C4: Operations Management

Module 4

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Contents

Module 4

Introduction

This module is about inventory, supply chain management, projects and performance measurement.

At first sight this may appear a real mix of topics, however, the whole course has been building towards this end. We have developed processes and improved processes so we can deliver products and services to satisfy customer requirements.

Inventory is the output of a production system and is used as inputs to other production systems and during service delivery. The supply chain describes the flow of raw material inventories from suppliers through plants that transform them into useful products and finally to distribution centres that deliver those products to end customers.

So that takes care of inventory and supply chain management.

In a modern business, most process improvement initiatives are undertaken as a project. This is particularly true for six sigma quality projects. A project is a once-only activity and can change the way a business operates and sometimes this change is irreversible. That makes project success so important.

Finally, performance measurement provides the means for determining progress and measuring success (or failure). Business organisations regularly report on their financial achievements and not-for-profit organisations have to achieve results within limited expense budgets that have to be contained.

Traditional performance measurement that measures profit, or return on investment, is relatively easily understood. The approach today requires a proliferation of measurements and these include dimensions that are quantitative as well as qualitative.

Outcomes

Upon completion of this module you will be able to:

- *Explain* the reason for having inventory.
- *Explain* various inventory models including sales and operations planning, material requirements planning (MRP) and manufacturing resource planning (MRP II).
- *Discuss* the theory of constraints.
- *Define* supply chain management from a strategic view.
- *Discuss* the bullwhip effect or demand amplification.
- *Define* collaborative supply chains.
- *Describe* the nature of project management and the strategic nature of projects.
- *Describe* project organisation structures.
- *Discuss* the critical chain method.
- *Describe* measurements for business excellence.
- *Describe* the Hoshin process for setting goals and using measurement systems.
- *Describe* the balanced scorecard approach to performance measurement.

Unit 9

Inventory planning and management

Introduction

The terms “stock” and “inventory” are synonymous as far as operations management is concerned. The term stock is possibly more widely, although not exclusively, associated with finished goods. In retailing, for example, the goods in store and on the shelves are referred to as stock. Both terms are employed in manufacturing industries although the term inventory is probably more widely used.

In some applications inventory is held to provide immediate supply but in manufacturing, inventory is not restricted to finished products. Manufacturers use raw material inventory, work in process inventory as well as maintenance and operating supplies.

Managing how much to order, and when, occupies considerable attention within the operations function. By planning the time when specific types of material are available or requesting specific products to be made, we can co-ordinate the work within the firm. This is usually provided by material requirements planning and enterprise resource planning systems. This leads directly to ideas about different lot-sizing rules and the different ways of controlling the system in long, medium and short time frames.

The theory of constraints is implemented in many organisations and is often combined with lean thinking ideas to provide hybrid implementations.

In this unit we start by defining inventory and explaining why an organisation should have inventory. This is followed by an explanation of why the economic order quantity is not appropriate for modern business, even though it is widely used and accepted. Several models, including a fixed-order quantity model and a periodic review model, are introduced and lead times and safety stocks are discussed.

The processes for sales and operations planning, material requirements planning (MRP) and manufacturing resource planning (MRP II) are discussed and put in perspective.

The theory of constraints is introduced by describing a bottleneck process. This is followed by an explanation of the theory of

constraints, logical thinking process and the drum-buffer-rope concepts.

We conclude by describing the operations scheduling process including backward and forward scheduling and finite and infinite loading.

Upon completion of this unit you will be able to:

Outcomes

- *Explain* the reason for having inventory.
- *Explain* why the economic order quantity is not appropriate for modern business.
- *Describe* a fixed-order quantity model and a periodic review model.
- *Describe* how lead times and safety stock affect inventory management.
- *Describe* the process for sales and operations planning.
- *Describe* material requirements planning (MRP).
- *Describe* manufacturing resource planning (MRP II).
- *Explain* a bottleneck process.
- *Discuss* the theory of constraints.
- *Explain* the theory of constraints logical thinking process.
- *Discuss* the drum-buffer-rope.
- *Describe* the operations scheduling process.
- *Differentiate* between backward and forward scheduling.

Terminology

Bill of materials (BOM) Bill of materials (BOM) is a listing of the number and type of sub-assemblies, components and raw materials needed to make an assembly. Bills of materials are also called formulas, recipes, formulations or ingredient lists.

Bottleneck Bottleneck is an operation, resource, function or facility that has insufficient capacity to meet demand.

Carrying cost Carrying cost is the cost of carrying or holding inventory. Carrying cost depends mainly on the cost of capital invested in the inventory but also includes insurance, obsolescence, spoilage and space occupied. It includes all warehouse operational expenses such as receiving, putting away, picking and delivery functions. If, for example, the inventory requires temperature and atmosphere-controlled storage, the carrying cost is considerably higher than inventory that can be

	stored in ambient conditions.
Capacity constrained resource (CCR)	Capacity-constrained resource is a resource that is not a constraint but can become a constraint unless scheduled carefully.
Constraint	Constraint, in theory of constraints, is any resource lack that prevents the system from achieving continuously higher levels of performance.
Finished goods inventory	Finished goods inventory are the items for which all the production processes have been completed.
Fixed order quantity	Fixed order quantity is a lot-sizing technique that sets the order quantity to a fixed quantity or a multiple of a fixed quantity.
Inventory	Inventory is the stock of items used to support production processes (raw material and work in process), customer service (finished goods and spare parts) and other activities such as maintenance and repairs.
Lead time	Lead time is the time between recognition of the need for an order and the receipt of that order.
Material requirements planning (MRP)	Material requirements planning (MRP) is a set of techniques that uses bills of material, inventory data and the master production schedule to calculate the requirements of component materials. MRP starts with each specific item and quantity listed in the master production schedule and calculates the quantities of all components and materials required to make those items, and the date those items must be available for use. MRP explodes the bill of material, makes adjustments for inventory quantities that are on hand or already on order, and calculates net requirements that are offset by the lead time.
Manufacturing resource planning (MRP II)	Manufacturing resource planning (MRP II) is a method for the effective planning of all resources of a manufacturing company. Ideally it addresses operational planning in

	units, financial planning in dollars, and has a simulation capability to answer what-if questions.
Ordering costs	Ordering costs are the costs incurred because of the work involved in placing purchase orders with suppliers and organising the ordered items for production within a plant. It includes costs associated with preparing, releasing, monitoring, receiving and payment of orders.
Periodic review system	Periodic review system is an inventory management system in which the inventory position is checked only at fixed intervals. It is synonymous with fixed order period inventory model.
Planned order	Planned order is a suggested order quantity, release date and due date created by the logic of a planning system when it encounters a net requirement in MRP. Planned orders are created by the computer, exist only within the computer and may be changed or deleted by the computer during subsequent processing if conditions change.
Raw material inventory	Raw material inventory was originally the raw material extracted from the ground to start a production process. Now it is any purchased or extracted item used as input to the production process and converted into components and finished products.
Reorder point	Reorder point is a predetermined inventory level where, if the total stock on hand plus on order reaches this point or falls below it, a replenishment action is initiated. The order point is usually calculated as the demand during replenishment lead time plus safety stock.
Safety stock	Safety stock is a quantity of inventory used to protect against fluctuations in demand and/or supply. Supply and usage fluctuations include an allowance for a known percentage of reject material. So, when a material consistently contains a small percentage of reject, this percentage should be factored into safety

stock.

Sales and operations planning	Sales and operations planning is a business process that helps companies keep demand and supply in balance. It does that by focusing on aggregate volumes (product families and groups) so that mix issues (individual products and customer orders) can be handled more readily. It occurs on a monthly cycle and displays information in units and dollars. It links the company's strategic plans and business plan to its detailed processes. Used properly, it enables the organisation's managers to view the business holistically and gives them a window into the future.
Service level	Service level is the probability that customer demand will be satisfied by current inventory or planned production in time to meet customer-requested delivery dates and quantities.
Set-up costs	Set-up costs are the fixed costs associated with production that include paperwork, machine set-up, calibration, downtime and start-up scrap that can be associated with the changeover from one product to the next.
Target inventory level	Target inventory level is the quantity set as the target level and equals the order point plus a variable order quantity.
Theory of constraints	Theory of constraints (TOC) is a philosophy of continuous improvement based on the premise that constraints determine the performance of any system.
Work in process (WIP) inventory	Work in process (WIP) inventory is the material and components in a production process between the first input (raw material) and the final output stage (finished goods).

Terminology sourced from Gardiner (2010).

Inventory – definitions and purpose

Inventory is the stock of items used to support production processes (raw material and work in process), customer service (finished goods and spare parts) and other activities such as maintenance and repairs.

Raw material inventory was originally the raw material extracted from the ground to start a production process. Now it is any purchased or extracted item used as input to the production process and converted into components and finished products.

Work in process (WIP) inventory is the material and components in a production process between the first input (raw material) and the final output stage (finished goods).

Finished goods inventory are the items for which all production processes have been completed.

Inventory management is the process of planning and controlling physical inventory.

Nearly all organisations have inventory although some service organisations may not call it inventory and may not visualise inventory as a problem.

It is easy for production organisations to visualise inventory since they are purchasing raw materials in (large) quantities and transforming them into finished goods all the time. That is their role in life. They survive by being able to manage the inflow of raw materials, process them effectively through production processes and sell the outputs to customers.

Service firms have inventory as well. Supermarkets have inventory stocks on their shelves and constantly replenish empty spaces as customers remove items from the shelves. Restaurants have food items as inventory and the kitchen staff estimate how much is required on a regular basis and purchase accordingly. Hospitals and medical centres purchase medicines, pharmaceuticals, instruments, dressings, food, blood supplies and cleaning materials. Banks and financial institutions have stocks of stationery, information technology equipment and other items. Property management organisations hold an inventory of properties being managed. Plumbers, builders, painters and maintenance companies carry limited amounts of inventory with employees as they travel from one job to the next. Domestic households have a refrigerator and a pantry with food items waiting to be consumed by the household.

Service inventory refers to the tangible goods to be sold and sometimes it is required to deliver the service. Service inventory may be classed as goods for sale or rent, physical space, number of workspaces, service personnel, productive equipment and supplies.

All of these are inventory and all have the same inventory problems to solve. What is the order quantity? When should the order be placed?

Inventory management is the process of planning and controlling physical inventory.

Activity 4.1

Activity

Now that we have introduced the subject, reflect on what inventory does for an organisation. Think of an organisation with which you are familiar and try answering these questions:

1. How much inventory should the organisation have?
2. When should you pay for it?
3. How much should you pay for it?
4. What happens if you have too much inventory?
5. What happens if you have too little inventory?
6. Where is inventory stored?
7. How much storage space is required?
8. How is inventory transported?
9. How much inventory is transported at one time?
10. How is inventory stored?
11. What happens if the inventory is a hazardous substance (or dangerous to handle)?
12. How do you keep track of what inventory you have?
13. What is the value of the inventory you have?
14. What can you do with the inventory you do have?
15. We could consider many more questions at this stage but the above give some idea of where we are heading.

Why have inventory?

The main reason for holding inventory is because of demand uncertainty. If an organisation knew exactly what demand would be tomorrow it could take immediate steps to ensure it had exactly that quantity ready for sale (or use) first thing tomorrow morning. By evening, all would be sold (or used) and inventory would be zero. The real situation is not as easy as this and the problem starts because firms do not know exactly what demand will be tomorrow, or the next day, so they hold extra stock to maintain a service level or just in case.

Usually, demand varies from day to day and demand requirements are available as a probability distribution. Safety stocks are maintained to provide some level of protection against stock-outs. One approach is to set the safety stock at a point that allows a specified percentage of total demand to be met from stock on hand. This is called the service level.

Service level is the probability that customer demand will be satisfied by current inventory, or planned production, in time to meet customer-requested delivery dates and quantities. Lead time is the time between recognition of the need for an order and receipt of that order. Organisations may carry some safety stock to protect them from demand and lead time fluctuations.

If delivery was instantaneous and delivery quantities guaranteed, there would be no need to store inventory. Electricity and water supplies for individual consumers are replenished instantly and whatever quantity is required is available (within reason). This example is based on an organisation or a household in a town or city in a developed country. It does not belittle the supply problems of the generation, distribution and supply organisations as they manage limited resources to maintain the instantaneous replenishment and flexible volume requirements demanded of their services.

Some organisations use lead time-based pricing as a way to increase revenue when demand is random and capacity fixed. Using this model, a make-to-order firm, operating in its own best interests, can dynamically quote lead times and vary the associated prices when customers accept, or reject, a delay in delivery. The policies are both highly intuitive and provide delay guarantees for all served customers. Shorter delivery periods carry higher prices. Significant revenue benefits to the supplier can accrue by using these dynamic policies and, likewise, cost benefits accrue to the customer when they adjust their expectation of delivery time.

Food processing companies buy up the entire harvest during harvest time and partially process the food so that it can be held for some months before continuing the process. Therefore, the

inventory is obtained during periods of abundance to compensate for periods of restricted supply, or even no supply. Tomato processing and green pea processing are examples of crops that are usually owned by the processing company or contracted before the seeds are sown. The contract might say the company will take the lot regardless of available quantity at harvest. This provides guarantee of a sale to the farmer, but provides processing uncertainty to the processor.

Sometimes inventory is held so that it can appreciate in value. This may be seen as an investment opportunity, but nevertheless is an investment in inventory and requires the same management decisions as regular purchases of depreciating inventory. Examples of appreciating inventory are fine art, stamps and fine wines.

Some organisations obtain inventory in bulk to obtain a lower unit price. This is referred to as a lot-size inventory and is a good practice when the quantity obtained matches a shipping quantity such as a pallet or a container and the quantity itself can be consumed in a reasonable timeframe. It is not good practice when storage costs, quality issues, obsolescence, pilferage and other carrying costs are greater than the gain made with the initial purchase.

Pipeline inventory is inventory in the transportation network and in the distribution system. Someone owns it and someone is carrying the cost of ownership. Pipeline inventory can be reduced when the supplier is near the customer and delivery methods fast. Flow time through the pipeline has a major effect on the amount of inventory required in the pipeline. The quantity of inventory in a pipeline is generally inversely proportionate to the flow time.

Economic order quantity model

The economic order quantity model considers ordering costs (set-up), carrying costs (storage) and purchase costs (acquisition) and calculates an optimum order quantity.

Ordering cost is the cost incurred to issue purchase orders with suppliers and to issue manufacturing orders within a factory. Typical costs include those associated with preparing, releasing, monitoring, receiving and payment of orders, and the physical handling of inwards goods.

Carrying cost is the cost of carrying or holding inventory. Carrying cost depends mainly on the cost of capital invested in the inventory but also includes insurance, obsolescence, spoilage and space occupied.

The inventory debate has traditionally been cost-based. The total cost of inventory is added up and inventory analysts attempt to

minimise the total cost of inventory. Organisations try to cut inventory costs by optimising the total cost equation.

This is a staple diet for nearly all books and courses on inventory. However, the economic order quantity model is not appropriate for modern business applications.

To calculate the optimum lot size requires the following assumptions:

- All costs are assumed to be variables, when for most organisations they are fixed. The permanent staff involved with processing orders and fulfilling warehouse functions are fixed (monthly salaries for example) and do not vary as a function of order sizes and numbers of orders.
- Production is assumed to be instantaneous, suggesting that capacity is not constrained.
- Delivery is assumed to be immediate, indicating no delay between production and availability.
- Demand is assumed to be deterministic, which means there is no uncertainty about quantity or timing of demand.
- Demand is assumed to be constant over time and so constant that the demand curve is a straight horizontal line.
- Each production run is assumed to incur a fixed set-up cost, which is the same regardless of actual quantity being made and regardless of the previous job that was running.
- It is assumed the products can be analysed individually, which suggests there is no sharing of resources.

Very rarely will these assumptions hold true. For most organisations capacity is a constraint, at least for some of the time and demand is not usually deterministic and definitely not constant over time. As for set-up, the time to perform a set-up varies according to the previous product being made and the teardown is a function of the following product. Thus, set-up is a variable and not a constant.

Additionally, it does not consider the cost of not having inventory.

Organisations that use the economic order quantity use an arbitrary value for holding inventory and an arbitrary value for ordering. These values are rarely reviewed and can be manipulated to force long runs and large batches.

Sufficient inventory is enough

For want of a nail the shoe was lost

For want of a shoe the horse was lost

For want of a horse the rider was lost

For want of a rider the battle was lost

For want of a battle the kingdom was lost

And all for the want of a horseshoe nail.

(Attributed to Benjamin Franklin, 1758)

The correct amount of inventory is sufficient to satisfy customer demand. A balance is required between the cost of having inventory and the cost of not having it.

Lead time is the time between recognition of the need for an order and receipt of that order. The longer the lead time, the longer the period of demand uncertainty and the greater the possibility of lead time variation, therefore the greater the need for safety stock. Safety stock is an overhead cost and when not being used on a regular basis it acts as an additional storage and cost burden for the organisation. The need for safety stock diminishes as demand uncertainty and lead time decreases.

Inventory turnover is the number of times an inventory "turns over" in a year. The usual method to calculate inventory turnover is to divide the annual cost of sales by the average inventory value. Inventory turnover or inventory turns is a common measure for evaluating inventory. A higher number of turns are better. It is a good check on how the inventory model is performing, even if the calculations are not accurate.

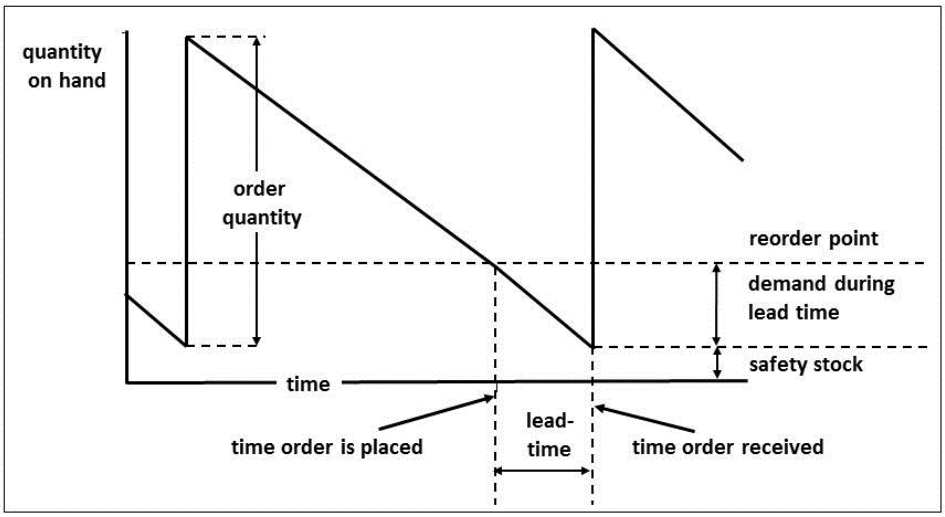
A supermarket should experience inventory turnover of at least 50 per year or once a week. The metric measures inventory turnover but excludes service level.

Inventory models

The demand for inventory can be either independent or dependent. Independent items supply the demand that comes from outside the organisation. These can be managed by fixed quantity, fixed period, minimum-maximum, or budget allocation inventory control systems. Dependent demand items supply requirements from inside the organisation. They are components of other products so their rate of use is dependent on the production schedule and the rate of use of the parent items. Dependent demand items are managed by material requirements planning and lean thinking approaches to keep inventories as low as possible.

A reorder point is a predetermined inventory level where, if the total stock on hand plus on order reaches this point or falls below it, a replenishment action is initiated. The order point is usually calculated as the demand during replenishment lead time plus safety stock.

Fixed order quantity is a lot-sizing technique that sets the order quantity to a fixed quantity or a multiple of a fixed quantity. In this system, a predetermined constant quantity is ordered whenever the number of units on hand reaches a specified reorder point. This means the same amount is ordered each time.



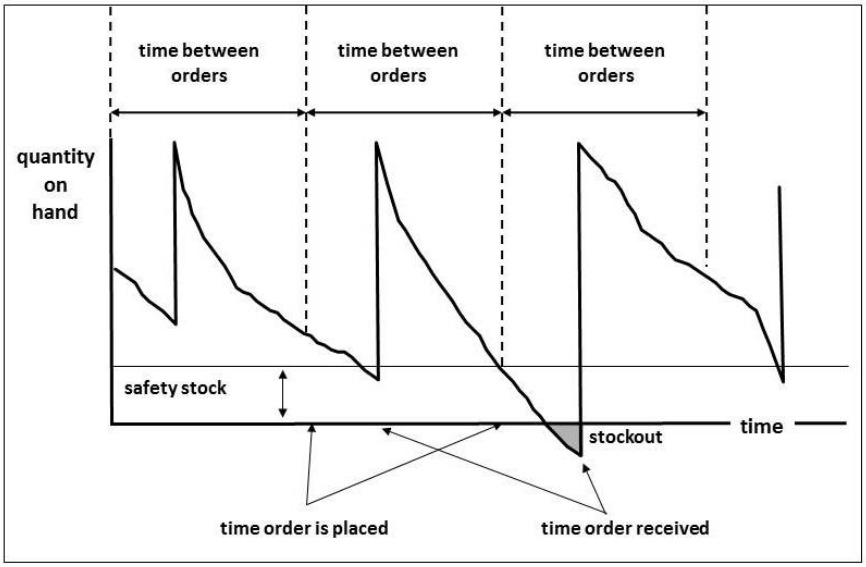
(Gardiner, 2010, p. 276)

The diagram above illustrates the fixed order quantity model. The quantity ordered each time is a constant. As an example, an organisation orders 100 units every time (or multiples of 100). The reorder point can be calculated and equals the demand during the lead time plus any safety stock requirements.

This model works when the predicted demand during the lead time is close to actual demand and the safety stock is sufficient to cover variations of demand. This model fails, however, when actual demand exceeds predicted demand by more than the safety stock. The stock-out problem is alleviated by short lead times, reliable suppliers and a dynamic safety stock calculation.

Periodic review is an inventory management system in which the inventory is checked only at fixed intervals. In this system, an order is placed at the end of a specified period and the quantity is adjusted to bring inventory up to a predetermined level. This system is very common with small retail outlets that deal with high volumes of low-valued items. They may check their inventory once a week or when the supplier representative calls for an order.

The order quantity has to be sufficient to last from the time the order is received until the next order is received. The quantity ordered considers the demand during the review period plus the demand during the lead time.



(Gardiner, 2010, p. 277)

The diagram above illustrates the periodic review model. The time between placing each order is a constant (for example, an order is placed every Wednesday morning).

Calculations based on the periodic review system use target inventory level which is the quantity set as the target level and equals the order point plus a variable order quantity.

Most inventory models use a reorder point. As inventory is consumed the quantity on hand diminishes until it reaches some arbitrary point called the reorder point. When this point is reached a trigger of some sort initiates a replenishment order. Possibly the most common trigger signal is the orange light on a motor vehicle dashboard to indicate low fuel levels. When interpreted correctly, it signals that the vehicle requires additional fuel. Some drivers may estimate how long they have before they run out and this may be 50–100 kilometres. Depending on the driver, the conditions and the level of risk that can be tolerated and the level of excitement required, this trigger might indicate two or three days of driving. Whichever way you look at it, it is a reorder point.

With inventory models the key questions relate to order quantity, order time, lead time and time of order receipt. Quantitative analysis becomes complicated and convoluted as analysts attempt to find the optimum quantity to be placed at the optimum time so that optimum performance is achieved. The complication develops with demand uncertainty. When demand is known the calculations become easier. The other difficulty is lead time uncertainty. When lead time is known and reliable the calculations become easier.

Sales and operations planning (S&OP)

Sales and operations planning is a business process that helps organisations balance demand with supply. It does that by focusing on aggregate volumes (product families and groups) so that mix issues (individual products and customer orders) can be handled more readily.

It usually occurs on a monthly cycle and displays information in quantity units and financial units. It links the organisation's strategic plan and business plan to its detailed processes. Used properly, it enables the organisation's managers to view the organisation holistically and gives them a window into the future.

The monthly process starts with an unconstrained baseline demand forecast. The sales team captures actual customer demand, regardless of any influencing factors (in other words, unconstrained). The demand capture process involves working collaboratively with end customers to understand the true demand drivers. This demand is presented at an aggregate or family level, and extends from three months to three years. Typically, an organisation would have between six and 12 groups or families.

The sales and marketing function makes adjustments based on planned advertising and promotional activity and considers any new product launches, competitive activity, economic conditions and industry dynamics before releasing the plan to operations and supply chain for their inputs.

The operations and supply chain function uses the demand data from sales and marketing and attempts to balance supply with demand. Key information such as the business inventory strategy, production throughput capacity, production constraints, supply chain capacity and all internal constraints such as workforce, health and safety, shifts and so on are brought into the mix.

Supply attributes are considered on a rough-cut basis which does not consider inventory levels and production lead times. Accuracy, reliability and consistency of all demand and supply data is critical and has to represent what can and will be delivered. This analysis may identify demand which cannot be met or supply that exceeds demand. Data used to identify supply constraints must represent reality and provide some credibility to the decisions made in subsequent planning meetings. Demand, supply, financial, new product development and performance measurement data has to be consistent and accurate to maintain the integrity of the entire process.

The sales, operations and supply chain functions meet regularly to develop the final operating plan for the following periods. This team is cross-functional and includes sales and marketing (demand

management, forecasting), operations (purchasing, inventory management, supply chain, operations, master production scheduling, warehousing, transport), new product development and finance.

Sales and operations planning sets the volume of production required to meet demand and subsequent steps disseminate the volume figures into specific product, quantity and date.

Various scenarios are discussed until agreement on the final volume plan is reached. When agreement cannot be reached, the planning meeting documents the issues, researches the options and presents these for senior management to resolve.

Upon agreement, both the demand and the supply numbers are disseminated for detailed planning by the operations, supply chain and sales functions. A mature planning process is capable of highlighting potential issues and constraints, and communicating collaboratively with customers and suppliers. This allows external parties full visibility of the confirmed plan so they in turn can plan more accurately.

A formal meeting to sign off the plan is convened, usually towards the end of the planning month. All functions attend and sign off on the plan for the next period. Moreover, the signing process is indicative that they are prepared to deliver precisely to that plan. Often this step is described as “signing with blood” and because of this connotation, senior executives should champion the whole process to ensure it maintains the correct focus.

Organisations often struggle to implement sales and operations planning processes due not only to the need to develop new business processes, but also the need to develop a new internal collaborative culture and a breaking down of functional, isolating silos. When developed, the model needs to be continuously improved to incorporate gradual changes in the understanding and requirements. This framework moves from the silo-driven to event-driven collaboration and the organisation moves from limited integration to a seamlessly integrated organisation that focuses on organisation profit optimisation rather than using a cost/profit-centre approach.

Material requirements planning (MRP)

Manufacturing requirements planning (MRP) was developed in 1960 by Joseph Orlicky (1975). Before this, manufacturing companies managed all inventories as if they exhibited independent demand. They relied on the reorder point to trigger the need and fixed order quantities to satisfy that need. Manufacturers relied on

excess stocks, rough estimates and hoped that they had enough materials.

Orlicky used a computer (albeit very slow by today's standards) to calculate the requirements of each component that made up the finished product. Starting with a statement of the specific quantity of each specific product for each specific required date, called the master production schedule, he exploded the bills of material to calculate the quantities of components. He considered the lead time for each item and offset the release of the replenishment order to compensate for the lead time. Progressively, this built up gross requirements at the next level down the bill of material so he subjected these to the same logic.

This development had profound implications for manufacturing systems.

The driver to this method is the master production schedule, which has to be realistic and achievable. At the finished goods level, it reflects the quantities of finished products that must be available for sale in each time period. If this is a true statement the subsequent calculations may deliver meaningful results.

The bill of materials should reflect actual material requirements per item. The bill of materials is like a recipe or a formula. In fact, some industries, such as pharmaceuticals and food processing, refer to their bills of materials as recipes and formulas. Some compensation is introduced to allow for variation, scrap, wastage, shrinkage, loss, pilferage and misplacement. The quantity for each is the quantity of the component for one of the parent items. This number has to be correct.

Lead times are usually entered as fixed numbers and these offset the release of each replenishment order. So an item will be reordered next week if it is required in four weeks and it takes three weeks to be delivered. This allows raw material supply to be calculated and delivered at the latest possible due date.

Inventory accuracy of quantities on hand and on order is required. If the computer shows an item is in plentiful supply, the MRP system will not suggest replenishment. If the storage bin is empty, it remains empty until the item is required, at which time it is too late to obtain replacement.

This capability reduces inventory, reduces idle time, reduces set-up and tear-down costs, increases sales and provides better customer service and response to market demands.

MRP systems are well developed and the logic is quite straightforward. The theory of MRP is right, but the execution leaves a lot to be desired. The variables are too great for many organisations to manage.

Activity 4.2

Activity

Now that we have introduced the subject of material requirements planning, try answering this question:

What data is required to develop a very basic MRP?

Activity feedback can be found at the end of this module.

Material resource planning (MRP II)

Manufacturing resource planning (MRP II) is a method for the effective planning of all resources of a manufacturing company. Ideally it addresses operational planning in units, financial planning in money units (dollars) and has a simulation capability to answer what-if questions.

Oliver Wight and George Plossl (Orlicky 1975) pioneered the concept of manufacturing resource planning (MRP II) which is linked to MRP but adds all the activities of a manufacturing company, including sales, purchasing, finance, maintenance, design and engineering.

Manufacturing resource planning (MRP II) plans all the resources of a manufacturing company including business planning, sales and operations planning, master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity requirements planning and production. Output of these systems is integrated with financial reports such as the business plan, purchasing commitment plans, logistics budgets and inventory projections. Manufacturing resource planning (MRP II) is a direct outgrowth and extension of MRP.

Constraint management

When a process is flowing, the inputs are processed as they arrive and the outputs delivered to customers as they demand them. It would be marvellous if this actually happened.

Bottleneck processes hold up production and are usually easy to identify because a queue forms in front of the process because the process has insufficient capacity to meet demand.

By definition, a bottleneck process is slower than other processes. When non-bottleneck processes get behind, they have the ability to

catch up because they are not the slowest. However, the slowest process can never catch up because other processes are faster.

Thus, the bottleneck becomes the constraint that limits system performance and total output can never exceed the average output from the constraint.

A non-bottleneck is a resource whose capacity is greater than the demand placed upon it and it contains idle time. A capacity-constrained resource is one whose utilisation is close to capacity and could become a bottleneck if not scheduled carefully.

The theory of constraints emphasises the need to identify and manage constraints or bottlenecks within the production system, the organisation itself, or the network of supply and distribution activities.

Common constraints involve machines and people. Each machine is capable of producing a volume of output which is its capacity. People are capable of delivering an amount of work, which is their capacity. When these capacities are insufficient to meet demand they become constraints or capacity-constrained resources.

Effective planning and management of capacity-constrained resources uses realistic production goals that consider capacity constraints. Production plans, master production schedules and all other plans should focus on bottleneck activities since these limit system outputs. Unrealistic demands on bottleneck resources create unrealistic demands and expectations on the entire system.

Operations managers should adapt work flows to encourage effective use of capacity-constrained resources.

Theory of constraints

Eliyahu Goldratt and Jeff Cox (1984) introduced the theory of constraints in the book, *The Goal: A Process of Ongoing Improvement*. The book is a novel as well as a powerful textbook. It is about creating and accepting improvements, making continuous progress and changing for the better.

Theory of constraints (TOC) is a philosophy of continuous improvement based on the premise that constraints determine the performance of any system.

The philosophy is based on three very interesting definitions: throughput, inventory and operating expense.

- Throughput is the rate at which the firm generates money through sales.
- Inventory items purchased for resale including finished goods, work in process and raw materials. In the theory of constraints, inventory is valued at purchase price and

includes no added-value costs. This is in contrast to the traditional cost accounting practice of increasing the value of inventory as the item progresses through production.

- Operating expense is the money spent in converting inventory to throughput.

Goldratt and Cox (1984) explain that the goal of the firm is to make money by:

- Increasing throughput, which is the rate at which money is generated by sales.
- Reducing inventory, which is the money spent on buying items for subsequent sale.
- Reducing operating expense, which is the money spent to convert inventory into throughput.

Traditionally, management emphasises reducing operating expense and reducing inventory. Organisations take pride in proclaiming they are on a "cost-cutting drive". They target opportunities to cut expenses and reduce inventory. Expenses are easy to cut when the organisation stops spending money. Likewise, inventory is easy to reduce when the organisation stops replenishing supplies.

Looking at both operating expense and inventory, what happens when the organisation reaches zero? Managers argue that they will not actually reach zero and they will stop before they reach that limit. But they do not tell anyone where to stop, when to stop or how to stop. They just say, "Reduce operating expenses and inventory!" The finite limit is zero.

What kind of organisation have you built when operating expense is zero and inventory is zero?

There is no finite limit to increasing throughput, which is defined as the rate at which money is generated by sales.

The theory of constraints uses a logical thinking process to evaluate a system and seek to improve its performance by following these steps:

1. Identify the system constraint.
2. Decide how to exploit the constraint.
3. Subordinate everything else to the constraint.
4. Elevate the constraint in the system.
5. If the constraint is broken, return to step 1.

Drum-buffer-rope is a finite scheduling process that balances the flow of the system. The drum is a system constraint or other critical resource that sets the pace that drives the rest of the schedule. Buffers are work in process inventories maintained just in front of the resource. The ropes are schedules that tie the release of raw

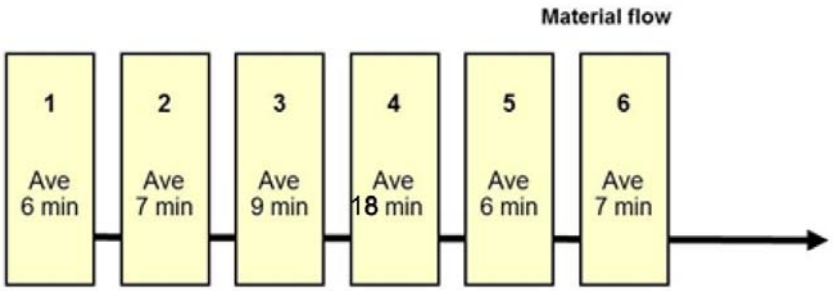
materials and customer promise dates to the production at the drum.

Production is controlled using a drum at the bottleneck. This is a figurative term because the drum strikes the beat for the rest of the system. All parts of the process influenced by the drum respond to the drum beat. If there is no bottleneck, then the drum is located at a capacity-constrained resource.

Two things happen at the drum:

1. A **buffer** inventory (or time buffer) is placed in front of the bottleneck or capacity constrained resource to make sure it never runs out of work. If it does run out of work it will never catch up so it should always have something to work on.
2. A **rope** or communication link is established upstream to the material release point so new work is released to the system at the rate it is passing through the bottleneck or capacity-constrained resource. It releases work to the beat of the drum.

The buffer is used to decouple, or eliminate, direct dependencies between resources. A time buffer creates a physical amount of stock which is sufficient to last for an order delivery period. A constraint buffer is placed immediately before the constraint to make sure the constraint does not run out of work. An assembly buffer uses non-constraint parts before an assembly to make sure any assembly can be put together. A shipping buffer is placed immediately before shipping to absorb disruptions that could delay shipment.



In the diagram above, the material is flowing from left to right and passes through six process steps. Process step four is by far the longest and takes twice as long as step three. Assuming all process steps keep working, it will not take long for a queue to form in front of process step four. Process step four is the bottleneck. It does not matter how fast or how long the other process steps operate because the output of the total process is determined by the performance at process step four.

Knowing that process step four is the bottleneck, it is essential for the production planner to ensure process step four does not run out of work to do (assuming demand remains). Therefore, the production planner puts a buffer stock of work in process between process step three and process step four. The quantity of the buffer stock can be calculated depending on demand but could. For example, be equivalent to one day's production.

A number of operating guidelines develop from the theory of constraints.

- The material flow through the factory should be balanced, rather than balancing the capacity.
- An hour lost at a bottleneck is an hour lost to the entire system since it can never catch up.
- An hour lost at a non-bottleneck can catch up since the non-bottleneck is faster than the bottleneck.
- Bottlenecks govern throughput, inventory and quality.
- Processing batch sizes should be allowed to vary both along an order's route and over time.
- Lot sizes should be variable and not fixed. Lot sizes are a function of the schedule and thus should not be fixed over time or from one operation to the next. When different components are manufactured on different machines, the lot size should be varied to achieve a smooth and timely flow of products to the customer.
- Production schedules should simultaneously accommodate all constraints.
- Lead times result from scheduled sequences, so planners cannot determine them in advance. Lead times are usually determined before the product is made and is often communicated to the customer in advance. These are usually accepted as fixed periods.

The theory of constraints requires that schedules are established once all the system constraints are known and this suggests that perhaps, by adjusting the schedule, client lead times in the supply chain can be improved.

The objective of operations scheduling is to meet customer delivery promise dates. Inherent in this objective is the need to minimise lead times, set-up time, work-in-process inventory and use of resources.

Scheduling and controlling operations involves the dynamic interaction of a constantly changing variety of jobs that are usually competing for the same resources. Many random variables, such as

differences in materials, skills, attitudes and machine breakdowns influence performance. Many criteria could be used and some are mutually conflicting.

The process of determining which product is started on a particular machine or process is known as priority sequencing.

The scheduling problem in service organisations concentrates on staffing levels and scheduling each work period. Various cut-and-try heuristics and optimising methods are used.

Load is the amount of planned work scheduled and the actual work already released to a facility, or a work centre, for a specific period. It is usually expressed in a common unit such as standard hours or units of production.

Load profile is a graphical display of future capacity requirements based on released orders and/or planned orders over a given time period.

Forward scheduling is a technique that starts with a known start date and schedules each activity to follow the finish of the previous activity.

Backward scheduling is a technique that starts with a known order due date and schedules each preceding activity to end at the start of the following activity.

Activity 4.3

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Explain why the economic order quantity model is not appropriate for modern business.
2. Explain the difference between MRP and MRP II.
3. Explain the sales and operations planning process.
4. Explain why sales and operations planning is performed at the aggregate level.
5. Explain the theory of constraints.
6. Explain how the drum-buffer-rope works.
7. Explain the difference between a capacity-constrained resource and a bottleneck.
8. Explain why an organisation might carry safety stock.

Unit summary

Summary

In this unit you learned about the reason for having inventory and why the economic order quantity is not appropriate for modern business. We described a fixed-order quantity model and a periodic review model and how lead times and safety stock affect inventory management.

The process for sales and operations planning, material requirements planning and manufacturing resource planning were discussed.

Under the general topic of theory of constraints, we explained a bottleneck process, discussed the logical thinking process and discussed the drum-buffer-rope method for production scheduling.

We described the operations scheduling process and differentiated between backward and forward scheduling.

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Unit 10

Supply chain management

Introduction

The role of collaboration and co-operation in operations needs to be emphasised as something that should be designed into a product or service from the onset rather than being considered as an afterthought.

Customer requirements for flexibility, agility, cost efficiency and product variety force companies to reconfigure their supply chains to meet those requirements.

This unit will focus on external influences on operations looking at how suppliers, and those that are supplied, affect the design of an internal operation. It will also look at the operational implications of partnerships; how they come about, how they can be managed and how they evolve.

This study unit will introduce key concepts and strategies related to the management of supply chains starting with a definition of supply chains and examining supply chains from a strategic view.

The bullwhip effect (or demand amplification) is discussed.

The concept of collaborative supply chain is introduced with reference to the Triple-A approach involving agility, adaptability and alignment.

The purchasing function and replenishment programmes are introduced.

Outcomes

Upon completion of this unit you will be able to:

- *Define* supply chain management from a strategic view.
- *Discuss* the bullwhip effect or demand amplification.
- *Define* collaborative supply chains.
- *Explain* the triple-A approach to supply chains.
- *Discuss* the strategic role of inventory in supply chains.
- *Discuss* the criteria for supplier selection.

Terminology

Agility	The ability to economically produce a variety of products in any quantity with rapid changeovers. Agility merges the four competitive capabilities: cost, quality, delivery and flexibility.
Bullwhip effect — demand amplification	Creates large oscillations of inventory in the supply chain network. Large changes in the supply position upstream are caused by small changes in downstream demand created by large numbers of players along the supply chain. The effect, also known as demand amplification, can be eliminated (or minimised) by synchronising the supply chain.
Collaborative supply chain	Collaborative supply chain is based on collaborative planning, forecasting and replenishment.
Supplier	An entity that provides inputs to a process.
Supply chain	A network that describes the flow of raw materials from suppliers through plants that transform them into useful products, and finally to distribution centres that deliver those products to end customers.
Supply chain management	An integrated approach to obtaining, producing, and delivering products and services to customers, and includes the management of materials, as well as information flow and cash flows.

Terminology sourced from Gardiner (2010).

What is supply chain management?

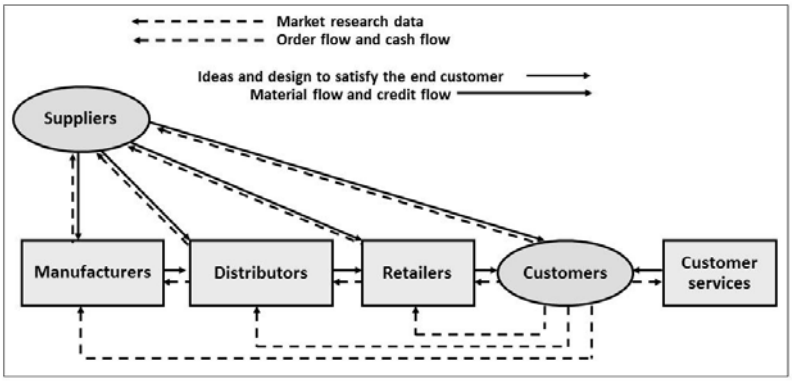
The supply chain is a network that describes the flow of raw materials from suppliers through plants that transform them into useful products, and finally to distribution centres that deliver those products to end customers.

Supply chain management should be viewed as all of the interactions that occur, starting at the point of original supply through to the end customer or consumer.

Generally, the supply chain involves the flow of materials from suppliers to customers until the product reaches the end consumer. It is these linkages that constitute the supply chain.

Clearly the strength of the entire chain depends on its weakest link and the end customer satisfaction depends on how well all linkages in the supply chain work.

The supply chain involves more than just the flow of materials. It involves market research data, customer requirements, the flow of orders and the flow of cash in a reverse direction from customer to supplier. Thus the flow of information and cash flows from end customer back up the supply chain to original supplier.



(Gardiner, 2010, p. 303)

The diagram above illustrates a supply chain and shows the material flow (from left to right) and the information flow (from right to left).

In the same direction as the material flow, each supplier sends ideas and design suggestions to satisfy the customer and credit facilities are provided to customers.

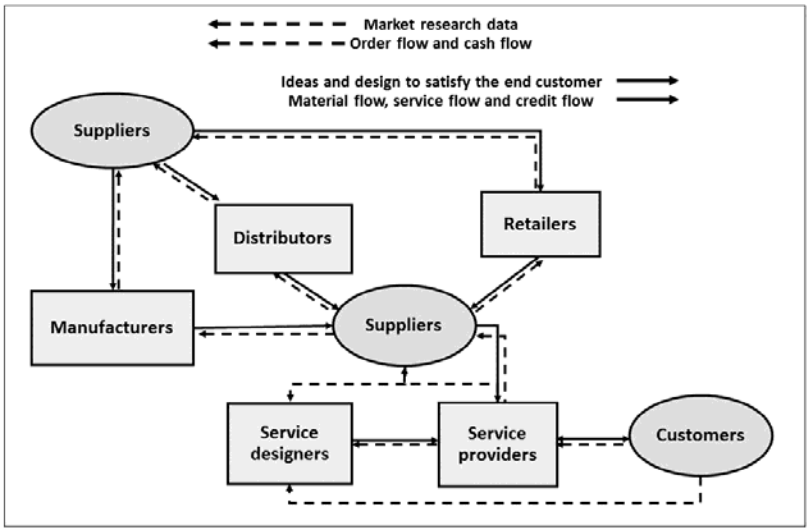
Service companies often see themselves as different from supply chain companies. The reality is that they are usually an integral part of the supply chain. Transport companies supply transport services over land, sea and air. Banks and finance companies provide credit and other facilities at every interaction in a supply chain. Insurance

companies, import/export companies, advertising companies and promotion companies ease the material and data flows of supply chains.

Manufacturers, distributors and retailers provide services to ensure service suppliers have the goods to provide to their customers. Hotels and restaurants rely on inwards goods arriving at the end of a supply chain. Health services need inwards goods such as pharmaceuticals, food, uniforms, pens and papers and operating supplies before they can even start providing care and attention to patients.

Each firm has a set of suppliers and a set of customers. These are referred to as first echelon suppliers and first echelon customers. They represent the first tier of contact along the supply chain for that firm. Additionally, each first echelon supplier may have their own set of suppliers that supply goods and services to them. Relative to the first firm, these are now the second echelon suppliers. Similarly, a firm may have second echelon customers.

This sequence of supplier/customer linkages continues upstream as far as the original supplier and downstream as far as the end customer. When designing supply chains and thinking about the dynamics of supply chains all these interactions need to be considered.



(Gardiner, 2010, p 303)

The diagram above illustrates a supply chain involving service organisations at the consumer interface. Service providers may view themselves as unrelated to manufacturing, but they are a vital link in the functioning of the entire supply chain.

The average manufacturer buys two thirds of what goes into the final product — two thirds of the cost of goods sold. This percentage is rising due to increasing use of technology and labour-

saving devices. The effect of savings on the bought-in material costs of most organisations has a disproportionate effect on their profitability. The greater the proportion of their total costs devoted to bought-in materials the greater the saving for a given reduction in bought-in material costs. Therefore, through its philosophies, knowledge of processes, knowledge of materials and vendor selection, the purchasing department has many more opportunities to affect quality as the production department does.

Supply chain management from a strategic view

A customer who walks into a retail store and purchases an item is, by default, acknowledging all the interactions of the entire supply chain that delivered the product to the retail store. The entire supply chain should benefit from each retail transaction. A successful retailer demands more goods and services of wholesalers and distributors. Successful wholesalers and distributors demand more goods and services from manufacturers. Successful manufacturers demand more goods and services of processors (or fabricators or manufacturers of components). Successful processors demand more goods and services from raw material suppliers.

Traditionally, when a retailer needed more supplies to fill up shelves, they would place an order on their wholesaler or distributor. They in turn would place an order on their manufacturer when their warehouse levels reached a reorder point. When the stock on hand of raw materials and components at the manufacturer reached a level that necessitated additional supplies, they would contact the raw material supplier and place an order. This all takes time and is subject to quantity consolidation which tends to amplify the true demand. This leads to a phenomenon known as the bullwhip effect or demand amplification.

Bullwhip effect — demand amplification

The bullwhip effect, described by Lee, Padmanabhan and Whang (1997) creates large oscillations of inventory in the supply chain network. Small changes in downstream demand create large changes in the supply position upstream. This effect can be eliminated by synchronising the supply chain.

When each link in the supply does not fully understand the dynamics of the consumer sales pattern, the pattern gets distorted and amplified as demand is transmitted up the supply chain.

The effect can occur with any range of products and at any level in the supply chain but is most noticeable with consumer commodity products. If demand for an item is relatively constant at the consumer level, then the available inventory in the retail store

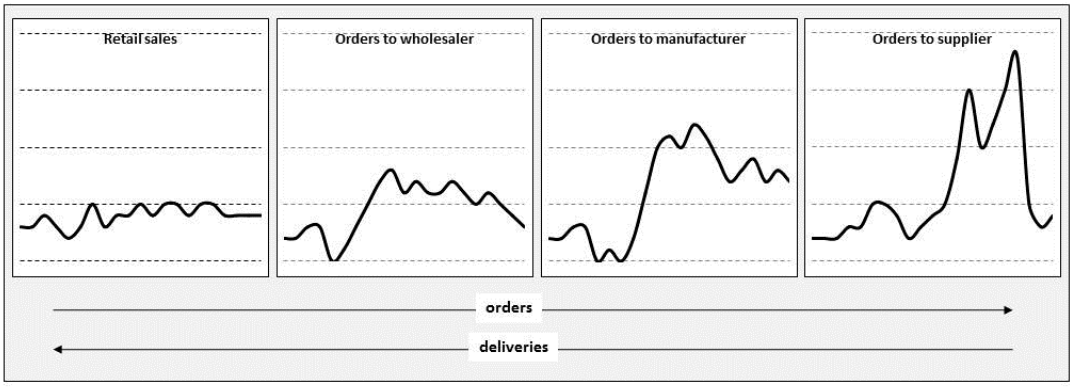
gradually diminishes until it is time for the retailer to place a replenishment order with the wholesaler.

The wholesaler is expected to hold relatively large quantities of products so they can meet supply demands from multiple retailers. The wholesaler wants favourable pricing arrangements and this encourages the wholesaler to order large quantities from the manufacturer. The wholesaler may even hold off ordering from the manufacturer until the order is large enough to secure even better payment and delivery terms.

Thus, the manufacturer is removed from the actual demand at the consumer level and confronted with a large order from the wholesaler. This may indicate the demanded product is experiencing an increase in popularity and, to compensate for that popularity, the manufacturer schedules larger production runs.

However, to be able to make the larger production run the manufacturer must secure raw material from its supplier. Original suppliers supply in bulk and often have large minimum and large multiple orders. Therefore, the manufacturer orders an even larger quantity of raw material.

The bullwhip effect is a direct result of individuals making rational decisions within the supply chain infrastructure. If firms want to mitigate the effects, they first have to examine the infrastructure of the supply chain rather than attempt to change the rational behaviour patterns.



(Gardiner, 2010, p. 320)

The above diagram illustrates the bullwhip effect. It shows a relatively stable environment at retail but a very dynamic environment at supplier level.

Lee et al (1997) identified four major causes of the bullwhip effect:

1. Demand forecast updating.
2. Order batching.
3. Price fluctuation.
4. Rationing and shortage gaming.

Demand forecast updating

Every supply chain firm needs to replace the products it sells. They study their demand patterns and somehow forecast demand. The quantity they order from their supplier will need to consider the supplier lead time and anticipated demand during that lead time. The firm will usually carry safety stocks in case demand exceeds expectation or delivery lead time extends beyond what is expected.

The supplier at the next echelon up the supply chain studies the demand pattern presented and somehow forecasts demand. Again, they will usually carry safety stocks in case demand exceeds expectation or delivery lead time extends beyond what is expected.

Order batching

In a supply chain most firms calculate order sizes based on price breaks for higher volumes, minimum order sizes introduced by the suppliers, or lot sizes such as full container loads. Often the cost of placing orders and receiving orders forces firms to change behaviour and place larger orders less frequently. This is the opposite effect to that encouraged by lean thinking.

This encourages a highly erratic stream of orders with spikes often appearing at the beginning of the month. This method of periodic ordering and batching of orders amplifies variability and contributes to the bullwhip effect.

Price fluctuation

Suppliers may introduce inducements to encourage buying more than is required in the short term and buying sooner than actually required. The supplier will offer incentives such as quantity discounts, end-of-year specials, clearance sales, stock-take specials, rebates and — although they may not admit it — will sometimes offer personal kickbacks to the purchaser. Thus, the customer buys in quantities greater than needed and before they are needed.

This is the opposite effect to that encouraged by lean thinking and encourages the bullwhip effect.

Rationing and shortage gaming

During times of supply shortage, the supplier may choose to ration supply. They may, for example, limit supply to 50 per cent of each order. As soon as the customer realises this behaviour is present they will order twice as much as they need and be presented with 50 per cent of that quantity, which is what they wanted anyway.

How to counteract the bullwhip effect

Demand forecast updating can be minimised when every firm in the supply chain understands the system dynamics. Rather than

have every firm base their demand forecast on just those parts of the supply chain that they can see, it would benefit all participants if the demand data occurring downstream is made available upstream. In this way both firms use the same demand data.

Order batching can be minimised by encouraging firms to order regular smaller batches. In a traditional supplier–customer relationship, pricing may depend upon purchase order volumes. If the quantity discount was available over an extended period, the size of each order would not matter.

Forward buying and diversions can be avoided with stable prices. Two terms now being used are everyday low prices (EDLP) and everyday low costs (EDLC).

Eliminate the gaming activities that exist at times of shortage. Firms should allocate orders on the basis of past orders. Regular customers can continue to receive regular deliveries.

Collaborative supply chains

The supply chain is a partnership between organisations involved in delivering a product or service to the customer. This usually involves organisations at many levels within the supply chain. The raw materials provider, manufacturer and retailer are but a few of the many entities involved in processing a product before it gets to the end customer.

A collaborative supply chain indicates that members of the supply chain have co-ordinated their effort in some manner to achieve their ultimate goal, which is the satisfactory supply to the end user. This is the very essence of a collaborative supply chain.

Characteristics of a collaborative supply chain

Cox (1999) described eight defining characteristics of a collaborative supply chain. These are:

1. Based on collaborative relationships and a win-win situation rather than the arm's-length scenario of the past where it was always a win-lose situation.
2. Recognise the stakeholder status of those involved and therefore the need for each stakeholder to create value in the chain.
3. Operate a pull strategy (rather than a push) since the focus is on the end customer and everything must be based on the end customer and true demand.
4. Strive to deliver value to the end customer and, as with any strategy, the aim is to create as much value as possible, in this case for the benefit of the end customer.

5. Eliminate waste which can be achieved by mitigating the bullwhip effect.
6. Create lean logistics processes to ensure maximum efficiencies in delivery and output.
7. Segment suppliers and customers since each subset of suppliers and customers may have differing requirements and need to be treated separately.
8. Develop a supplier network to share experiences and learning.

Strategic view of supply chains

Supply chains work well when the rewards are fairly distributed throughout the chain. Firms should encourage other participants in the supply chain to improve everyone's performance and benefits. They should not attempt to optimise their own position. Each firm should strive to do what is best for the supply chain rather than what they believe is best for themselves.

Narayanan and Raman (2004) identified the need for alignment in the supply chain by observing that when incentives were aligned it was possible to obtain a bigger share of the profits since the costs of the entire supply chain were reduced. This creates a win-win situation for all participants.

Alignment is difficult when one firm has access to information such as cost data, profit margins, capacity cushions or potential disruptions that the other firm does not. Small and medium enterprises are reluctant to disclose their cost structures for fear that they will have their profit margins squeezed by larger firms. Therefore they hold back on releasing that data and protect their rights to it.

Incentive schemes are often poorly designed and result in the opposite effect to what was intended. Assume that a steelmaker offers production managers a bonus based on tonnes of output. Any self-respecting manager would then arrange for the production schedule to include extra tonnes of the fastest and heaviest product to make. In reinforcing steel rods this is a 50 mm round. This product is one of the easiest to make in a steel rolling mill and generates more tonnes of output a day than any other. The managers receive an excellent bonus for lifting production volumes but what happens to the extra tonnes of output? These are discounted to the market so the company receives fewer dollars for their efforts. The result is that the company may lose because of poorly designed incentives.

Triple-A supply chain approach

The whole approach to collaboration is based on speed and cost reduction. Unfortunately, the real benefits are not realised by all participants. Lee (2004) proposed that supply chains needed the Triple-A approach which is based on agility, adaptability and alignment.

Agility

The objective of agility is to respond to short-term changes in demand or supply quickly and handle external disruptions smoothly. Both demand and supply patterns change rapidly and firms struggle to get a balance between demand and supply. For commodity products with established demand patterns it should be relatively easy to maintain supply. For new product introductions it is virtually impossible to establish in advance the true level of demand and thus the required level of supply.

Firms typically focus on costs, or speed of delivery and lose track of the need to be agile. Demand shocks seem to happen more often and with greater effect. Who would have anticipated the effects on demand as a result of the terrorist attacks in New York in 2001? Or the demand patterns following a natural disaster such as the tsunami in South East Asia at the end of 2004. Demand patterns are further disrupted when fear infiltrates our news systems and changes consumer behaviour. Examples include the SARS (severe acute respiratory syndrome) epidemic of 2002/3 and the threat of a bird flu pandemic.

The reality is that demand patterns change and firms have to be agile to respond to those changes.

Adaptability

The objective of adaptability is to adjust the design of the supply chain to meet structural shifts in markets and modify the supply network to changing strategies, products and technologies. Markets do not stand still and the needs of customers are not static. Therefore, it makes sense to have a supply chain that can adapt to changes in market structure, the economy, demand patterns, political and social environments, and advances in technology.

Once a firm has identified the competitive priorities that it will emphasise, it translates these priorities into patterns of decisions. These strategic decisions are of two types, structural and infrastructural. The categories of structural decisions include capacity, facilities, process technology, and vertical integration and supplier relationships. Categories of infrastructural decisions include human resources, quality, production planning/inventory control, new product and service development, performance measurement and reward, and organisation/systems.

Adaptability may require changes in structural decisions as well as infrastructural decisions.

Alignment

The objective of alignment is to create incentives for better performance. Alignment is helped by exchanging information and knowledge freely with suppliers and customers, discussing and documenting roles, tasks, and responsibilities clearly for suppliers and customers and sharing the risks, the costs and the improvement gains equitably.

Supplier selection

In a collaborative supply chain the choice of supplier assumes an extremely important position. It is unfortunate that the majority of small and medium firms still pick suppliers based on price. One of the first questions asked in negotiation is “What is your price?”

With the modern approach to collaboration each supplier should be evaluated on the following criteria:

- Potential to develop a close long-term relationship.
- Financial strength and capability.
- Quality performance, including process capability and ability to conform to agreed specification.
- Research, technical ability and new product development strategy.
- Ability to deliver frequently, quickly and reliably.
- Management structures and attitudes to collaboration.
- Pricing structures and dependencies.
- Trustworthiness and ability to have timely communications on any problems.

Activity 4.4

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Explain the bullwhip effect. In particular, explain how it happens and what can be done to minimise adverse effects.
2. Describe the Triple-A supply chain approach.
3. Explain vertical integration as a means to secure more linkages in the supply chain.
4. Evaluate the criteria for selecting a supplier.

Unit summary

Summary

This unit started by defining supply chain management from a strategic view. This led directly to the bullwhip effect or demand amplification. The concept of collaborative supply chains was introduced and one method for approaching collaboration, the Triple-A approach, was introduced. The unit concluded by discussing the strategic role of inventory in supply chains and the criteria for supplier selection.

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Unit 11

Project management

Introduction

This unit will consider the challenges facing operations managers in order to help them understand the difficulties and complexities of managing projects.

This unit will treat projects as a derivative of a fixed-position process structure and provide an operations manager with some fundamental tools for communicating with project management.

Many process improvement tools discussed in this course will require a project management approach for implementation. Thus the operations manager needs an appreciation and understanding of the requirements and issues faced by a project manager.

This unit begins by investigating the strategic nature of projects, the project life cycle and project organisation structures. This is followed by a description of the project manager. Project management structures are developed. Then the concepts of the critical chain, as proposed by Goldratt, are presented. Finally, we examine why projects fail and what makes projects successful.

Outcomes

Upon completion of this unit you will be able to:

- *Define* a project.
- *Describe* the nature of project management.
- *Discuss* the strategic nature of projects.
- *Describe* project organisation structures.
- *Discuss* the role of the project manager.
- *Discuss* project management processes.
- *Define* a critical path.
- *Discuss* project risk and uncertainty.
- *Discuss* the critical chain method.
- *Outline* what makes a project successful.

Terminology

Critical chain	The longest route through a project network considering both technical precedence and resource contention constraints in completing the project.
Critical path	Critical path is the longest path through the project network. Activities on the critical path determine the duration of the project.
Functional organisation	Functional organisation is a structure where a group of people perform the duties required by their function and they report to only one person, the functional manager.
Matrix organisation	Matrix organisation is a structure in which individuals report to a project manager as well as their functional manager. The responsibility for assigning priorities and directing work activities is shared by the functional manager and the project manager.
Progressive elaboration	Progressive elaboration is a project management technique to continuously refine and expand activities. A project may start with a sketchy outline and this is expanded on an iterative basis as more information becomes available and as the project develops.
Project	Project is a temporary endeavour undertaken to create a unique product, service or result.
Project life cycle	Project life cycle is the stages on the path from start to completion of a project.

Project management	Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements.
Project scope	Project scope is the work that must be performed to deliver a product, service or result with the specified features and functions.
Projectised organisation	A projectised organisation is a self-contained team working full time under the control of a project manager who has full responsibility for assigning priorities and directing work activities.

Terminology sourced from Gardiner (2010) and Project Management Institute (2008).

Managing projects

The Project Management Institute (2008) defines a project as a temporary endeavour undertaken to create a unique product or result. There are two key words in that definition: *temporary* and *unique*. Temporary means the project has a definite beginning and ending. Unique means the product or service is different in some way from all other products and services.

Construction industries, consulting services, infrastructure development and major events management are all examples of projects.

New product and service development is usually undertaken by a project team. The people involved with new product and service development would more than likely be developing on a continuous basis, but for the duration of one particular product, it is deemed to be one project.

Finding, or building, a new facility and equipping it with process technology would typically be managed as a project. Software development and a major upgrade in computing and information technology software and hardware would typically be managed as a project.

A project is developed using progressive elaboration, or an iterative approach. It needs a purpose, is temporary in nature, requires resources, needs a primary sponsor and has uncertainty (which implies risk).

A successful project requires a balance between time, scope of the project, cost of resources and quality of the result. The most important factor to evaluate whether or not a project has been successful is to determine whether the customer is satisfied. A project could easily finish on time and within the cost allocation but the customer may not be happy with the result.

Differences in scope often occur when the project "creeps" with function being added without allocating more time and money.

Project management is the integration of resources, such as people, equipment and material that are employed to carry out project processes, such as initiating, planning, executing, monitoring and controlling, and closing, to meet the quality, cost and time constraints of the project. Projects can be large or small. Large-scale projects are typically expensive, one-of-a-kind endeavours that may require months or years to complete and involve major portions of an organisation's resources.

Effective project management requires clearly identified project requirements, clearly stated objectives, a simple and timely progress reporting system and good people management practices.

Insufficient planning, an unmanaged change in the scope, a lack of direction and lack of talent can all lead to project failure.

Strategic nature of projects

The cost of most projects suggests an organisation would not want to repeat them if the first attempt had to be scrapped. Internal and external failure is not an option. By definition, each project must be successful the first time. This also means sufficient finance is allocated and the project delivers within the scope of allocated financial resources.

Major events such as an Olympic Games or the FIFA World Cup have published dates for the events to start. Event management projects must finish on time and any completion delays are untenable.

The management skills required during project management are essentially the same as required for general management. Financial, purchasing, marketing, operational, supply chain, planning, health and safety, and information and communications technology skills are all required at some stage in most projects. All these skills may not be found in one person, so the skill and ability of the project manager uses available resources to provide these skills in a timely and cost-effective manner.

Communicating, influencing, motivating, leading, resolving conflict, negotiating and other interpersonal skills are of prime

importance to a project and should be considered when selecting project personnel.

Project life cycle

A project is made up of several phases and there is no general agreement on how these are put together. The decision rests with the project manager and the project team. The phases are usually put together in some logical sequence based on the actual project. A construction project may, for example, have a resource consent phase, a foundations phase, a structural phase, an essential services phase, a fitting-out phase, a commissioning phase and a closeout phase. These overlap and intertwine in some areas.

In each phase, the cost elements start at a low level and increase at the peak of the phase and taper off towards the end. Uncertainty is at its highest at the start of each phase and diminishes as each phase approaches completion. When all phases are superimposed onto the whole project this pattern of cost and uncertainty is repeated.

One thing that separates project phases from structured new product and service development is that project phases deliver phase-dependent outcomes and the next phase is not dependent on the previous, or any other phase. With structured new product and service development, the completion of one step authorises the start of the next.

Project phases pass through the various steps and deliver the product at the end of the project. At that stage, the project life cycle ceases but the product life cycle keeps going. The product life cycle includes the development, production, operation and ongoing use of the product until it is disposed of or destroyed. It is likely that product management may ask for a modification to the product and, in that case, it would start as an additional project and quite separate from the original.

Project stakeholders include:

- the sponsor who finances the project
- the project manager who manages the project
- the customer who uses the product outcome of the project
- the project management team who perform management activities of the project
- the project team who perform the work
- anyone affected by or able to be affected by the project.

Project organisation structures

Projects can be organised as functional organisations, matrix organisations or projectised organisations.

Functional organisation

A functional organisation uses people on a part-time basis from within the same organisation to manage the project, which is clearly the responsibility of one department. An existing manager from within the department acts as the project manager and project team members are usually not dedicated to the project. The functional manager controls the budget and allocation of resources. The project manager is assigned part time and has little or no authority.

The advantages of using a functional organisation structure are:

- Team members are familiar with each other and individual skill levels are known.
- Each team member can work on more than one project.
- Staff members can be assigned as needed and then returned to their normal roles within the organisation.
- The lines of authority and communication are clearly understood and conflicts are minimised.

The disadvantages of using a functional organisational structure are:

- The project often lacks focus.
- Motivation is often weak.
- Bureaucratic procedures may slow process and decision-making as there may be more levels of approval than needed.
- The needs and priorities of the department are often placed before the needs of the customer.

Matrix organisation

A matrix organisation attempts to blend the properties of functional and projectised project structures. The project manager decides what tasks take place and when, but functional managers control how the tasks take place and who performs each task.

The matrix organisation can be weak, balanced or strong, with the main differences being the role the project manager assumes. With the weak matrix structure, the project manager is assigned part time and has little or no authority while the functional manager controls the budget and allocates resources. With the strong matrix, the project manager is assigned full time, has a moderate to high level of authority and manages the budget. The balanced matrix organisation structure is somewhere in between.

The advantages of using a matrix organisational structure are:

- Communication is enhanced.
- It provides an efficient use of resources.

- Team members are more secure in their functional role and their participation in the project.
- Policies are set and followed.

The disadvantages of using a matrix organisational structure are:

- It generates complex command and authority relationships when staff report to more than one manager.
- It is prone to failure with weak project management skills and poor negotiation skills.

Projectised organisation

A projectised organisation structure involves a team or a task force being put together to accomplish the goals of the project. With this type of structure all project team members report directly to the project manager only for the duration of the project. When a team member's role has finished, the person is reassigned to another project. Smaller projects may have a flat structure where the project manager is directly responsible for all members of the project. Larger projects may have a project management team and the project manager manages the team.

In a projectised organisation structure, the project manager is full time, has full budget control and can allocate and assign resources. Project team members are also full time on the project.

The advantages of using a projectised organisation structure are:

- The project manager has clear authority over the entire project.
- Project communication is simplified with everyone reporting to one manager.
- Project activities are focused.
- Team pride, motivation and commitment are maintained at a high level.

The disadvantages of the projectised organisation structure are:

- Equipment and people are not shared across projects and this leads to some duplication.
- While strong loyalties are developed within the project, the uncertainty about what will happen when the project finishes may cause disharmony within members of the project team.

The role of the project manager

The role played by the project manager is critical to the success of every project and it is not easy to find really good project managers for every project. It certainly helps when the project manager has an understanding and an appreciation of the technical aspects associated with the project, but the project manager does not have

to be an expert in the field. A project manager for a project assembled to implement new information and communications technology, for example, should have an appreciation of the strategic role computers play in a business environment, but the manager does not have to be a computer technician. The technical knowledge, though, must be sufficient to be able to ask the right questions and make the right decisions.

The project manager should be able to ask penetrating questions, have credibility, sensitivity and the ability to handle stress.

Leadership and expertise in strategy are essential attributes for the project manager. Leadership is necessary to provide direction, motivation and facilitation to all project team members and the strategy expertise is required to gain the overall perspective of the business need for the project.

A defining characteristic of the project manager is communication and people skills displayed at all times. The project manager may have to deal with a personal issue with one individual at one time and at another time communicate project progress to the media and stakeholders. The project manager must be able to resolve interpersonal conflicts. This range of skills makes this role challenging and rewarding to the point that a good project manager should never complain about having a boring job.

The project basics of planning, executing and controlling resources such as people, equipment and material need to be managed to meet the quality, cost and time constraints of the project. Monitoring and control activities include measuring the volume of work being completed, the quality of work being performed, the costs compared to budget, the attitudes of those involved, including team members and customers, the co-operation of the team and the status of the work being performed compared to plan.

Management resource is often applied to the cost and time constraints and trying to keep the project within budget. The reality is that unless the project is quite similar to other projects, or contains quantifiable work packages, the original time and cost budget is a guess and wishful thinking. Instead of concentrating solely on cost and time elements, a good project manager manages change and risk.

A change of scope is allowed, but it has to be approved by the customer and the project plan has to be updated to reflect the change. Project danger arises from scope creep that allows changes to creep into the project without customer approval, without an allocation for additional resources and without adjusting the project duration. Most projects have creep of some form or other and a good project manager does not allow it to happen.

The best way to prevent project creep is to establish a clear project charter and an agreed scope statement before detailed execution commences.

As for risk, the project manager should plan all risk elements, identifying risk, performing a qualitative risk analysis, performing a quantitative risk analysis and developing a risk response plan. The project manager should be able to spot unstated assumptions. These risk elements are strategic in nature. They may be boring, but when identified risk occurs as an event the project is able to handle it within the scope of the project. It does not arrive out of the blue.

Project management processes

The processes required to manage projects are: initiating, planning, executing, monitoring and control, and closing.

Initiating process

The first step in any project is to obtain a project charter. It is a clear statement from the sponsor that the project exists and that it is part of the strategic plan for the organisation. In other words, the organisation needs the project to be completed and will be better off when it has been completed. There should be a definite business need for every project to proceed.

The scope of the project defines the limits of what should be included within the project activities. It is a clear statement of the eventual outcome expected from the project and specifies the features and functions of the product or service that forms the end result.

The project scope statement describes the major deliverables, objectives, assumptions, constraints, and is a statement of work that provides a documented basis for making future project decisions. It forms the basis of common understanding. The scope statement describes the purpose, history, deliverables and measurable success indicators of a project and quantifies the support required from the customer. Contingency plans for events that could throw the project off course are identified. The scope statement can be a persuasive document.

To prevent scope creep, the scope document has to be carefully prepared and agreed among all parties. It should not be seen as a binding limitation on the project outcome because, if a change in scope is envisaged, then a scope change can be authorised by the customer.

The project scope statement describes what will be delivered to the customer, the assumptions made in terms of outcomes and resource availability, the constraints identified, as well as the overall

objective of the project. This statement is crucial in terms of project success.

Planning process

The planning process involves planning and defining the scope, developing the work breakdown structure, defining activities to be performed, sequencing those activities, estimating the resources required to complete each activity, estimating the duration of each activity, developing the schedule, estimating the cost of each activity, estimating the budget to create a cost baseline, planning the quality, planning human resource requirements, developing the communications plan, planning all risk elements, identifying risk, performing a qualitative risk analysis, performing a quantitative risk analysis, developing a risk response plan, planning purchases and acquisitions and planning contractor requirements.

Executing process

The executing process includes directing and managing the actual project execution, performing quality assurance, acquiring project team members, developing the project team and distributing project information.

Monitoring and controlling process

The monitoring and controlling processes include controlling any changes to the scope of the project, verifying the scope, controlling the schedule, controlling cost elements, controlling quality, managing the project team, performing project reporting, managing the stakeholders, managing risk and performing administration.

Closing process

The closing process closes the project and closes contracts.

Critical chain

The concept of the critical chain was introduced by Eliyahu Goldratt (1997) in his book, *Critical Chain*, because of inherent problems with project management. He identified typical problems and behaviours, such as:

- Activity durations are inflated to make sure they can be completed on schedule.
- Project team members procrastinate because they know activity durations have built-in slack time.
- Safety time is wasted at the beginning of each activity instead of completing the activity and preparing for the next one.

- Project team members multitask because they know activities have built-in slack and they want to demonstrate that they are busy.
- Activity schedules are based on start dates and end dates so if an activity finishes early it is unlikely that the next activity can start early.
- An early finish cannot compensate for lateness in another activity.
- A late finish is passed on to subsequent activities and may have cost implications as the project attempts to catch up.
- Resources allocated to catch-up activities cannot be used on other scheduled activities so this problem of lateness is compounded.

Critical chain is the longest route through a project network considering both technical precedence and resource contention constraints in completing the project.

The following techniques are used in critical chain scheduling:

- Resources are levelled so that contentious resources are available for just one activity at a time. This minimises the muddling of priorities caused by multi-tasking.
- Activity duration estimates are set at the average level to minimise procrastination.
- The time initially cut from each activity is accumulated and used as a project buffer placed strategically at the end of the project. This prevents activity safety time from actually existing and then subsequently being lost. The project buffer is a safety time added to the end of the critical chain to protect the project completion date.
- Resource buffers are used to ensure the availability of resources on the critical chain. They ensure that resources (such as rental equipment) are available to perform critical chain activities when scheduled.
- Feeding buffers are placed on all activities leading to the critical chain to ensure activities feeding into the critical chain are completed on time and do not hold up critical activities. Feeding buffers protect the critical chain from delays.
- Project progress is measured as a percentage of critical chain completion.

Why projects fail

Projects fail when:

- The customer is not happy with the resulting product.
- The project charter is not drawn up.
- The project scope statement is not discussed and agreed upon.
- The project creeps by adding function and features that have not been agreed to by the customer.
- Not enough resources are available to complete the project.
- Not enough time is allowed to complete the project in a quality fashion.
- Expectations are not clear.
- Stakeholders disagree about the expectations of the project.

Why projects are successful

The following are some good basic rules for a successful project:

- Gain consensus on project deliverables.
- State project objectives clearly.
- Build the best possible project team.
- Outline activities and sequence them correctly.
- Develop accurate time and cost estimates.
- Identify and eliminate duplicate activities.
- Develop a comprehensive schedule and keep it up to date.
- Determine the level of activities to get things done.
- Have a realistic and achievable activity schedule.
- Remember that people can and do make a difference.
- Assign system-oriented personnel for major decisions.
- Gain the full support of management and stakeholders.
- Be willing to accept change, but make it formal by including scope changes in the scope statement and rescheduling activities accordingly.
- Maintain excellent communications and keep people informed of changes and progress.
- Use project management tools to monitor progress.
- Take risks and try new methods and new technologies.
- Demonstrate real leadership.
- Enjoy life and have fun!

Project management success means the project has been completed on time and on budget (as in the scope statement). However, project success is ultimately measured by the customer. The project is successful when the project team delivers to the customer exactly what the customer wants, when they want it, and how they want it. In other words, the customer is entirely happy with the result.

Activity 4.5

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. What is a project?
2. What makes a project different from other business activities?
3. What is project "creep" and what should be done to prevent it?
4. Explain the critical chain method.
5. What makes a project successful?
6. As a project manager, how would you ensure that your project is successful?

Unit summary

Summary

This unit began by investigating the strategic nature of projects, the project life cycle and organisation structures. This was followed by a description of the project manager and the role expected of a project manager. Project management structures were developed. Then the concept of the critical chain was presented. Finally, we examined why projects fail and what makes projects successful.

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Readings for further study

Reading

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Unit 12

Performance measurement

Introduction

In public sector service organisations, stakeholders and the press demand information to enable them to construct rankings. Hospitals, schools, local councils and charities are among the organisations now scrutinised on an annual basis against a set of performance measures. With this comes the problem of misunderstanding or misinterpretation.

With traditional accounting measures, profit, or return on investment, is relatively easily understood. It represents one approach to performance measurement that is based on a few quantifiable financial measurements. The approach today requires a proliferation of measurements and these measurements include dimensions that are quantitative as well as qualitative.

This unit begins by investigating the need to have a balanced view on performance measurement. The Hoshin process is described for setting the goals and using measurement systems. The balanced scorecard approach to performance measurement is presented. The closed-loop management system involving developing the strategy, translating the strategy, planning the operations, monitoring and learning, and testing and adapting the strategy is presented.

The driving forces of performance and benchmarking are discussed.

Outcomes

Upon completion of this unit you will be able to:

- *Describe* measurements for business excellence.
- *Describe* the Hoshin process for setting goals and using measurement systems.
- *Describe* the balanced scorecard approach to performance measurement.
- *Describe* how the closed-loop management system links strategy and operations.
- *Describe* benchmarking.

Terminology

Balanced scorecard	Balanced scorecard is a set of performance measures designed to reflect strategy and uniquely communicate a vision to the organisation. Usually includes a customer perspective, financial perspective, internal business processes and innovation and learning.
Benchmarking	Benchmarking is the process of measuring a company's products, services, costs and practices and comparing that measurement with the best in the industry, the best-of-class or world-class. The aim is to use that measurement as a means to improve performance.
Best practice	Best practice is the measurement or performance standard by which similar items are evaluated. Approaches that produce exceptional results are usually innovative in terms of the use of technology or human resources, and are recognised by customers or industry experts.
Hoshin planning	Hoshin planning is a systematic process that looks at the organisation and defines long-range business objectives. The methodology provides for breakthrough objective focus to determine the most effective actions and the development of plans to support those actions. Formal review processes are implemented to measure performance and provide a framework for learning.
Performance measure	Performance measure, in a performance measurement system, is the actual value

measured for the criterion. The performance criterion is the characteristic to be measured.

Developing balanced results

To enable business leaders to make effective and timely decisions, a firm needs to develop the key set of results required to monitor progress against the vision, mission and strategy of the organisation.

Operations management plays a strategic role in every organisation and the ultimate performance test is survival. If the organisation intends to remain a viable entity and survive, then by definition, it is successful. Executives are often worried by the survival target saying that to just survive is an underachievement and most organisations should be able to do better. Look at it the other way. If the organisation does not survive, that is untenable. At the very worst, to survive is the minimum positive achievement.

The operations function has an excellent opportunity for changing overall performance of the organisation. In fact, the foundation theme of operations is process improvement and product improvement in an environment of increasing customer expectations and requirements. Therefore, to have any chance of success, an organisation needs to raise performance level at least as fast as customer requirements rise.

Performance measurement provides some advice on progress and may highlight areas of particular concern that require more attention or more resources. Potential areas and topics are discussed in this section.

Strategy

Strategy sets a vision of where the organisation is headed and the philosophy underlying the vision statement. It uses broad statements that set the direction for the organisation to take. It specifies how to satisfy customers, how to grow the business, how to compete in its environment, how to manage the organisation, how to develop capabilities within the business and how to achieve financial objectives. A high-performance organisation achieves these objectives.

Demand management

The performance of a forecasting system is measured by most firms using some form of accuracy measure. They typically use measures such as mean absolute percentage error (MAPE), mean absolute deviation (MAD) and bias. These measures do not tell what the forecast should have been. They report past performance but do not attempt to assist the forecasting process to perform a better job.

Capacity management

Capacity management can be measured at the aggregate level to improve performance.

Capacity performance measurement is usually linked with demand performance measurement since both are calculated at the aggregate level.

Process design

The real measures on process design relate to how well the process can cope with the variability of customer demand. This translates into shorter lead times and increased flexibility.

Process improvement

Process thinking is not about overhead allocation and cost accounting, not about confusion and delay; it is a discipline that designs outstanding performance rather than relying on luck.

Traditional company measurement systems look at history and tell (approximately) what has happened. The missing link is telling you what to do to make things better. That is where process thinking develops a structure to improve performance across the whole organisation.

Lean thinking

Often the metrics for lean thinking are aimed at technical issues or process issues that are of little or no value to the customer. The real metric for lean thinking should be a measure of the value being added and that value is determined by the customer. Is the customer willing to pay? Is the customer willing to pay a premium?

The next metric should be related to the waste inherent in the process. Few customers are happy paying for waste and lean thinking is all about eliminating waste.

Product design

The performance wants and excitement characteristics of new products and services provide an excellent opportunity for an organisation to gain competitive advantage. Knowledge about each market segment and the changing customer requirements helps to hit customer targets. Quality function deployment is epistemic and allows invisible customer requirements to be visible.

Quality

Excellence is creating sustainable customer value and achieving results that delight all the organisation's stakeholders. It requires visionary and inspirational leadership, coupled with constancy of purpose. The organisation is managed by processes and facts and

by allowing employees to maximise their contribution through their development and involvement.

Inventory and resources

Inventory measurements are based on increasing customer satisfaction, stock availability, service levels, forecast accuracy, supply chain confidence, honest and true communication; increasing flexibility and throughput as products that are demanded are stocked and supplied, and products are not sitting for extended periods waiting for a customer.

Inventory measurements are also based on decreasing demand uncertainty, and the number of customer complaints because customers have the required products in the required quantities and the products meet the expected quality standards, decreasing conflicts as organisations satisfy all demands and do not need to trade off one customer demand against another, decreasing delivery quantities, safety stock, lead time uncertainty, lead times and obsolescence as inventory flows through the system and is consumed.

Supply chain management

A supply chain works well when the rewards are fairly distributed throughout the chain. Firms should not endeavour to optimise their position; rather they should encourage other participants in the supply chain to improve everyone's performance and benefits.

Supply chain objectives should be aligned since any misalignment might lead to non-optimal financial performance. A collaborative supply chain must show a propensity towards elimination of waste. This means a desire to deliver value to the customer and requires continuous elimination of waste in all processes.

Project management

Project management success occurs when the project team delivers exactly what the customer wants, when and how the customer wants it. Moreover, the customer is entirely happy with the result.

Project management failure occurs when the customer is not happy with the result.

Hoshin planning

Any organisation wanting to exceed their customers' expectations and to stay competitive needs a long-range strategic plan that is forward-looking, visionary and achievable. The best way to obtain the desired outcome is to ensure all employees fully understand the long-range goals and follow a co-ordinated plan to make that vision a reality.

Additionally, there has to be a set of fundamental process measures which have to be monitored to ensure the continuous improvement of the organisation's key business processes. Essentially, everyone is heading in the same direction with the same sense of control.

This is the basic premise behind Hoshin planning.

Hoshin planning is a systematic process that looks at the organisation and defines long-range business objectives. The methodology provides for a breakthrough objective focus to determine the most effective actions and the development of plans to support those actions. Formal review processes are implemented to measure performance and provide a framework for learning.

Breakthrough activities are aimed at achieving significant performance improvements or making significant changes in the way the organisation operates. Usually, critical business issues the organisation will face in the next two to five years are identified and plans are implemented to address these. In its broadest sense, these business issues may relate to profitability, growth, market share, quality problems or maybe the need for a new product or service. It is essential to identify critical business issues facing the organisation and to select an objective and a goal to overcome each issue.

Supporting strategies are developed and specific goals for each strategy are established. These require a regular review and monitoring of progress.

Formal review processes are implemented on a monthly and annual basis. Organisations may use balanced scorecard reporting (as discussed below) to develop the process performance measurement and the balanced scorecard approach may identify initiatives required. The planning system itself may need revision.

A Hoshin review table is used for each strategy using the plan-do-check-act cycle to measure the progress against the target that was set at the beginning of the year (plan). Actual results are written alongside each strategy (do) and any difference between the target and the actual are noted (check). The impact or effect of any difference is documented (act). This analysis is conducted for the objectives that were successful and also for those that were not successful or not completed.

For each objective successfully completed, an analysis is performed to determine what went right and to determine if the supporting strategies and performance measures were appropriate. Any exceptional results are noted with details on how they were obtained. This is a learning step and is vital to knowing how to do better and to transfer that knowledge to the organisation.

As the planning table is completed, it is passed down the hierarchy to the next level within the organisation so that the lower level can add their inputs and interpret the planning document as it affects them. This is the cascading attribute of the Hoshin planning process and is a vital step in empowering the organisation. It is all part of the buy-in at every level and a locking-in of the plan, resulting in total ownership of the plan.

The Hoshin planning process encourages an organisation to learn from the problems that are solved and the business successes. This is fundamental to building a learning organisation.

Hoshin enables an organisation to accumulate performance information about itself from the routine day-to-day activities and from longer-term strategic initiatives. It helps the organisation reflect on where it is headed, the best way to get there and to do that while in full control.

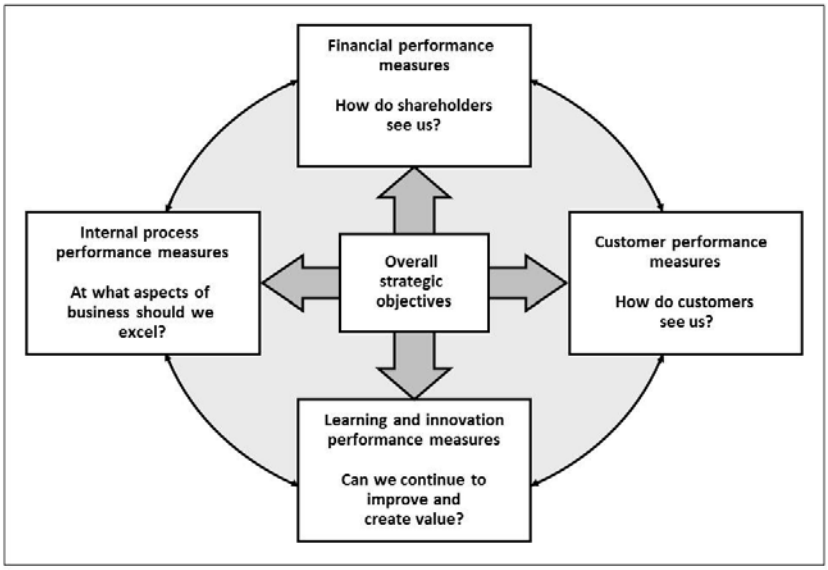
Balanced scorecard

Balanced scorecard is a balanced set of performance measures designed to reflect strategy and uniquely communicate a vision to the organisation. Usually includes a customer perspective, financial perspective, internal business processes, and innovation and learning.

The balanced scorecard was developed by Kaplan and Norton in 1992. It was introduced when most business performance measurements were finance-based and aimed only at controlling the business from a financial perspective.

Traditional performance measurement was compared to a set of predetermined actions that were expected to be followed. This may be, for example, to achieve a given sales target or keep within a given cost budget. It was assumed the organisation was successful when these targets were achieved. By relying on traditional financial measures, management does not receive the necessary feedback to stimulate continuous improvement and innovation.

The balanced scorecard approach aims at cross-functional integration, customer-supplier partnerships, global scale, continuous achievement, and team rather than individual accountability. This provides a balanced view of both financial and operational performance measures.



The diagram above, illustrating the balanced scorecard, was developed by Kaplan and Norton (1992).

The balanced scorecard measures business performance from four perspectives:

1. Customer perspective
2. Internal perspective
3. Innovation and learning perspective
4. Financial perspective.

Customer perspective

The customer perspective asks, "how do customers see us?". Organisations may have a strategic objective to add value to customers, satisfy customer needs, listen to customer wants, allow customers to participate in process and product design and to act and think from a customer's viewpoint. This needs measuring from a customer perspective by asking customers for their views.

Competitive capability is based on cost, quality, delivery, flexibility and service. Customers share these concerns.

A customer view of cost considers the total cost and not just the price. An organisation establishes prices for their products and services, and they receive these amounts for products produced and services delivered. The missing part is the extra that the customer has to add to the price to arrive at the total cost to the customer. Additional cost could be taxes, freight, storage, inspection, quality assurance, quarantine, pilferage, deterioration and obsolescence. This needs measuring from a customer perspective.

Quality can be measured inside the organisation using quality control, quality assurance and process capability. Customers only

see external quality. They value the product on their own hands and measure aspects such as delivery in full on time and in specification (DIFOTIS).

Delivery measurements often measure the time and date products leave the supplier's premises and the actual delivery performance is up to the customer to negotiate. Customers do not see it this way. They want products delivered to their premises when and how they want them.

Flexibility is often demonstrated by organisations after they have stated the rules of engagement. Flexibility is often at the supplier's convenience, not when it suits the customer. Delivery is often made at a supplier-determined schedule. Passenger and freight transport is arranged at the transport operator's advertised schedule.

Internal perspective

The customer perspective looks at the organisation from the outside while the internal perspective looks at the organisation from the inside and asks, "at what aspects of business should we excel?". Process design and process improvement all occur internally and the results of these initiatives affect customers.

Processes measured as part of the balanced scorecard have the most impact on customer satisfaction. Clearly these affect lead time, throughput time, employee skills and attitudes, flexibility, availability, responsiveness and information systems.

Organisations decide on competitive capability as a part of strategy and develop core competence to deliver that capability. Processes are designed and improved to enhance core competence from a customer perspective. These are all internal processes and can be measured from an internal perspective.

Information and communication technology play an important part in the internal perspective. When problems are identified by the balanced scorecard, analysis of the relevant data is often a responsibility of information systems. As an example, if delivery performance is highlighted as a customer issue, the delivery data can be analysed to determine the delivery status and possibly identify root cause.

Innovation and learning perspective

Innovation and learning perspective asks, "can we continue to improve and create value?". Competitive activities are constantly challenging every organisation's position. All other organisations challenge the organisation at the top of the league. Even organisations positioned somewhere in the middle have to face constant challenges for their position. Customer expectations are constantly changing and these force organisations to be totally aware of the range and scope of those changes.

Each business requires an ability to create new products and services and to update how those products and services are delivered to customers. This requires innovation and learning.

Innovation provides new ideas, concepts, processes, approaches and technologies. Existing ideas, concepts, processes, approaches and technologies have to be updated. This requires learning. Businesses listen to their customers and learn from comments and reactions received. This requires understanding and judgement.

Financial perspective

The financial perspective asks, “how do shareholders see us?”. In the end it is the bottom line that counts. Firms can have any amount of customer satisfaction, close to perfection with internal processes, unlimited innovation and learning and still fail on financial measures.

The trick is to capitalise on the other perspectives and translate gains into financial achievements.

Financial measures are often short term. Quarterly and half-yearly reporting does not provide much opportunity for process improvement and capital spending to generate tangible figures. The improvements may be present but the reality is determined by financial outcomes.

Taking a quality view, organisations should concentrate on operational excellence and allow financial results to flow naturally from that. Traditional financial measures do not improve customer satisfaction, quality, throughput time and employee motivation. In fact, some financial measures, such as a price increase, alienate customers and force them to go elsewhere.

Linking strategy with operations

Ever since Kaplan and Norton published their balanced scorecard approach, various authors have attacked their premise by quoting examples that suggest the balanced scorecard was difficult to implement and often only partially implemented. It has been widely acknowledged (even by its authors) that the original balanced scorecard was not a perfect tool.

In their original concept of the strategy map and the balanced scorecard, Kaplan and Norton encouraged companies to select initiatives independently for each objective. They came to realise, however, that by doing so, companies would fail to benefit from the integrated and cumulative impact of multiple, related strategic initiatives (Kaplan & Norton, 2008).

They continued experimenting and researching, and suggested that if firms were having trouble using the balanced scorecard they

should try using strategy maps. They maintained that the balanced scorecard could be implemented better by using strategy maps (Kaplan & Norton, 2000).

While the balanced scorecard is a tool for the implementation of strategy, it does not, in itself, ensure best strategy is implemented. Successfully implementing a money-losing or disastrous strategy will result in successfully losing money or disaster. The tool is not to blame.

Closed-loop management system

An organisation's underperformance is caused largely by a breakdown in the organisation's management system which includes the integrated set of processes and tools an organisation uses to develop its strategy, translate it into operational actions, and monitor and improve the effectiveness of both. This can be avoided by using a closed-loop management system comprising the following stages:

- Develop the strategy
- Translate the strategy
- Plan the operations
- Monitor and learn
- Test and adapt the strategy.

Develop the strategy

Developing the strategy starts with defining the mission, vision and values of the organisation. Essentially this answers the question, "what business we are in and why". A strategic analysis follows to answer the question, "what are the key issues we face as a business?". This should look at external as well as internal situations and challenges, before stating clearly how the business is going to achieve the vision.

Translate the strategy

Now that the strategy has been formulated, the organisation needs to translate it into objectives and measurements that can be clearly and succinctly communicated to all employees and in a language they can understand. The strategy map provides a powerful tool for visualising the strategy as a chain of cause-and-effect relationships between strategic objectives. Start with the organisation's long-term financial objectives and link these to objectives for customer loyalty and the value proposition. Continue to link to goals related to critical processes and eventually to the people, technology and organisational climate and culture required for successful strategy execution.

Plan the operations

The organisation next develops an operational plan that lays out the actions that will accomplish the strategic objectives. This stage starts with setting priorities for process improvement projects, followed by preparing a detailed sales plan, a resource capacity plan, and operating and capital budgets.

Monitor and learn

The execution of business processes takes place between the previous step and this step. The performance of operating departments and business functions should be reviewed to address any problems that have arisen or remain. Strategy management meetings that review balanced scorecard performance indicators are convened to assess progress and identify barriers to strategy execution.

Test and adapt the strategy

In this step, the performance of the strategy itself is assessed and changed if necessary. From time to time managers may discover some assumptions underlying their strategy are flawed, or are no longer applicable, or relevant. When that happens, managers need to rigorously re-examine their strategy and change it by deciding whether incremental improvements will be sufficient or whether a new, transformational, strategy is required. This step closes the loop of the management system.

Benchmarking

Benchmarking is the process of measuring a company's products, services, costs and practices and comparing that measurement with the best in the industry, the best-of-class or world-class. The aim is to use that measurement as a means to improve performance.

Best practice is the measurement or performance standard by which similar items are evaluated. Approaches that produce exceptional results are usually innovative in terms of the use of technology or human resources, and are recognised by customers or industry experts.

A benchmark is a standard or point of reference by which something can be measured or judged and competitive benchmarking involves analysing the performance and practices of best-of-class companies. The best practice is demonstrated by the best-of-class and their performance becomes a benchmark to which a firm can compare its own performance. Once a comparison has been made, the firm can improve its processes.

Activity 4.6

Activity

Work through the following questions. You may need to go back and reread the unit to help you.

1. Describe the balanced scorecard approach.
2. Evaluate Hoshin planning as a strategic planning system.
3. Evaluate Hoshin planning as a performance measuring system.
4. What are some financial measurements for an organisation?
5. What are some operational measurements for an organisation?
6. How can innovation and learning be measured?
7. What is an appropriate measurement for internal processes?
8. What performance measurements are suitable for a call centre?
9. How does benchmarking benefit an organisation?

Unit summary

Summary

In this unit you learned descriptive measurements for business excellence. You learned about the Hoshin process for setting the goals and using measurement systems. The balanced scorecard approach to performance measurement was introduced and discussed. The closed-loop management system linking strategy and operations was described and finally, benchmarking was discussed.

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Readings for further study

Reading

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Activity feedback

Activity 4.1

Inventory costs money so when an organisation obtains more inventory it costs it more money. If it obtains a lot more inventory it costs it a lot more money. That money is now tied up with the inventory investment and cannot be used for any other purpose. While inventory is being held it may appreciate in value but, more than likely, it will depreciate in value. Appreciation arises in times of rising prices and currency fluctuations. Depreciation is more common as customers are not prepared to pay full price for something that is not brand new or fresh.

Inventory hides problems and compensates for poor delivery performance, high levels of scrap and rework, poorly maintained equipment, incorrect quantities used and supplied, and poor buying decisions. Inventory, in this sense, encourages ineffective behaviour and poor performance.

Inventory requires storage places. Warehouses, storage sheds, retail shelves, containers and transport systems are built to hold and manage inventory. This is a real concern when the items held are large, bulky and carry little value. Foam used in packaging and upholstery is an example of a product made almost entirely of air that is relatively cheap to make but expensive to store.

Inventory slows the speed of production as batches of product move through production systems. When more inventories are used, transport systems are bigger, slower, clumsier and less able to cope with changing customer demands.

Inventory encourages obsolescence or may even become obsolete. The use-by date on supermarket items encourages households to buy in smaller quantities and hold smaller quantities in their homes to prevent the goods expiring.

Inventory requires special handling conditions and may be hazardous to store. Dangerous chemicals and inflammable liquids need specially constructed storage areas and staff need specialist training when handling and using these items.

Inventory is counted, administered, managed and may also be insured against loss. These actions take up time and money for the people involved.

Activity 4.2

Material requirements planning (MRP) is a set of techniques that uses the master production schedule, bills of material and inventory data to calculate the requirements of component materials.

MRP uses the master production schedule which is the list of products, quantities and dates for the next few months. It starts with each specific item and quantity listed, and calculates the quantities of all components and materials required to make those items and the date those items must be available for use.

To calculate the quantities of all components and materials required, it uses the bill of materials indicating the quantities of components to be used to make each product. Bills of materials are also called formulas, recipes, formulations or ingredient lists.

MRP explodes the bill of material, adjusts for inventory quantities on hand or already on order, and calculates net requirements that are offset by the lead time.

The inventory data needed for a basic MRP system includes lead time required to obtain or manufacture all products and materials, the quantity to order or the batch size and the quantity on-hand or the current inventory balance.

The master production schedule entries are translated into gross requirements for all materials by time period.

The gross requirement is the total requirement of an item generated from the master production schedule and subsequent levels in the bill of material. The gross requirement is balanced with inventory on hand, scheduled receipts and safety stock to calculate net requirements.

The net requirement is the result of applying a gross requirement against inventory on hand, allocations, scheduled receipts and safety stock. The net requirement is then lot-sized and offset for lead time and becomes a planned order.

MRP calculates the net requirements by subtracting current stocks and current on order quantities from the overall gross requirement. The explosion process is controlled by the bills of material. If net requirements are greater than zero, order receipts must be planned. The order release is offset from the required order receipt date by the lead time.

MRP outputs include planned orders, order release notices, changes in open orders due to rescheduling, and inventory status data. The resulting planned order releases which become the detailed production schedules are examined for availability of resources for each time period. If the capacity is inadequate to meet the schedule, the MPS is modified and the MRP programme run again. The

procedure is repeated until the MPS and available capacity have a reasonable match.

Activities 4.3–4.6

All answers are in the learning material.