items are ordered from an outside source of supply, that cost reflects the cost of the clerical work to prepare, release, monitor, and receive the order. This cost is considered to be constant regardless of the size of the order. When items are to be manufactured internally, the order cost reflects the setup costs necessary to prepare the equipment for the manufacture of that order. Once again, this cost is constant regardless of how many items are eventually manufactured in the batch. If one increases the size of the

orders for a particular inventory item, fewer of those orders will have to be placed during the course of the year, hence the total annual cost of placing orders will decline.

For the most part ordering cost is primarily the labor associated with processing the order however you can include the other costs such as the costs of phone calls, faxes, postage, envelopes, etc.

Example:

Suppose the cost per order is $100 and the company uses 1200 units of a material during the year. The size of the order and the total ordering costs to be incurred by the company are given below.

- Size of order (units) 100, 150 and 200
- Number of orders in a year in each case of size of order unites:

= 1200/ 100 = 12

= 1200/150 = 8

= 1200/200 = 6

- Total ordering costs @ $ 100 / order

= 12 × 100 = $1200

= 8 × 100 = $800

= 6 × 100 = $600

From the above example, it can be easily seen that a company can reduce its total ordering costs by increasing the order size

which in turn will reduce the number of orders. However, reduction in ordering costs is usually followed by an increase in carrying costs to be discussed now.

Holding costs (also called carrying costs):

Any items that are held in inventory will incur a cost for their storage. This cost will be comprised of a variety of components. One obvious cost would be the cost of the storage facility (warehouse space charges and utility charges, cost of material handlers and material handling equipment in the warehouse). In addition to that, there are some other, more subtle expenses that add to the holding cost. These include such things as insurance on the held inventory; taxes on the held inventory; damage to, theft of, deterioration of, or obsolescence of the held items. The order size decision impacts the average level of inventory that must be carried. If smaller quantities are ordered, on average there will be fewer units being held in inventory, resulting in lower annual inventory holding costs. If larger quantities are ordered, on average there will be more units being held in inventory, resulting in higher annual inventory holding costs.

By and large, carrying costs are considered to be a given percentage of the value of inventory held in the warehouse, despite some of the fixed elements of costs which comprise only a small portion of total carrying costs. Approximately, carrying costs are considered to be around 25 percent of the value of inventory held in

storage. The greater the investment in inventory, the greater the carrying costs.

In the example considered in the case of ordering costs, let us assume that the price per unit of material is $40 and that on an average about half-of the inventory will be held in storage. Then, the average values of inventory for sizes of order 100, 150 and 200 along with carrying cost @ 25 percent of the inventory held in storage are given below.

- Size of orders (units): 100, 150 and 200
- Average value of inventory:

    1. when size of orders (units) 100

= 40 × 100/2 = $2000

    2. when size of orders (units): 150

= 40 × 150/2 = $3000

    3. when size of orders (units): 200

= 40 × 200/2 =$4000

- Carrying cost @ 25 percent of above:

    1. When average value of inventory $2000:

= 25% ×2000 = $500

    2. When average value of inventory $3000:

= 25% ×3000 = $750

    3. When average value of inventory $4000:

= 25% ×4000 = $1000

From the above calculations, it can be easily seen that as the order size increases, the carrying cost also is increasing in a directly proportionate manner.

Shortage costs:

Companies incur shortage costs whenever demand for an item exceeds the available inventory. These shortage costs can manifest themselves in the form of lost sales, loss of good will, customer irritation, backorder and expediting charges, etc. Companies are less likely to experience shortages if they have high levels of inventory, and are more likely to experience shortages if they have low levels of inventory.

The order size decision directly impacts the average level of inventory. Larger orders mean more inventories are being acquired than is immediately needed, so the excess will go into inventory. Hence, smaller order quantities lead to lower levels of inventory, and correspondingly a higher likelihood of shortages and their associated shortage costs. Larger order quantities lead to higher levels of inventory, and correspondingly a lower likelihood of shortages and their associated costs. The bottom line is this: larger order sizes will lead to lower annual shortage costs.

These costs have both quantitative and qualitative dimensions. These are, in the case of raw materials, the loss of production due to

stoppage of work, the uneconomical prices associated with `cash' purchases and the set-up costs, which can be quantified in monetary terms with a reasonable degree of precision.

As a consequence of this, the production department may not be able to reach its target in providing finished goods for sale. Its cost has qualitative dimensions as discussed below:

When marketing personnel are unable to honor their commitment to the customers in making finished goods available for sale, the sale may be lost. This can be quantified to a certain extent. However, the erosion of the good customer relations and the consequent damage done to the image and good will of the company fall into the qualitative dimension and elude quantification.

Even if the stock-out cost cannot be fully quantified, a reasonable measure based on the loss of sales for want of finished goods inventory can be used with the understanding that the amount so measured cannot capture the qualitative aspects.

The important costs are the ordering cost, the cost of placing an order, and the cost of carrying or holding a unit of inventory in stock. All other costs such as, for example, the purchase cost of the inventory itself, are constant and therefore not relevant to the Economic Order Quantity model.

Reduce Inventory with Supplier Partnership Strategies

Here are three inventory reduction strategies that are a result of supplier partnerships. Each strategy requires closer relationships with suppliers in addition to web-enabled information systems to track and monitor product movement and create better forecasts. Issues to consider when considering these strategies include confidentiality and inventory ownership.

- Quick Response Strategy

This strategy has been successfully used in the grocery retailing industry. Using this strategy, suppliers have links to the retailer's Point of Sale (POS) data, which is essentially sourced from cash register terminals from all retail locations. Suppliers use this information to optimize their production and inventory levels using actual demand. The retailer is still responsible for ordering, however the supplier is better able to manage its inventory and reduce lead times as it improves its forecast.

- Continuous Replenishment Strategy

As with the Quick Response strategy, retailers must share their POS data with the supplier. An agreement is then made on the delivery frequency and inventory levels with both parties. The result is increased inventory levels. Typically, the supplier gradually reduces inventory levels further while maintaining service levels.

- Vendor Managed Inventory (VMI)

The supplier takes on more responsibility with this initiative, as it determines both the inventory levels and delivery frequency to

maintain agreed-upon in-stock levels. Wal-Mart, in conjunction with Proctor and Gamble significantly increased inventory turns when they first piloted this initiative and they have rolled-out this concept to many of their suppliers using their in-house Retail-Link information system. This system tracks past sales history, trends, out-of-stocks and other performance data going back two years to help reduce inventories while maintaining service levels.

Issues to Consider:

- Confidentiality

By far the most important consideration is the sharing of competitive information with suppliers. The development of a high level of trust is a prerequisite before undertaking such a partnership. In the VMI case, the retailer is relying on the supplier to have an appropriate level of stock at their locations. Failure to do so would mean lost sales for the retailer.

- Information Systems

Advanced information systems are necessary to facilitate the transfer of data to/from the retailer and supplier. The system should be web-enabled and use bar-coding or even better, RFID technology to ensure data accuracy. The system may either be developed in-house, or outsourced to a B2B e-commerce provider.

- Inventory Ownership

The ownership of inventory is dependent on the level of the supplier relationship described above. Who decides on the replenishment of

inventory will determine who is responsible for the inventory. Under the VMI agreement, Walt-Mart does not pay for the inventory until after it sells it to its customer. This greatly reduces inventory costs for the retailer, pushing them back to the supplier. Ultimately, in order to have a sustainable partnership it is important to calculate inventory cost reductions and share the savings between both partners.

Questions

1. Write short notes in each of the following:
    a. Purpose of inventory.
    b. The effect of inventory size on the cost of operation.
    c. Types of inventory.
    d. The role of inventory management in working capital.
    e. The importance of inventory management.
    f. Functions of inventory management.
2. Discuss the different types of cost related to inventory.
6. The different inventory reduction strategies that are the result of supplier partnerships.

Chapter 6

Inventory control systems

Introduction:

Inventory represents a significant investment of capital for most companies. Inventory management is fundamental to establish a long-term competitive advantage. It involves the control of assets being produced for the purposes of sale in the normal course of the company's operations. This chapter addresses issues related to the inventory control. It focuses on the following subjects:

1. Inventory Catalog
2. ABC Analysis
3. Other Inventory Control Systems
4. Reorder Point
5. Safety Stock
6. Stockless Buying Just In Time System

The Inventory Catalog

An inventory catalog is a type of data storage that holds inventory data for the products and variants for single or multiple product catalogs. One of the first steps in organizing an effective inventory control system is to know something about each item stocked. An analysis, tabulation, and classification of the characteristics of commodities are made and listed in a catalog, which is issued to all departments so that all know what items are carried in stock.

The catalog should list all items, completely described and identified by manufacturer's product number and cross referenced to the company's own stock number. This will also serve to reduce the number of duplicate items (same item from several suppliers with their stock number).

ABC Analysis System

The ABC inventory control technique is based on the principle that a small portion of the items may typically represent the bulk of money value of the total inventory used in the production process, while a relatively large number of items may from a small part of the money value of stores. The money value is ascertained by multiplying the quantity of material of each item by its unit price.

According to this approach to inventory control high value items are more closely controlled than low value items. Each item of inventory is given A, B or C denomination depending upon the amount spent for that particular item. "A" or the highest value items should be under the tight control and under responsibility of the most experienced personnel, while "C" or the lowest value may be under simple physical control.

It may also be clear with the help of the following examples:

“A” Category – 5% to 10% of the items represent 70% to 75% of the money value.

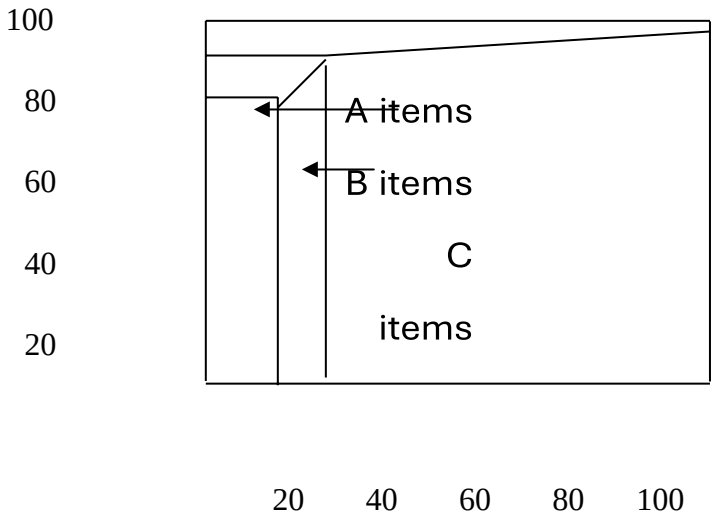
“B” Category – 15% to 20% of the items represent 15% to 20% of the money.

“C” Category – The remaining number of the items represent 5% to 10% of the money value.

The relative position of these items show that items of category A should be under the maximum control, items of category B may not be given that much attention and item C may be under a loose control.

Particulars	**A item**	**B item**	**C item**
Control	Tight	Moderate	Loose
Requirement	Exact	Exact	Estimated
Check	Close	Some	Little
Expenditure	Regular	Some	No
Posting	Industrial	Individual	Group/none

Safety Stock	Low	Medium	Lare



After classification, the items are ranked by their value and then the cumulative percentage of total value against the percentage of item are noted. A detailed analysis of inventory may indicate above figure that only 10 per cent of item may account for 75 per cent of the value, another 10 per cent of item may account for 15 per cent of the value and remaining percentage items may account for 10 per cent of the value. The importance of this tool lies in the fact that it directs attention to the key items.

Advantages of ABC Analysis

1. It ensures a closer and a more strict control over such items, which are having a sizable investment in there.

2. It releases working capital, which would otherwise

have been locked up for a more profitable channel of investment.

3. It reduces inventory-carrying cost.

4. It enables the relaxation of control for the 'C' items and thus makes it possible for a sufficient buffer stock to be created.

5. It enables the maintenance of high inventory turn over rate.

The **A-B-C** approach classifies inventory items according to some measure of importance, usually annual dollar usage (i.e., dollar value per unit multiplied by annual usage rate), and then allocates control efforts accordingly. Typically, three classes of items are used: A (very important), B (moderately important), and C (least important).

The actual number of categories varies from organization to organization, depending on the extent to which a firm wants to differentiate control efforts. With three classes of items, A items generally account for about 15 to 20 percent of the number of items in inventory but about 60 to 70 percent of the dollar usage. At the other end of the scale, C items might account for about 60 percent of the number of items but only about 10 percent of the dollar usage of an inventory.

This type of inventory analysis is known by several names, the most common being the ABC analysis system (next tables).

ABC analysis system

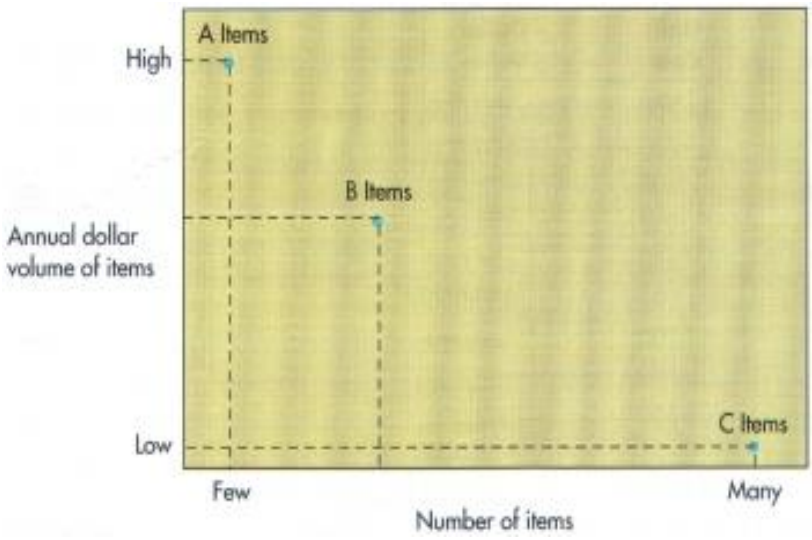
Inventory Item Number	**Annual Usage**	**Value Per Unit**	**Annual Dollar Usage**
1	25,000	$3	75,000
2	5,000	$4	20,000
3	1,000	$10	10,000
4	10,000	$2	20,000
5	4,000	$5	20,000
6	70,000	$10	700,000
7	25,000	$5	125,000
8	5,000	$1	5,000
9	3,000	$5	15,000
10	2,000	$5	10,000

ABC analysis system

Item Number	Annual $ Usage	% of Items	Cumulative % of Items	% of Value	Cumulative % of Value	ABC Class*
6	$700,000	10%	10%	70	70	A
7	$125,000	10%	20%	12.5	82.5	A
1	$75,000	10%	30%	7.5	90	B
2	$20,000	10%	40%	2	92	C
4	$20,000	10%	50%	2	94	C
5	$20,000	10%	60%	2	96	C
9	$15,000	10%	70%	1.5	97.5	C
3	$10,000	10%	80%	1	98.5	C
10	$10,000	10%	90%	1	99.5	C
8	$5,000	10%	100%	.5	100	C
Total	$1,000,000					

*When classifying the items as A, B, or C items, it can be somewhat subjective as to where the lines are drawn.

With the unrealistically small demonstration above, the first 20% of the inventory items constitute 82.5% of the inventory value, so these items (Items 6 and 7) will be designated as A items. On the other extreme, 70% of the items constitute only 10% of the inventory value, so these items (Items 2, 4, 5, 9, 3, 10, and 8) will be designated as C items. Finally, 10% of the items constitute 7.5 % of the inventory value, so this item (Item 1) will be designated as a B item.



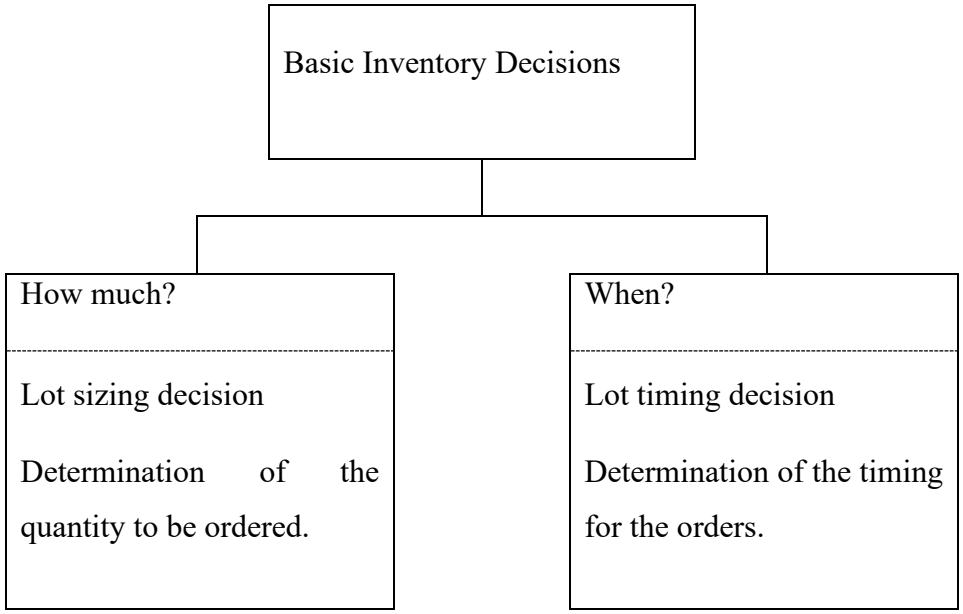
The purpose of the ABC:

The ABC system is one of the keys to inventory control. The purpose of the ABC classification was to separate the "important few" from the "trivial many" so that the appropriate level of control can be assigned to each item. A items should receive close attention through frequent reviews of amounts on hand and control over withdraws, where possible, to make sure that customer service levels are attained. The C items do not need very close scrutiny, and the B items should have controls that lie between the two extremes.

Note that C items are not necessarily unimportant; incurring a stockout of C items such as the nuts and bolts used to assemble manufactured goods can result in a costly shutdown of an assembly line. However, due to the low annual dollar volume of C items, there may not be much additional cost incurred by ordering larger quantities of some items, or ordering them a bit earlier

Other Inventory Control Systems

There are two basic decisions that must be made for every item that is maintained in inventory. These decisions, as shown in the next figure, have to do with the timing of orders for the item and the size of orders for the item. To accomplish this, the inventory manager must know the need and application for each item stocked, whether the item is a "dependent-demand" or an "independent-demand" item.



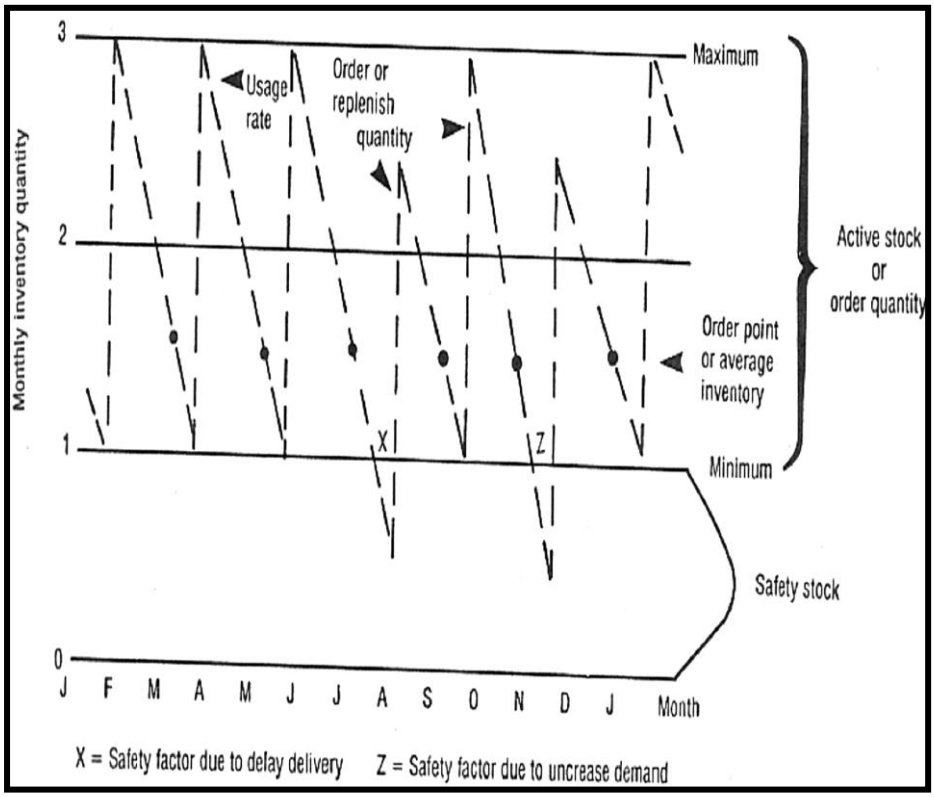
- ***A dependent demand*** **item**, also known as an internal-demand item, is that item whose use is directly related to or derived from the demand of other items or end product. Demand for a car translates into demand for four tires, one engine, one transmission, and so on. The items used in the production of that car are the dependent demand items.

- ***An independent demand*** **item**, also called external-demand item, is an item that is unrelated to the demand of items entering the finished product. The demand for lubricating oil for machine operation is independent from the demands of items entering the manufacturing process itself.

Other inventory control systems include:

- The ***cyclical ordering system*** is a **time-based system** and relies upon scheduled periodic review of stock levels for initiating a purchase request if stock is below a certain level. Its disadvantage is that not all items have the same usage rate and not reordering in time makes this system inefficient and can cause production problems
- The ***fixed-order quantity system***, which is based on the order quantity factor rather than the time factor, operates smoothly when the items exhibit stable usage and lead time. When these factors change, a new order quantity is again predetermined.
- The ***two-bin system***, which, as the name implies, has inventory stocked in two bins, and when one bin is emptied and the second begun – an order is placed for one bin of material.
- The ***maximum-minimum system***. This system is used when the items are comparatively standard in character and used in steady quantities and there is an established minimum level, maximum level, and fixed-order point. Theoretically, the minimum level

would be reached when the last unit was used and new shipment arrives. This makes the minimum level at zero and the quantity delivered as the maximum level. However, this theoretical policy becomes inoperative when there are unforeseen contingencies, such as a sudden increase in demand, late delivery, or receipt of non-conforming goods.



In the real world, manufacturers maintain a safety reserve to take care of any contingency that may arise. The amount of safety reserve or safety stock depends on the rate of consumption, importance of the time to production, and the lead time to obtain replacement. Safety stock is essential to prevent production interruption or loss of revenue.

The order quantity should take into consideration the maximum and minimum levels of the active stock plus the safety stock. In the previous figure, we have the following facts:

1. The normal use is 100 units per month;
2. The maximum level is 300 units, representing three months' supply (200 units for active stock and 100 units safety stock);
3. The order point is at the average inventory stock level of 150 units, with the reorder quantity of 200 units (the active stock quantity); and
4. The lead time is one half month. If the production rate is steady, using 100 units per month the safety factor could be reduced or entirely eliminated. That is, when the last unit of the active stock is at its minimum level (at zero), the new stock arrives to boost the stock level to its maximum, and there is no need for safety stock.
5. The constant threat of that unknown contingency, however, demands that we carry a **safety stock**.

- **The effect of delay in delivery:** In the previous figure, see that in July there was a contingency due to delay in delivery**,** and without the safety factor there would have been a temporary slowdown, or even a shutdown, causing loss to the company.
- **The effect of Increase in demand:** We also see that during October there was a sudden increase in demand, and the

November delivery would not arrive in time to meet this increased demand. Again the safety stock prevented disruption of the manufacturing process. The safety factor is a safeguard against such occurrences.

Hence **Safety Stock is** the quantity of stock held to satisfy unexpectedly high requirements in the stocking-up period. The purpose of the safety stock is to prevent a material shortage from occurring.

In order to determine the safety stock level, you must first specify the risk of a material shortage and also the desired service level. Usually the safety stock will not be used in production. More discussion of the safety stock will be addressed at the end of this chapter.

The active inventory stock is that portion of the total inventory supply intended to meet normal expected requirements for the material. This is directly related to the order quantity. Calculation of the **economic order quantity** is the expected annual requirements divided by the number of purchase orders per year, which proves to be the most economical quantity based on the cost of acquisition, the cost of carrying the inventory and total costs. The next chapter will address the economic order quantity in details.

The above mainstays of conventional inventory control systems have always been subject to review and reevaluation. This restoration of inventory to the maximum level was to have inventory always available when needed. This maximum level for inventory is the exact opposite

of what top management wanted from inventory management. They want the lowest capital investment in inventory with sufficient stock available for continuous operation.

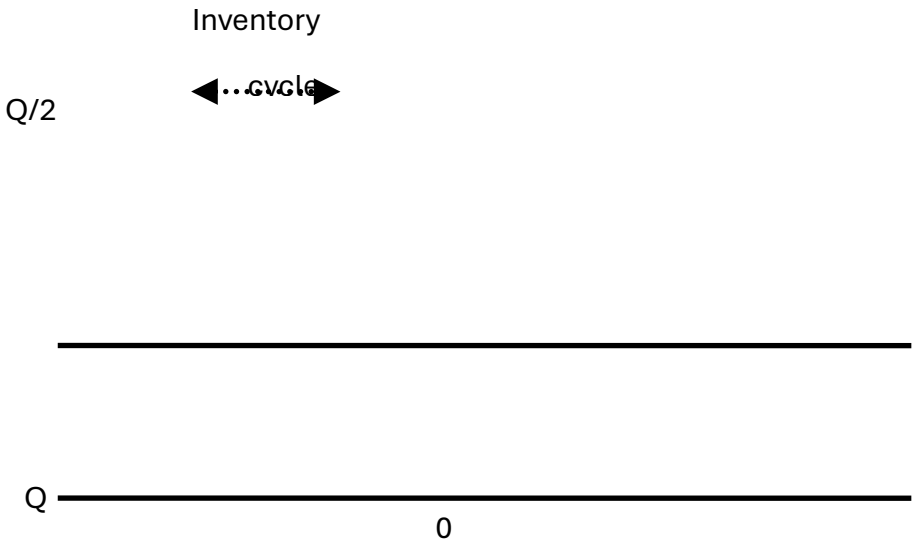
Reorder Point and Lead Time

Reorder point is Inventory level of an item which signals the need for placement of a replenishment order, taking into account the consumption of the item during order lead time and the quantity required for the safety stock. Also called reorder level, reorder quantity, or replenishment order quantity.

Inventory System with No Lead-Time

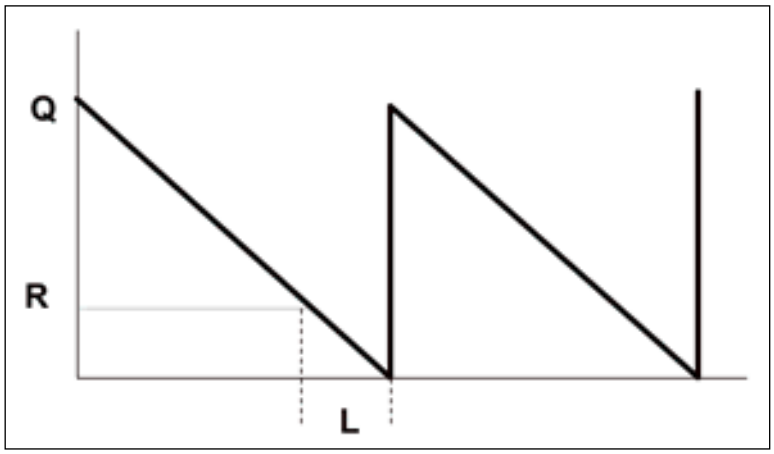
If we assume that the lead-time for procuring material is zero. Consequently, the reorder point for replenishment of stock occurs when the level of inventory drops down to zero, see the next graph.

Consider drawing a horizontal line at Q/2 in the above diagram. If you were to draw this line then it is clear that the times when stock exceeds Q/2 are exactly balanced by the times when stock falls below Q/2. In other words we could equivalently regard the above diagram as representing a constant stock level of Q/2 over time.



Inventory System with No Lead-Time

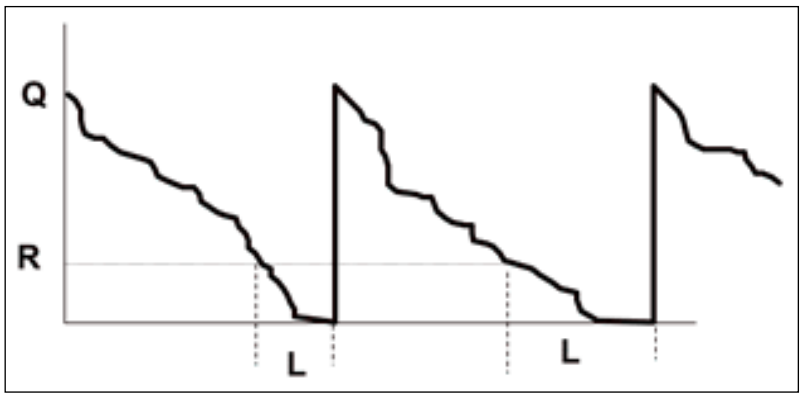
In view of instantaneous replenishment of stock the level of inventory jumps to the original level from zero level. In real life situations one never encounters a zero lead-time. There is always a time lag from the date of placing an order for material and the date on which materials are received.



Reorder point

As a result, as the above figure show, the reorder level is always at a level higher than zero, and if the firm places the order when the inventory reaches the reorder point, the new goods will arrive before the firm runs out of goods to sell. Sometimes the usage rate or lead time varies, hence the reorder point and lead time behavior can be as shown in the next figure.

The decision on how much stock to hold is generally referred to as **the order point problem**, that is, how low should the inventory be depleted before it is reordered.



Reorder point with different lead time and usage rate

The two factors that determine the appropriate order point are the procurement or delivery time stock which is the Inventory needed during the lead time (i.e., the difference between the order date and the receipt of the inventory ordered) and the safety stock which is the

minimum level of inventory that is held as a protection against shortages.

Reorder Point = Normal consumption during lead-time + Safety Stock.

Several factors determine how much delivery time stock and safety stock should be held. In summary, the efficiency of a replenishment system affects how much delivery time is needed.

Since the delivery time stock is the expected inventory usage between ordering and receiving inventory, efficient replenishment of inventory would reduce the need for delivery time stock. And the determination of level of safety stock involves a basic trade-off between the risk of stock-out, resulting in possible customer dissatisfaction and lost sales, and the increased costs associated with carrying additional inventory.

Another method of calculating reorder level involves the calculation of usage rate per day, lead time which is the amount of time between placing an order and receiving the goods and the safety stock level expressed in terms of several days' sales.

Reorder level:
= Average daily usage rate × lead-time in days + safety stock level

From the above formula it can be easily deduced that an order for replenishment of materials be made when the level of inventory is just adequate to meet the needs of production during lead-time.

Example

There is no safety stock.

Demand = 10,000 unit/year

Store open 311 days/year

Daily demand = d = 10,000 / 311

= 32.154 unit /day

Lead time = L = 10 days

Reorder point = R = (d × L) + safety stock = (32.154) (10) + 0 = 321.54 units

Example

Suppose there is no safety stock. If the average daily usage rate of a material is 50 units and the lead-time is seven days, count the reorder level.

Reorder level = Average daily usage rate x Lead time in days + safety stock level

= (50 units x 7 days) + 0 = 350 units

When the inventory level reaches 350 units an order should be placed for material. By the time the inventory level reaches zero towards the end of the seventh day from placing the order materials will reach and there is no cause for concern.

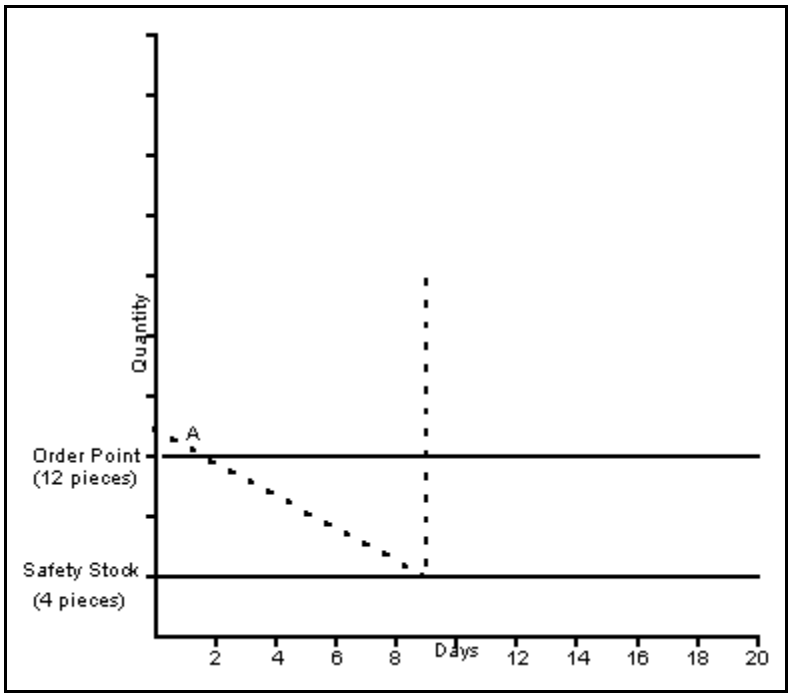
Safety Stock

As has been discussed before the order point formula contains one element which is the safety stock. Safety stock provides protection against running out of stock during the time it takes to replenish inventory. Why is this protection necessary?

- Demand is a prediction based on past history, trend factor(s), and/or known future usage of a product. The item's actual usage will probably be more or less than this quantity. Safety stock is needed for those occasions when actual usage exceeds forecasted demand. It is "insurance" to help ensure that you can fulfill customer requests for a product during the time necessary to replenish inventory.
- The anticipated lead time is also a prediction, usually based on the lead times from the last several stock receipts. Sometimes the actual lead time will be greater than what was projected. Safety stock provides protection from stock outs when the time it takes to receive a replenishment shipment exceeds the projected lead time.

The following diagrams illustrate how safety stock is used. The dotted line in the graph represents the available quantity (On-Hand – Committed) of the item. A replenishment order is placed on the first of the month as the available quantity available reaches the order point ("A" in the graph). In this example, there is none of the product

currently on incoming replenishment orders. Therefore, at point "A," the item's available quantity equals its replenishment position.



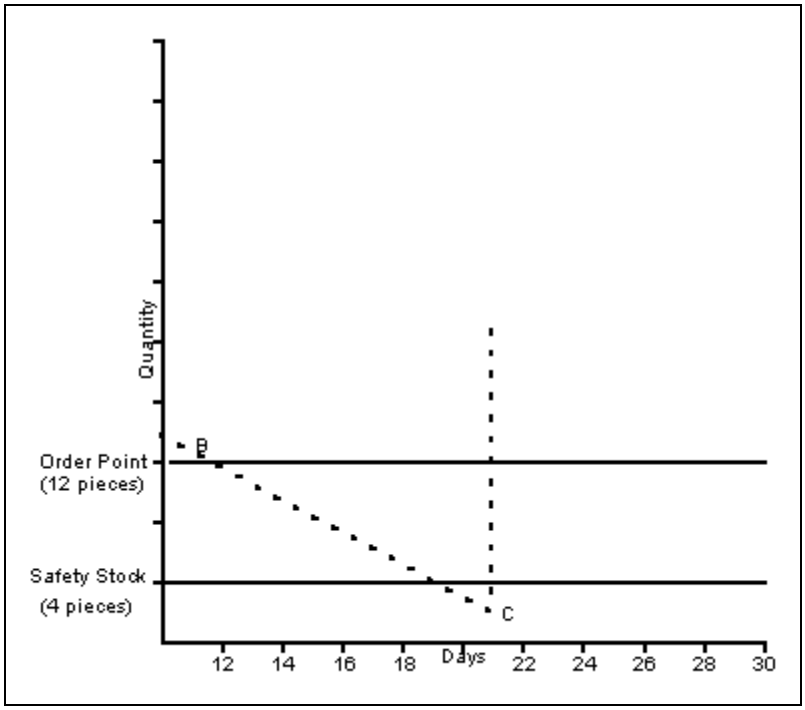
Projected Lead Time = 8 Days

Demand = 1 piece/day

On Order with Vendor = 0

The actual usage of eight pieces during the lead time is consistent with projected demand. The shipment arrives on the 9th of the month. As the stock receipt is processed, the available quantity on the shelf is equal to the safety stock quantity. The protection provided by the safety stock was not needed.

The product again reaches the order point on the 11th of the following month ("B" in the following graph):



Projected Lead Time = 8 Days

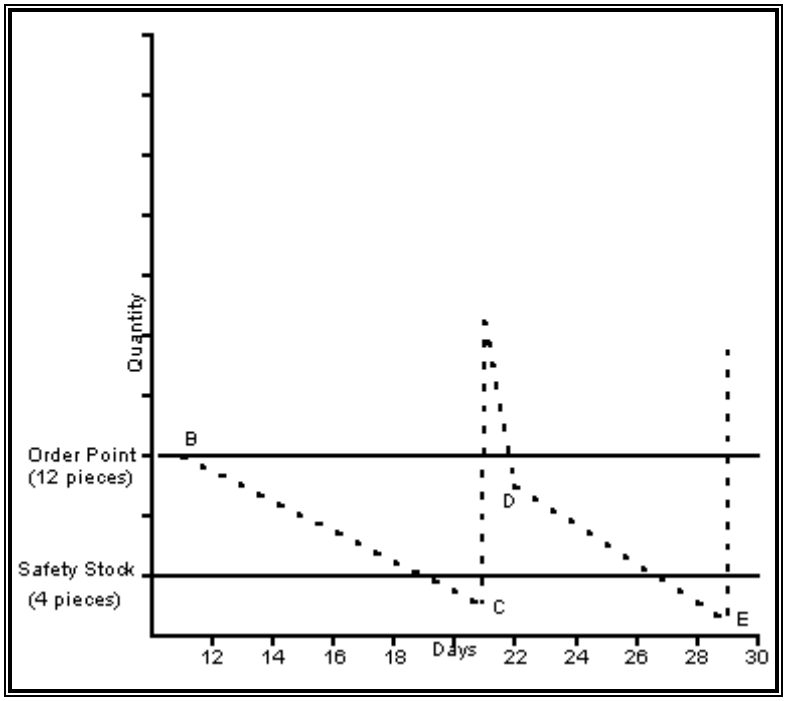
Demand = 1 piece/day

On Order with Vendor = 0

Another order is placed with the supplier. But the vendor is temporarily experiencing manufacturing problems and the shipment arrives two days late ("C" in the graph). If it were not for the safety stock, we would have run out of the product.

Shortly after the shipment arrives, a customer orders 10 pieces of the product. You experience more than a week's usage in just one day. The available quantity falls to "D" in the following graph. A replenishment order is issued that day, but the available quantity is already below the order point.

The safety stock quantity allows you to satisfy customer demand for the product until the replenishment shipment arrives from the supplier on the 29th of the month ("E" in the graph). Again, safety stock prevented a stock out.



Example:

Average daily demand = 50 units per day

Operating year contains 300 days of operation

Ordering cost S = $3 per order

Holding cost H = $1 per unit per year

Lead time = 1 day

EOQ = 300 units per order.

- Count the number of orders and reorder point.

Computations:

D = 15,000 units per year

Resulting number of orders per year = D/Q = 15000 units / 300 units = 50 orders per year

Reorder point = (the average number of units demanded during the 1 day lead time) = 50 × 1 = 50 units

Additional Data:

If the demand is not always a constant 50 units per day. There is variability in daily demand according to the following table of demands and probabilities:

Daily Demand	10	20	30	40	50	60	70	80	90
Probability	.01	.04	.05	0.2	0.4	0.2	.05	.04	.01

The previous table suggests that if you waited until you had 50 units left in inventory before placing an order for 300 more units, you would be O.K. if the demand during the 1 day lead time was 10, 20, 30, 40, or 50.

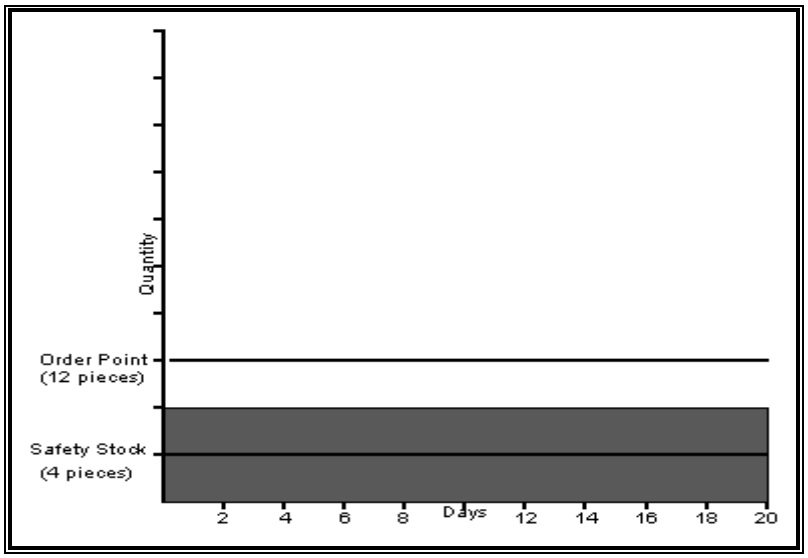
However, if the demand during the 1 day lead time was 60, 70, 80, or 90 you would have had a shortage. The size of the shortage would depend upon how many units were demanded during the lead time, but the maximum possible shortage would have been 40 units (if demand

was the largest possible value of 90). You can prevent shortages by providing safety stock when there is uncertainty in demand.

If you wanted to guarantee that you would never have a shortage in this situation, you would need 40 units of safety stock at the bottom of the graph to "dip into" if demand spiked to higher than average values. But, adding 40 units of safety stock really means that you have elevated your reorder point. You are not waiting until there are only 50 units in inventory to place your order. You are ordering when there are 90 units in inventory. (And, of course, 90 units is sufficient to cover the worst case scenario for this problem.)

How Much Safety Stock Do You Need?

Take a look at the next graph. When a replenishment shipment arrives, the available quantity is usually somewhere in the shaded area of the graph. Notice that the safety stock quantity is in the middle of the shaded area. Half the time you will use some or all of the safety stock before the replenishment shipment arrives. The other 50% of stock receipts will arrive before you use any of the safety stock. On average, the full safety stock quantity is always on the shelf when the replenishment shipment arrives. It is, on average, "non-moving" inventory.



A distributor puts inventory in his warehouse to sell it to customers. Profits from these sales are necessary to pay the distributor's expenses and provide a return on his investment. With this thought in mind, it seems as though it would not be a good idea for a distributor to intentionally have non-moving inventory in stock.

On the other hand, keep in mind the goal of effective inventory management:

"Effective inventory management allows a distributor to meet or exceed his (or her) customers' expectations of product availability with the amount of each item that will maximize the distributor's net profits."

Safety stock is, in reality, an expense of doing business. But it is necessary to ensure good customer service. To maximize profits, we must carefully control all expenses, including safety stock. Therefore, we want to achieve our customer service goals with the least possible amount of safety stock.

The Conventional Ways of Calculating Safety Stock

There are two common conventional methods for calculating the safety stock quantity for a product:

- Percentage of Lead Time Demand
- Days Supply

As we discuss the various methods for calculating safety stock quantities, we'll refer to two variables, "forecast demand" and "usage." Forecast demand is a prediction of how much of a product will be sold or otherwise used in a particular month, and usage is the quantity that was actually sold or used.

Percentage of Lead Time Demand

Retired inventory consultant Gordon Graham long advocated that, for most items, 50% of lead time demand provides an adequate safety stock quantity. Let's look at an example:

Demand/Day = (390/30) = 13 pieces

Projected Lead Time = 8 days

Demand During the Lead Time = (8 x 13) = 104 pieces

Safety Stock = (104 x 50%) = 52 pieces

The thirteen pieces per day is multiplied by the projected lead time of eight days resulting in a lead time demand of 104 pieces. Safety stock is half this amount, or 52 pieces. This quantity represents a four day (4 days x 13 pieces/day) reserve.

This method is easy to understand but it tends to maintain too much or too little safety stock for many items. For example:

- Products with long but very reliable lead times and with fairly consistent demand. If we use this method for an imported product with a 12-week lead time, we'll keep six weeks stock in reserve as safety stock. If we usually receive the shipment on time and demand doesn't vary substantially from month to month, we'll have too much safety stock – in other words, too much money tied up in non-productive inventory.
- Products with very short lead times and significant variations in demand from month to month. If a product had a one-week lead time, this method will keep a three or day supply of the item in reserve as safety stock. If usage tends to vary significantly from month to month, there probably won't be enough safety stock available to consistently fill customer demand and the company will experience stock outs.

Days Supply

The days supply method allows a buyer to manually specify a number of days supply of a product to hold in reserve as safety stock. Because a buyer usually does not have the time to review the safety stock parameters for every item each month, he or she will probably set the days supply to provide more than enough safety stock. After all, in the eyes of most buyers, excess inventory is usually preferable to stock

outs. As a result, the days supply method often results in the accumulation of non-producing inventory.

A Better Way of Maintaining Safety Stock

Remember that the purpose of safety stock is to protect customer service from unusual customer demand during the lead time or delays in receiving a replenishment shipment. Why not base the amount of safety stock maintained for each item on the variations in demand and lead time? The greater the variation in demand and/or lead time, the more safety stock will be maintained for the item. This is referred to as the "average deviation method."

Let's look at an example. We'll consider the variation or deviation in demand as the difference between the forecast demand of a product in a month and the actual usage in the past three months (it is common to use three to six month's history in this calculation). Consider an item with the following forecast demand and usage history:

Forecast demand and usage history

	Forecast Demand	Actual Usage	Deviation
January	50	60	10
February	76	80	4

March	80	70	-10

In January, the demand forecast was 50 pieces and actual usage was 60 pieces, resulting in a deviation or difference of 10 pieces. In February, the demand forecast was 76 pieces and actual usage was 80 pieces, which produced a deviation of four pieces. The average deviation is:

(10 + 4) ÷ 2 = 7 pieces per month

Note that the deviation for March, in which demand exceeded usage, is not considered in our calculation of safety stock. Why? Because if our prediction of what customers want exceeds actual sales, we certainly don't want to add more safety stock to inventory. We probably have more than enough on the shelf already.

Next we have to calculate the average deviation of the product's lead time. In calculating this amount, we'll just look at the last three stock receipts from the primary source of supply. Why so few? Well, a lot of things can occur over extended periods of time that will affect the lead time for an item. For example:

- Your vendor can add or shut down production lines.
- Freight carriers can use different routes.
- The availability of the raw materials needed to make the product may change.

Here are the three most recent stock receipts for the item along with the anticipated lead time for the product when the purchase order associated with the stock receipt was entered:

Date of Receipt	Anticipated Lead Time	Actual Lead Time	Deviation
June 15th	10 days	17 days	7 days
April 20th	8 days	13 days	5 days
February 2nd	8 days	6 days	-2 days

As with our analysis of demand and usage, we will not consider any stock receipt whose actual lead time was less than its anticipated lead time – in other words, any time we received the item early. The average lead time deviation of the remaining two stock receipts is six days:

$$(7 + 5) \div 2 = 6 \text{ days}$$

The six days is multiplied by the current anticipated demand per day to determine the anticipated usage during the six-day period. Demand per day is calculated by dividing the current monthly demand by the number of work days in the month. For example, say the current monthly demand is 90 pieces and the current month has 18 work days. The demand per day is five pieces; multiplied by the six-day deviation

equals 30 pieces. The 30 pieces is added to the demand deviation to determine the total safety stock for the item:

30 + 7 = 37 pieces

As a final step in determining the safety stock quantity, we'll multiply the average deviation by a deviation multiple. The deviation multiple used is dependent on the customer service level we want to provide to our customers.

Customer service level is defined as the percentage of line items for stocked products shipped complete by the promise date.

The higher the multiple, the more safety stock we'll maintain, and the higher the customer service level. Please refer to our other articles for a complete discussion of the customer service level.

Generally we have found that the following multiples provide the corresponding level of customer service:

Deviation Multiple	Resulting Customer Service Level
2	95%
3	97%
4	99%

If our goal is a 95% customer service level, we'll multiply the average deviation by a multiple of two (37 x 2 = 74 pieces). Be careful!

Using a higher deviation increases the amount of non-moving inventory on your shelf. In our example, the difference between a safety stock quantity derived using a deviation multiple of two or three is an additional 37 pieces!

Yes, this is a more involved way of calculating safety stock than the conventional methods previously discussed. But it reflects the variations in market conditions, and therefore better predicts if a particular product needs more or less safety stock. And, if your computer system calculates your replenishment parameters, you won't have to worry about performing the calculations.

However, you will have to properly assign deviation multiples to each item, in each warehouse, in order to meet your overall customer service level goals. We'll discuss that process next month.

Stockless Buying

Striving toward this goal has many purchasing agents using a stockless buying system whereby the responsibility for the inventory is shifted to the supplier. The buyer draws up a purchase agreement or contract with as many suppliers as needed for the agreement or contract with as many suppliers as needed for the many items required. When entering such program, the buyer must be extra careful in his selection of suppliers who can meet the delivery requirements of such program.

A blanket order is issued to the supplier, against which requests for shipment are made. This reduces the paperwork for the purchasing

department. Carrying costs are eliminated because the supplier stocks the goods. This arrangement is of equal importance to the supplier, for he knows what his customer will require over a specific period of time and can schedule his own production rate.

Then there is on-consignment inventory, which is another stockless buying method. In this situation, the supplier ships goods to your plant, at no charge when shipped, for you company to provide secured storage space with the expectation that your company will eventually use the product, whereby such action becomes a "sale of goods" for which you pay. You are acting as someone who is holding property in trust for some purpose. This method is used primarily by retailers. Suppliers want to expose their product to the customer. The retailer does not want to invest in a new product, but will handle such product without investment. Some non-profit hospitals have entered into such on-consignment agreements.

Just in Time Inventory Management System

Overview of Just-in-Time

Just-in-time is a movement and idea that has gained wide acceptance in the business community over the past decade. As companies became more and more competitive and the pressures from Japans continuous improvement culture, other firms were forced to find innovative ways to cut costs and compete.

The idea behind JIT, or lean manufacturing, is to have the supplies a firm needs at the exact moment that they are needed. In order to accomplish this goal a firm must constantly be seeking ways to reduce waste and enhance value.

As previously stated, one of the key components of JIT is to reduce waste and add value. There are several activities that a company must monitor as targets for reducing waste. Among these are, excessive waste times, inflated inventories, unneeded people or material movement, unnecessary processing steps, numerous variability throughout a firm's activities and any other non-value adding activity.

The layout and inventories that are part of a JIT strategy may seem the most logical steps to reduce waste and increase value. By simply redeveloping the layout of certain facilities a firm can reduce the time it takes for supplies to get to the next step in process and cut costs associated with that movement.

One way to do this is to have work-in-progress close to the next station in the manufacturing chain. Couple this with lowering inventories and a powerful combination is formed to reduce costs. In lowering inventories a firm can reap numerous benefits; batch sizes, set-up times and safety stock are all reduced, ergo costs are trimmed and value is added. But in order to achieve these things a firm must be willing to accept the problems that these actions can either uncover or create.

Going hand-in-hand with maintaining Just In Time inventory levels is JIT scheduling. By working to reduce inventory to the lowest possible working levels, a firm must constantly be adjusting its schedule of ordering and delivering.

In doing so, communication both up and down the supply chain is critical. Frequent orders are placed for supplies and small production runs are constantly being initiated. In order to achieve this breakneck pace of order/production schedule, a firm must constantly be making small changes to orders/production and recognize that Kanbans are of incredible importance.

The Kanban system is used to ensure that parts or materials are available when needed. The Kanban system is an information system that controls production by using markers or cards. It is responsible for ensuring that the necessary products are produced (or acquired) in the necessary quantities at the necessary time. It is the heart of the JIT system.

The basic Kanban system uses three cards: a withdrawal Kanban, a production Kanban, and a vendor Kanban. A withdrawal Kanban specifies the quantity that a subsequent process should withdraw from the preceding process. A production Kanban specifies the quantity that the preceding process should produce. Vendor Kanbans are used to notify suppliers to deliver more parts

Possibly the single piece of JIT that has the most relevance to a study of supply chain management is the partnerships that are essential to making JIT truly work. A firm cannot implement a JIT system by itself; it must have the complete cooperation of its entire supply chain.

The sheer amount of information that is needed for a JIT system to operate well demands partnerships to be formed and nurtured, almost to the point at which an entire supply chain operates as one firm.

Examples of these kinds of partnerships are everywhere in today's business world. XYZ-Company allows its key suppliers to work directly at their manufacturing sites and place orders as needed for the parts that that supplier supplies. By example Dell has its suppliers store raw materials directly at the manufacturing plants.

Other concepts of Just In Time also need to be introduced in order to have a discussion about what truly makes Just In Time a worthy endeavor. By the 1980s the Japanese had achieved manufacturing greatness by practicing continuous improvement, in that a firm is constantly working to improve in every facet of its business functions.

To do this a firm must always increase quality, look for innovative ways to solve problems and increase focus on the quality of its suppliers. All of these are cornerstones of a modern JIT system.

Lastly, getting the workforce to buy into a JIT lean manufacturing system is important because without the dedication of the workforce, any endeavor is sure to fail.

There are several ways to achieve workforce commitment. A simple way is to cross train the workforce members outside of their normal business function and help increase an employee's problem solving ability.

In doing so a firm is empowering its workforce to think about their function in a new way while looking for ways to improve and giving them an overall view of the entire firm, not just their single job. When this is coupled with the support of management, an increase in resources to solve problems, and an increase in employee roles and responsibility, a workforce will feel empowered and work to make Just In Time a success for the business.

Strengths of JIT

There is a lot of strength in incorporating JIT lean manufacturing in a company. The traditional approach to inventory management (just-in-case system) assumes that inventories are needed. The just-in-case theory provides various reasons to justify the need for inventories. Increased competition based on product diversity, quality, specialized features, and shorter life cycles have led many firms to reject the traditional EOQ model in favor of the just-in-time (JIT) model. JIT can offer greater cost efficiency and more flexibility to respond to customer demands.

The next table compare between the traditional systems and JIT systems. JIT makes production operations more efficient, cost effective and customer responsive. JIT allows manufacturers to purchase and

receive components just before they're needed on the assembly line, thus relieving manufacturers of the cost and burden of housing and managing idle parts.

Traditional systems:	JIT systems:
Balance setup and carrying costs *Satisfy customer demand* *Avoid manufacturing shutdowns* *Take advantage of discounts* *Hedge against future price increases*	*Drive setup and carrying costs to zero* *Use due-date performance* *Use total preventive maintenance* *Use total quality control* *Use the Kanban system*

Rather than holding inventories as a hedge against plant shutdowns, JIT attacks the plant shutdown problem by addressing these issues.

The benefit of carrying smaller amounts of inbound, in-process, and finished goods inventory exists regardless of the firm's operating context (size, production technology, etc…). Just In Time appeals to many companies because it helps prevent manufacturers from being stuck with inventory that may become obsolete.

JIT was initially developed and justified based on cost reduction and quality improvement dimensions. Now, companies view JIT as providing an approach to achieving excellence in the elimination of waste (thought of as all things that do not add value to the product), as well as making the company more responsive to short-term customer demand patterns.

JIT manufacturing can be a real money-saver for a company. Companies are not only more responsive to their customers, but they also have less capital tied up in raw materials and finished goods inventory, allowing companies to optimize their transportation and logistics operations (UPS, 2003).

Overall, JIT manufacturing results in lower total system costs and improved product quality. With JIT, some plants have reduced inventory more than fifty-percent and lead time more than eighty-percent (Droge, 1998). JIT is lowering costs and inventory, reducing waste, and raising the quality of products.

We can conclude that the benefits of JIT system are:

1. JIT reduces the costs of acquiring inventory to insignificant levels by:
    a- Drastically reducing setup time.
    b- Using long-term contracts for outside purchases.
2. Carrying costs are reduced to insignificant levels by reducing inventories to insignificant levels.
3. Lead times are reduced so that the company can meet requested delivery dates and respond quickly to customer demand. Lead times are reduced by:
    a- Reducing setup times.
    b- Improving quality.

c- Using cellular manufacturing.

4. The JIT approach avoids shutdowns by:
    a- Utilizing total preventive maintenance to reduce machine failures.
    b- Utilizing total quality control to reduce defective parts.
    c- Cultivating supplier relationships to ensure availability of quality raw materials and subassemblies.
    d- Using the Kanban system.
5. JIT deals with discounts and price increases through:
    a- Careful supplier selection.
    b- Long-term contracts with suppliers.
    c- Prices are stipulated (usually producing a significant savings).
    d- Quality is stipulated.
    e- The number of orders placed is reduced.

Weaknesses of JIT

Just as JIT has many strong points, there are weaknesses as well.

1. "In just-in-time, everything is very interdependent. Everyone relies on everybody else" (Greenberg, 2002). Because of this strong interdependence with JIT, a weakness in the supply chain

caused by a JIT weakness can be very costly to all linked in the chain.

2. JIT processes can be risky to certain businesses and vulnerable to the supply chain in situations such as labor strikes, interrupted supply lines, market demand fluctuations, stock outs, lack of communication upstream and downstream in the supply chain and unforeseen production interruptions.
3. Labor strikes, stock outs, and port lockouts can quickly disrupt an entire supply chain while JIT processes are in place. "Adhering to the just-in-time concept can be expensive in times of emergency such as at ports" (Greenburg, 2002). When a ship arriving from Asia full of supplies cannot make it to shore, the company using JIT generally has very little inventory to compensate for the emergency. This lack of inventory is exactly what makes JIT so great to companies in reducing costs, yet making it risky as well by in some cases not having enough buffer inventories to react and keep the supply chain moving.
4. Every year markets experience seasonal demand fluctuations as well as fluctuations due to demand from disasters or other unforeseen events. "Just-in-time delivery leaves retailers and manufacturers with little inventory as the holiday season approaches" (Greenberg, 2002).

5. Relying solely on JIT systems would leave supply chains in shock due to the overwhelming seasonal market demand at different times of the year for seasonal products. Not all products should be produced with JIT systems in place. Custom made items will not work well with JIT as JIT systems respond best to mass produced and highly automated production items.
6. Communication is king in a JIT rich supply chain. There is a risk involved with JIT when there is a communication breakdown and the company cannot get the right amount of supplies needed to keep the just-in-time system running smoothly.
7. Technology is playing a big role in JIT number, however, the reliance on technology can lead to breakdowns in the IT systems that can be costly to work around and go back to the 'pencil and paper' methods of doing supply/inventory demand calculations. Companies should always have backup systems in place to help thwart the possibility of technology or communication breakdown.
8. Weaknesses in JIT systems are very important to recognize. "From Cisco routers to Dell computers to the Gap's leather pants, companies have found their just-in-time manufacturing systems have let them down" (Johnson, 2001).

9. Companies must strongly evaluate the pros and cons of implementing JIT systems. The effects and risk to their supply chain must also be heavily considered.

Finally we have to say that although JIT has its weaknesses, in most cases, the benefits outweigh the risks to the JIT enabled company. Planning for and recognizing when things may go wrong with the JIT system are vital for the success of JIT implementation across all areas of supply chains.

Questions and Problems

1. Explain the ABC inventory classification system and indicate its advantages.
2. Identify specific benefits that accrue from holding inventories.
3. Distinguish between a fixed-order-quantity system and fixed-time-period system and give an example of each.
4. Describe the difference between independent and dependent demand and give an example of each for a pizza restaurant such as Domino's or Pizza Hut.
5. Discuss the strengths and weakness of JIT system.
6. Describe the difference between JIT and traditional inventory management systems.
7. Write short notes in each of the following:
    a. The system of Stockless Buying.
    b. The importance of safety stock.
    c. Methods of calculating safety stock.
    d. Lead time period.
    e. Reordering point.
    f. Maximum-minimum system in controlling inventory levels.

Problem 1:

Classify the inventory items as A, B, or C based on annual dollar value, given the following information:

Item	Annual Demand	Unit Cost	Annual Dollar Value
1	1,000	$4,300	$4,300,000
2	5,000	720	3,600,000
3	1,900	500	950,000
4	1,000	710	710,000
5	2,500	250	625,000
6	2,500	192	480,000
7	400	200	80,000
8	500	100	50,000
9	200	210	42,000
10	1,000	35	35,000
11	3,000	10	30,000
12	9,000	3	27,000

Problem 2

The following classification table contains figures on the monthly volume and unit costs for a random sample of 16 units from a list of 2,000 inventory items at a health care facility. Classify the inventory items as A, B, or C

Item	Unit Cost	Usage
K34	10	200
K35	25	600

K36	36	150
M10	16	25
M20	20	80
Z45	80	200
F14	20	300
F95	30	800
F99	20	60
D45	10	550
D48	12	90
D52	15	110
D57	40	120
N08	30	40
P05	16	500
P09	10	30

Chapter 7

Economic Order Quantity Model EOQ

Introduction:

The goal of effective inventory management is to minimize the total costs - direct and indirect - that are associated with holding inventories. However, the importance of inventory management to the company depends upon the extent of investment in inventory.

To further economize in the replenishment planning process, the most economic lot sizes or production sizes should be determined. Ordering an optimal amount helps eliminate unnecessary stock and maximize return-on investment.

There are many costs associated with the ordering process. The optimal order quantity is determined by minimizing the sum of these costs over the next year.

This chapter addresses the following subjects related to Economic Order Quantity Model:

1. What is Economic Order Quantity?
2. Assumptions of Economic Order Quantity.
3. Impact of changing assumptions of Economic Order Quantity.

Economic Order Quantity (EOQ)

Inventory is held to avoid the nuisance, the time and the cost etc. of constant replenishment. However, to replenish inventory only infrequently would necessitate the holding of very large inventories. It is therefore apparent that some balance or trade-off or compromise is

needed in deciding how much inventory to hold, and therefore how much inventory to order.

The EOQ model is a technique for determining the best answers to the how much and when questions. It is based on the premise that there is an optimal order size that will yield the lowest possible value of the total inventory cost. There are several assumptions regarding the behavior of the inventory item that are central to the development of the model

How much stock should we have?

There are two extreme answers to this question:

1. A lot

- this ensures that we never run out
- is an easy way of managing stock
- is expensive in stock costs, cheap in management costs

2. None/very little

- this is known (effectively) as Just-in-Time (JIT)
- is a difficult way of managing stock
- is cheap in stock costs, expensive in management costs

We shall consider the problem of ordering raw material stock but the same basic theory can be applied to the problem of:

- Deciding the finished goods stock.
- Deciding the size of a batch in a batch production process.

The costs that we need to consider so that we can decide the amount of stock to have can be divided into stock holding costs and stock ordering (and receiving) costs as below. Note here that, conventionally, management costs are ignored here.

Holding costs - associated with keeping stock over time

- storage costs
- rent/depreciation
- labor
- overheads (e.g. heating, lighting, security)
- money tied up (loss of interest, opportunity cost)
- obsolescence costs (if left with stock at end of product life)
- stock deterioration (lose money if product deteriorates whilst held)
- theft/insurance

Ordering costs - associated with ordering and receiving an order

- clerical/labor costs of processing orders
- inspection and return of poor quality products
- transport costs
- handling costs

Note here that a stock out occurs when we have insufficient stock to supply customers. Usually stock out occurs in the order lead time, the time between placing an order and the arrival of that order.

Given a stock out, the order may be lost completely or the customer may choose to backorder, i.e. to be prepared to wait until we have sufficient stock to supply their order.

Note here that whilst conceptually we can see that these cost elements are relevant it can often be difficult to arrive at an appropriate numeric figure (e.g. if the stock is stored in a building used for many other purposes, how then shall we decide an appropriate allocation of heating/lighting/security costs).

Assumptions of the Basic EOQ Model

When calculating the Economic Order Quantity, be aware of the following assumptions:

1. Demand for the item is known and constant.
2. Lead time is known and constant. (Lead time is the amount of time that elapses between when the order is placed and when it is received.)
3. The cost of all units ordered is the same, regardless of the quantity ordered (no quantity discounts).
4. Ordering costs are known and constant (the cost to place an order is always the same, regardless of the quantity ordered).

5. When an order is received, all the items ordered arrive at once (instantaneous replenishment).
6. Since there is certainty with respect to the demand rate and the lead time, orders can be timed to arrive just when we would have run out. Consequently the model assumes that there will be no shortages.

Based on the above assumptions, there are only two costs that will vary with changes in the order quantity, (1) the total annual ordering cost and (2) the total annual carrying (holding) cost. Shortage cost can be ignored because of assumption 6. Furthermore, since the cost per unit of all items ordered is the same, the total annual item cost will be a constant and will not be affected by the order quantity.

) c

Total Annual Inventory-System Costs Include:
1) Carrying (holding) cost 2) Ordering cost

To see how we can decide the inventory level to adopt, consider the very simple model below.

In this basic model we have the situation where:

- our company orders from an outside supplier;
- that outside supplier delivers to us precisely the quantity we ask for; and

- we pass that stock onto our customers (either external customers, or an internal customer within the same company (e.g. if ordering raw materials for use in the production process).

EOQ symbols:

D = annual demand (units per year)

S = cost per order (dollars per order)

H = holding cost per unit per year (dollars to carry one unit in inventory for one year)

Q = order quantity (Lot size)

We saw on the previous pages that the only costs that need to be considered for the EOQ model are the total annual ordering costs and the total annual holding costs.

Annual Ordering Cost

The annual cost of ordering is simply the number of orders placed per year times the cost of placing an order (S). The number of orders placed per year is a function of the order size. Bigger orders means fewer orders per year, while smaller orders means more orders per year. In general, the number of orders placed per year will be the total annual demand divided by the size of the orders (D/Q).

The number of orders placed per year = D/Q

Total Annual Ordering Cost = (D/Q) S

Annual Holding Cost

The annual cost of holding inventory is a bit trickier. If there was a constant level of inventory in the warehouse throughout the year, we could simply multiply that constant inventory level by the cost to carry a unit in inventory for a year. Unfortunately the inventory level is not constant throughout the year, but is instead constantly changing. It is at its maximum value (which is the order quantity, Q) when a new batch arrives, then steadily declines to zero. Just when that inventory is depleted, a new order is received, thereby immediately sending the inventory level back to its maximum value (Q). This pattern continues throughout, with the inventory level fluctuating between Q and zero. To get a handle on the holding cost we are incurring, we can use the average inventory level throughout the year (which is Q/2).

The cost of carrying those fluctuating inventory levels is equivalent to the cost that would be incurred if we had maintained that average inventory level continuously and steadily throughout the year. That cost would have been equal to the average inventory level (Q/2) times the cost to carry a unit in inventory for a year (H). In short,

Total Annual Holding Cost = (Q/2) H

Total Annual Cost

The total annual relevant inventory cost would be the sum of the annual ordering cost and annual holding cost, or

$$TC = (D/Q)\ S + (Q/2)\ H$$

This is the annual inventory cost associated with any order size, Q.

At this point we are not interested in any old Q value. We want to find the optimal Q (the EOQ, which is the order size that results in the lowest annual cost). This can be found using a little calculus (take a derivative of the total cost equation with respect to Q, set this equal to zero, then solve for Q).

For those whose calculus is a little rusty, there is another option which is using the graph. The unique characteristics of the ordering cost line and the holding cost line on a graph are such that the optimal order size will occur where the annual ordering cost is equal to the annual holding cost.

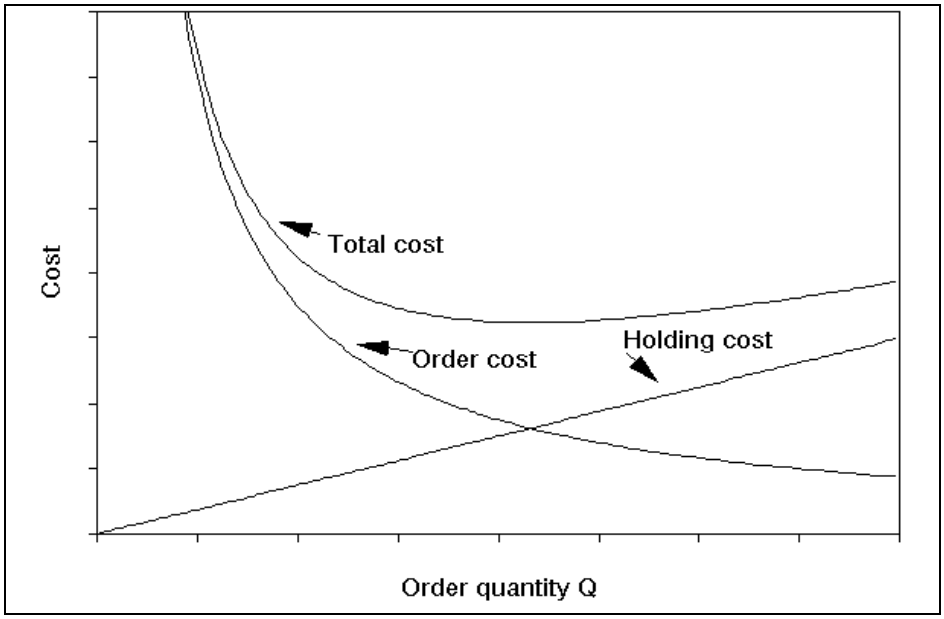
EOQ occurs when:

$$(D/Q)S = (Q/2)\,H$$

A little algebra clean-up on this equation yields the following:

$Q^2 = (2DS) / H$ and finally $\mathbf{Q = \sqrt{2DS / H}}$

The diagram below illustrates how these two components (annual holding cost and annual order cost) change as Q, the quantity ordered, changes.



As Q increases holding cost increases but order cost decreases. Hence the total annual cost curve is as shown below - somewhere on that curve lies a value of Q that corresponds to the minimum total cost.

We can calculate exactly which value of Q corresponds to the minimum total cost by differentiating total cost with respect to Q and equating to zero.

Comments:

- This formula for the EOQ is believed to have been first derived in the early 1900's and so EOQ dates from the beginnings of mass production/assembly line production.
- To return to the issue of management costs being ignored for a moment the basic justification for this is that if we consider the total cost curve shown above, then - assuming we are not operating a policy with a very low Q (JIT) or a very high Q -

we could argue that the management costs are effectively fixed for a fairly wide range of Q values. If this is so then such costs would not influence the decision as to what order quantity Q to adopt. Moreover if we wanted to adopt a more quantitative approach we would need some function that captures the relationship between the management costs we incur and our order quantity Q - estimating this function would certainly be a non-trivial task.

Example:

A retailer expects to sell about 200 units of a product per year. The storage space taken up in his premises by one unit of this product costs £20 per year. If the cost associated with ordering is £35 per order what is the economic order quantity given that interest rates are expected to remain close to 10% per year and the total cost of one unit is £100.

We use the EOQ formula:

$$Q = \sqrt{2DS/H}$$

Here:

D=200

S = 35

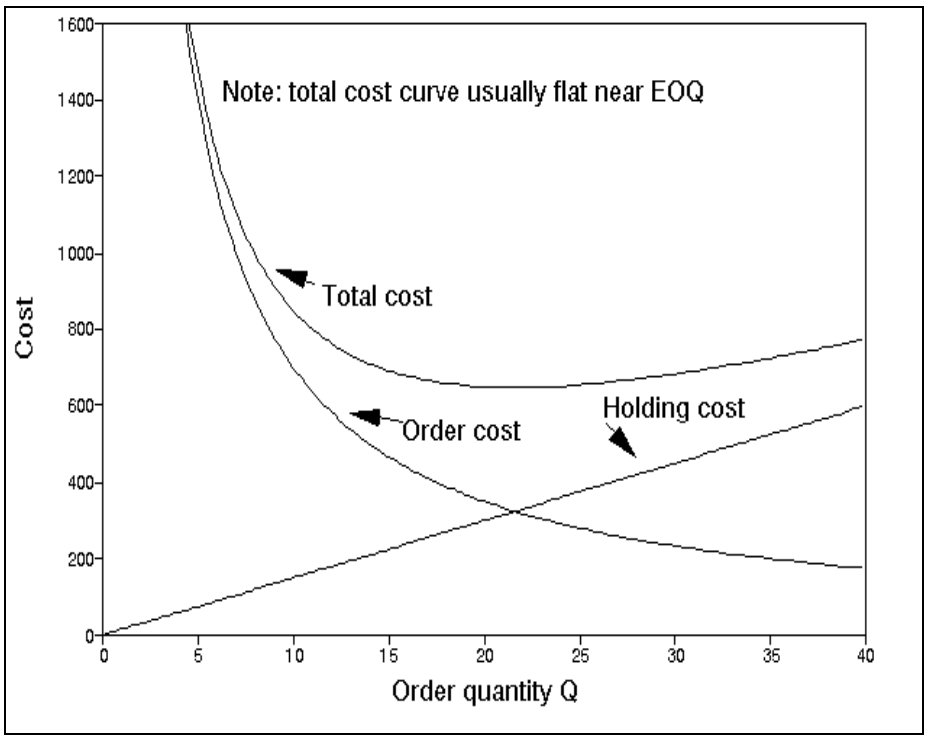
The holding cost H = £30 per unit per year

Hence EOQ = √ (2 x 200 x 35/30) = 21.602

But as we must order a whole number of units we have that:

EOQ = 22

We can illustrate this calculation by reference to the diagram below which shows order cost, holding cost and total cost for this example.



With this EOQ we can calculate our total annual cost from the equation

Total annual cost = TC = (D/Q) S + (Q/2) H

Hence for this example we have that

Total annual cost

= (35 x 200/22) + (30 x 22/2) = 318.2 + 330

= £648.2

Note: If we had used the exact Q value given by the EOQ formula (i.e. Q = 21.602) we would have had that the two terms relating to annual holding cost and annual order cost would have been exactly equal to each other.

i.e. holding cost = order cost at EOQ point (or, referring to the diagram above, the EOQ quantity is at the point associated with the Holding Cost curve and the Order Cost curve intersecting).

i.e. (Q/2) H = (R/Q) S so that Q = √2DS/H

In other words, as in fact might seem natural from the shape of the Holding Cost and Order Cost curves, the optimal order quantity coincides with the order quantity that exactly balances Holding Cost and Ordering Cost.

Note: Carrying cost is sometimes stated as a percentage of the purchase price of an item rather than as a dollar amount per unit. However, as long as the percentage is converted into a dollar amount, the EOQ formula is still appropriate.

Example: A local distributor for a national tire company expects to sell approximately 9,600 steel belted radial tires of a certain size and tread design next year. Annual carrying cost is $16 per tire, and ordering cost is $75. The distributor operates 288 days a year.

a. What is the EOQ?

b. How many times per year does the store reorder?

c. What is the length of an order cycle?

d. What is the total annual cost if the EOQ quantity is ordered?

Solution:

D = 9,600 tires per year

H = $16 per unit per year

S = $75

1. The EOQ

$$Q_0 = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(9{,}600)75}{16}} = 300 \text{ tires}$$

2. The number of reorders per year

$$\text{Number of orders per year} : \frac{D}{Q_0} = \frac{9{,}600 \text{ tires}}{300 \text{ tires}} = 32$$

3. The length of an order cycle

$$\text{Length of order cycle} : \frac{Q_0}{D} = \frac{300 \text{ tires}}{9{,}600 \text{ tires}} = \frac{1}{32} \text{ of a year} \Rightarrow \frac{1}{32} \times 288 = 9 \text{ workdays}$$

4. The total annual cost related to EOQ

$$TC = \text{carrying cost} + \text{ordering cost}$$
$$= \frac{Q_0}{2}H + \frac{D}{Q_0}S$$
$$= \frac{300}{2}\$16 + \frac{9,600}{300}\$75$$
$$= \$2,400 + \$2,400$$
$$= \$4,800$$

Example: Piddling Manufacturing assembles security monitors. It purchases 3,600 black-and-white cathode ray tubes a year at $65 each. Ordering costs are $31, and annual carrying costs are 20 percent of the purchase price. Compute the optimal quantity and the total annual cost of ordering and carrying the inventory.

Solution:

$$D = 3,600 \text{ cathode ray tubes per year}$$
$$S = \$31$$
$$H = .20(\$65) = \$13$$
$$Q_0 = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(3,600)(31)}{13}} = 131 \text{ cathode ray tubes}$$
$$TC = \text{carrying costs} + \text{ordering costs}$$
$$= \frac{Q_0}{2}H + \frac{D}{Q_0}S$$
$$= \frac{131}{2}13 + \frac{3,600}{131}31$$
$$= \$852 + \$852 = \$1,704$$

Quantity Discount Model

Quantity discounts are price reduction for large orders offered to customers to include them to buy in large quantities. If quantity

discounts are offered, the buyer must weigh the potential benefits of reduced purchase price and fewer orders that will result from buying in large quantities against the increase in carrying costs caused by higher average inventories. The buyer's goal with quantity discounts is to select the order quantity that will minimize total cost, where total cost is the sum of carrying cost, ordering cost, and purchasing cost.

Quantity Discount Model Assumptions

- Same as the EOQ, except that unit price depends upon the quantity ordered.
- Adjusted total cost equation is:

$$TC_{QD} = \left(\frac{D}{Q}S\right) + \left(\frac{Q}{2}H\right) + PD$$

Where P = unit price

When the supplier is willing to offer a lower price if large quantities of an item are ordered, the total annual purchase cost line will no longer be horizontal, but will instead have step decreases in it. This will lead to a total cost curve that has breaks in its continuity (step changes) resulting in a slightly different model for determining the optimal order size.

Quantity Discount Procedure

- Calculate the EOQ at the lowest price
- Determine whether the EOQ is feasible at that price

- Will the vendor sell that quantity at that price?

- If yes, stop – if no, continue
- Continue until you identify a feasible EOQ
- Check the feasibility of EOQ at the next higher price
- Calculate the total costs (including total item cost) for the feasible EOQ model
- Calculate the total costs of buying at the minimum quantity required for each of the cheaper unit prices
- Compare the total cost of each option & choose the lowest cost alternative

Example:

- Annual Demand = 5000 units
- Ordering cost = $49
- Annual carrying charge = 20%
- Unit price schedule:

Quantity	Unit Price
0 to 999	$5.00
1000 to 1999	$4.80
2000 and over	$4.75

Solution

Step 1

$$Q_{P=\$4.75} = \sqrt{\frac{2 \times 5{,}000 \times 49}{0.2 \times 4.75}} = 718 \ \ (not \ \ feasible)$$

$$Q_{P=\$4.80} = \sqrt{\frac{2 \times 5{,}000 \times 49}{0.2 \times 4.80}} = 714 \ \ (not \ \ feasible)$$

$$Q_{P=\$5.00} = \sqrt{\frac{2 \times 5{,}000 \times 49}{0.2 \times 5.00}} = 700 \ \ (feasible)$$

Step 2

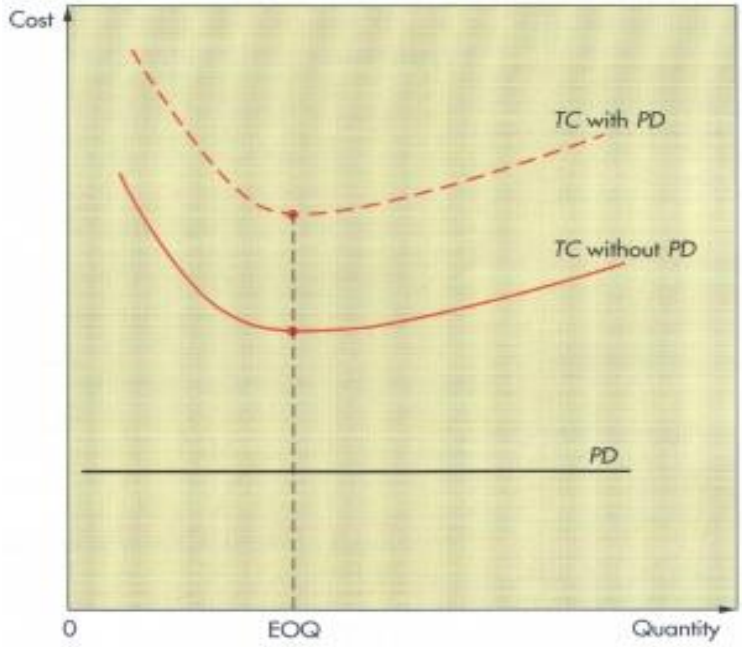
$$TC_{Q=700} = \frac{5{,}000}{700} \times 49 + \frac{700}{2} \times 0.2 \times 5.00 + 5.00 \times 5000 = \$25{,}700$$

$$TC_{Q=1000} = \frac{5{,}000}{1000} \times 49 + \frac{1000}{2} \times 0.2 \times 4.80 + 4.80 \times 5000 = \$24{,}725$$

$$TC_{Q=2000} = \frac{5{,}000}{2000} \times 49 + \frac{2000}{2} \times 0.2 \times 4.75 + 4.75 \times 5000 = \$24{,}822.50$$

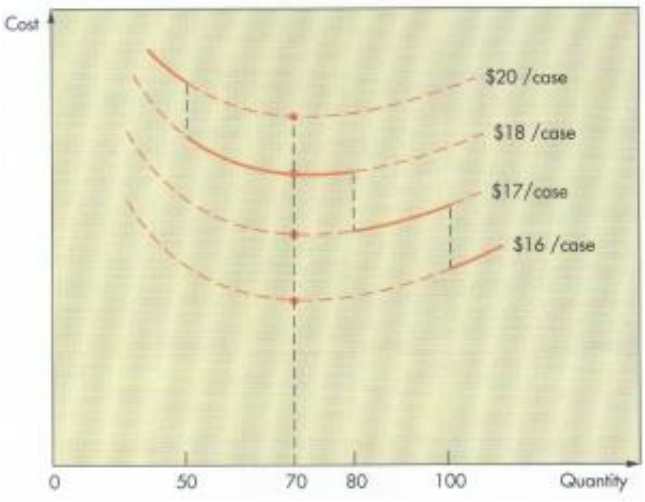
Recall that in the basic EOQ model, determination of order size does not involve the purchasing cost. The rationale for not including unit

price is that the assumption of no quantity discounts, price per unit is the same for all order sizes (when the demand, D, is known and a constant). Inclusion of unit price in the total cost computation is that case would merely increase the total cost by the amount PD, P times D. A graph of total annual purchase cost versus quantity would be a horizontal line. Hence, including purchasing costs would merely raise the total-cost curve by the same amount (PD) at every point. That would not change the EOQ curve.



Example: The maintenance department of a large hospital uses about 816 cases of liquid cleanser annually. Ordering costs are $12, carrying costs are $4 per case per year, and the new price schedule indicates that orders of less than 50 cases will cost $20 per case, 50 to 79 cases will cost $18 per case, 80 to 99 cases will cost $17 per case, and larger

orders will cost $16 per case. Determine the optimal order quantity and the total cost.



1. Compute the common EOQ: $\sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(816)12}{4}} = 70 \text{ cases}$
2. The 70 cases can be bought at $18 per case because 70 falls in the range of 50 to 79 cases. The total cost to purchase 816 cases a year, at the rate of 70 cases per order, will be

$$TC_{70} = \text{carrying cost} + \text{ordering cost} + \text{purchase cost}$$
$$= \frac{Q}{2}H + \frac{D}{Q_0}S + PD$$
$$= \frac{70}{2}4 + \frac{816}{70}12 + 18(816) = \$14,968$$

Because lower cost ranges exist, each must be checked against the minimum cost generated by 70 cases at $18 each. In order to buy at $17 per case, at least 80 cases must be purchased. (Because the TC curve is rising, 80 cases will have the lowest TC for that curve's feasible region.) The total cost at 80 cases will be

$$TC_{80} = (80/2)4 + (816/80)12 + 17(816) = \$14,154$$

To obtain a cost of $16 per case, at least 100 cases per order are required, and the total cost will be

$$TC_{100} = (100/2)4 + (816/100)12 + 16(816) = \$13{,}354$$

Therefore, because 100 cases per order yields the lowest total cost, 100 cases is the overall optimal order quantity.

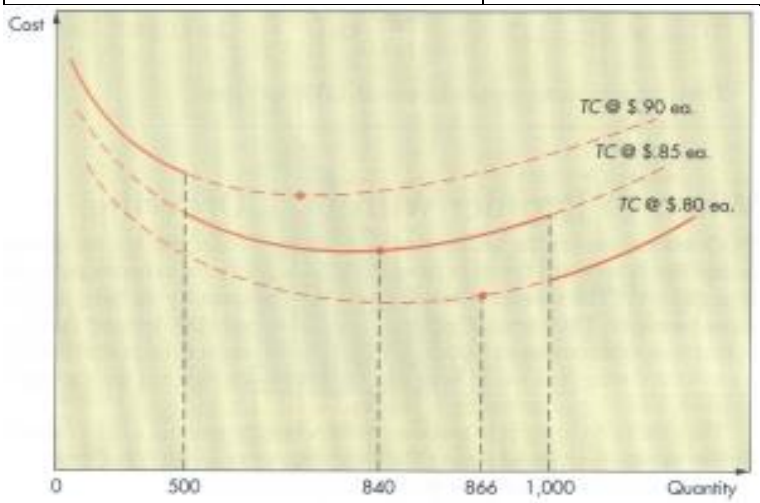
When carrying costs are expressed as a percentage of price, determine the best purchase quantity with the following procedure:

1. Beginning with the lowest unit price, compute the minimum points for each price range until you find a feasible minimum point (i.e., until a minimum point falls in the quantity range for its price).
2. If the minimum point for the lowest unit price is feasible, it is the optimal order quantity. If the minimum point is not feasible in the lowest price range, compare the total cost at the price break for all*lower* prices with the total cost of the largest feasible minimum point. The quantity that yields the lowest total cost is the optimum.

Example: Surge Electric uses 4,000 toggle switches a year. Switches are priced as follows: 1 to 499, 90 cents each; 500 to 999, 85 cents each; and 1,000 or more, 80 cents each It costs approximately $30 to prepare an order and receive it, and carrying costs are 40 percent of purchase price per unit on an annual basis. Determine the optimal order quantity and the total annual cost.

Solution: D = 4,000 switches per year, S = $30, H = .40P.

Range	Unit Price	H
1 to 499	$0.90	$0.36
500 to 999	$0.85	$0.34
1,000 or more	$0.80	$0.32



1. Find the minimum point for each price, starting with the lowest price, until you locate a feasible minimum point.

$$\text{minimum point}_{0.80} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(4{,}000)30}{0.32}} = 866 \text{ switches}$$

2. Because an order size of 866 switches will cost $0.85 each rather than $0.80 each, 866 is not a feasible minimum point for $0.80 per switch. Next, try $0.85 per unit.

$$\text{minimum point}_{0.85} = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(4{,}000)30}{0.34}} = 840 \text{ switches}$$

This is feasible; it falls in the $0.85 per switch range of 500 to 999.

3. Now compute the total cost for 840, and compare it to the total cost of the minimum quantity necessary to obtain a price of $0.80 per switch.

$$TC_{840} = \text{carrying cost} + \text{ordering cost} + \text{purchasing cost}$$

$$= \frac{Q}{2}H + \frac{D}{Q}S + PD$$

$$= \frac{840}{2}(.34) + \frac{4,000}{840}(30) + 0.85(4,000) = \$3,686$$

$$TC_{1,000} = \frac{1,000}{2}(.32) + \frac{4,000}{1,000}(30) + 0.80(4,000) = \$3,480$$

Thus, the minimum-cost order size is 1,000 switches.

Single-Period Inventory Model

Sometimes a unique situation that arises is one in which there will be demand for an item in only one period, so the challenge is to determine the order size (stock size) that will best accommodate the anticipated (and uncertain) demand. Any items stocked in excess of demand will be scrapped. Any demand in excess of what has been stocked will represent a missed opportunity for more profit. This problem is sometimes referred to as the newsboy problem, or the Christmas tree problem is used to handle ordering of perishables (fresh fruits, vegetables, seafood, cut flowers) and items that have a limited useful life (newspapers, magazines, spare parts for specialized equipment). The *period* for spare parts is the life of the equipment, assuming that the parts cannot be used for other equipment. What sets unsold or unused goods apart is that they are not typically carried over

from one period to the next, at least not without penalty. Day-old baked goods, for instance, are often sold at reduced prices, leftover seafood may be discarded, and out-of-date magazines may be offered to used book stores at bargain rates. There may even be some cost associated with disposal of leftover goods.

Analysis of single-period situations generally focuses on two costs: **shortage** and **excess**.

Shortage cost may include a charge for loss of customer goodwill as well as the opportunity cost of lost sales. Generally, **shortage cost** is simply unrealized profit per unit. That is,

$C_{shortage} = C_s$ = revenue per unit - cost per unit

If a shortage or a stockout relates to an item used in production or to a spare part for a machine, then shortage cost refers to the actual cost of lost production.

Excess cost pertains to items left over at the end of the period. In effect, excess cost is the difference between purchase cost and salvage value. That is,

$C_{excess} = C_e$ = original cost per unit - salvage value per unit

If there is cost associated with disposing of excess items, the salvage will be negative and will therefore *increase* the excess cost per unit.

The goal of the single-period model is to identify the order quantity, or stocking level, that will minimize the long-run excess and shortage costs.

There are two general categories of problems that we will consider: those for which demand can be approximated using a continuous distribution (perhaps a theoretical one such as a uniform or normal distribution) and those for which demand can be approximated using a discrete distribution (say, historical frequencies or a theoretical distribution such as the Poisson). The kind of inventory can indicate which type of model might be appropriate. For example, demand for petroleum, liquids, and gases, tends to vary over some *continuous scale*, thus lending itself to description by a continuous distribution. Demand for tractors, cars, and computers is expressed in terms of the *number of units* demanded and lends itself to description by a discrete distribution.

These discussed methods are but a few of the many variations to the basic EOQ model that are in existence. They all are designed to provide optimal answers to the how much and when questions. Choice of a model should be dictated by the characteristics of the inventory situation that you are facing.

Questions

1. Describe the major cost categories used in inventory analysis and their functional relationship to each other.
2. Explain how the order quantity is determined using the basic EOQ model.
3. What are the assumptions of the basic EOQ model and to what extent do they limit the usefulness of the model?
4. How are the reorder point and lead time related in inventory analysis?
5. How must the application of the basic EOQ model be altered in order to reflect quantity discounts?
6. Explain in general terms how a safety stock level is determined.

Problems

1. A company operates 250 days per year.

Annual demand (D) = 10,000 units per year.

Ordering cost (S) = $75 per order.

Holding cost (H) = $6 per unit per year.

Lead time = 5 days.

What is the EOQ, total annual inventory cost, number of orders placed, and time between the placements of orders?

Results of computations

- EOQ =
- Number of orders placed per year =
- Average inventory level =
- Annual ordering cost =
- Annual holding cost =
- Total annual inventory cost =

- Time between the placement of orders =

2. Consider calculating the total annual inventory cost, ordering cost and carrying cost using the following information.

Spreadsheet Implementation of EOQ Model		
Annual Demand	D	1000
Ordering Cost	S	$5.00
Holding Cost	H	$1.25
Lead Time	L	5
Item Cost	C	$12.50

Ordering cost

Carrying cost

Total annual inventory cost

3. A firm runs a mail-order business for gym equipment. Annual demand for the product number TS10 is 16,000. The unit cost is $25, the annual holding cost per unit is $2.50 and the cost to place an order is $50. Answer the following inventory policy questions for the company.

a- Calculate the EOQ.

b- What are the total annual inventory holding and ordering costs associated with your recommended EOQ?

Total annual inventory cost = Ordering cost + Carrying cost			
Q	(D/Q)*S	(Q/2)*H	TC
Order Quantity	Ordering Cost	Carrying Cost	Total Cost
10			
20			
30			
40			
50			
60			
70			
80			

90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			

c- What do you notice about the relationship between holding cost and ordering cost?

d- Use the information in the previous table to raw a graph to illustrate the relationship between holding cost and ordering cost and point the EOQ point.

e- If the company keeps a safety inventory to cover two days delay in supply, count the safety stock.

f- Assuming 250 days of operation per year and a lead time of 5 days, what is the reorder point for the Company?

g- Draw a graph to illustrate the different levels of inventory and discuss the importance of safety stock.

4. Electronic Village stocks and sells a particular brand of personal computer. It costs the store $450 each time it places an order with the manufacturer for the personal computers. The annual cost of carrying the PCs in inventory is $170. The store manager estimates that annual demand for the PCs will be 1,200 units. Determine the economic order quantity and the total minimum inventory cost.

The economic order quantity

The total minimum inventory cost

5. Use the following information:

- Annual demand = 12000 units
- Cost per unit = $6.75
- Ordering cost = $28
- Unit holding cost = $1.35
- Quantity each order = 461 units
- Number of orders = 26

Calculate:

- EOQ.
- Annual holding cost.
- Annual ordering cost.
- Combined cost.
- Annual purchase cost.
- Total cost.
- Draw the levels of inventory.
- Illustrate the relationship between holding cost and ordering cost.

6. Suppose the annual demand for an inventoried item is 1,200 units. The holding cost for it is $3 per unit per year. The ordering cost is $50 per order.

(6a) In this problem,

D=

S =

H =

(6b) If the current order quantity is Q=100 units per order, then

(a) The total annual ordering cost = S*(D/Q) =

(b) The total annual holding cost = H*(Q/2) =

(c) The total annual inventory cost =

7. Calculate the economic order quantity, Q*, for this problem.

$$Q^* = \sqrt{\frac{2DS}{H}} =$$

8. With the economic order quantity Q* as you have just calculated,

(a) How many orders will be placed in a year?

(b) What is the total annual ordering cost?

(c) What is the average inventory level?

(d) What is the total annual holding cost?

(e) What is the total annual inventory cost?

9. Suppose the order quantity is Q=300 units per order.

(a) Without calculations, the total inventory cost associated with this order quantity must be _____ that with Q*, the economic order quantity.

a. higher than b. lower than c. equal to

10. The total annual inventory cost associated with the economic order quantity, Q*, is the lowest comparing to any other order quantities.

a. True b. False

11. At the EOQ, the total annual holding cost is always _____ the total annual ordering cost.

a. greater than b. smaller than c. different from

d. same as e. None of the above. It depends on specific problems

12. A large bakery buys flour in 25-lb bags. The bakery uses an average of 4,680 bags a year. Preparing an order and receiving a shipment of flour involves a cost of $4 per order. Annual carrying costs are $30 per bag.

(a) Determine the economic order quantity

(b) What is the average number of bags on hand?

(c) How many orders per year will there be?

(d) Compute the total cost of ordering and carrying flour.

(e) If annual costs were to increase by $1 per order, how much would that affect the minimum total cost?

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