INFORMATION TECHNOLOGY IN THE SUPPLY CHAIN

Introduction

- Information is crucial to the performance of a supply chain because it provides the basis upon which supply chain managers make decisions.
- Information technology consists of the tools used both to gain awareness of this information and to analyze the information to make the best decisions for the supply chain.

Introduction

- This lecture explores the importance of information, its uses, and the technologies that enable supply chain managers to use information to make better decisions.
- We focus on information about both the product and the entire supply chain that makes the product.
Introduction

- Information is the supply chain driver that serves as the glue allowing the other three drivers to work together to create an integrated, coordinated supply chain.
- Information technology (IT) consists of the hardware and software used throughout a supply chain to gather and analyse information.
- IT serves as the eyes and ears of management in a supply chain, capturing and delivering the information necessary to make a good decision.

The Importance of Information in the Supply Chain

- Information is the key to the success of a supply chain because it enables management to make decisions over a broad scope that crosses both functions and companies.
- Successful supply chain strategy results from viewing the supply chain as a whole rather than looking only at the individual stages.

The Importance of Information in the Supply Chain

- By taking global scope across the entire supply chain, a manager is able to craft strategies that take into account all factors that affect the supply chain rather than just those factors affecting a particular stage or function within the supply chain.
- Taking the chain into account maximises the profit of the total supply chain, which then leads to higher profits for each individual company within the supply chain.
The information necessary to achieve a global scope may be divided into the following basic components, which correspond to different stages of the supply chain:

- **Supplier information.** What products can be purchased, at what price, with what lead time and where they can be delivered. Supplier information also includes order status, modification, and payment arrangements.

- **Manufacturing information.** What products can be made, how many, by use in what facilities, with what lead time, with what trade-offs, at what cost, and in what batch size.

- **Distribution and Retailing Information.** What is to be transported where, in as the what quantity, by what mode, at what price, how much is stored at each site, with what lead time.

- **Demand information.** Who is buying what, at what price, where, and what quantity. Demand information includes forecasting and demand distribution information.

Supply chain managers use information to make many important decisions relating to each of the supply chain drivers.

Information must have the following characteristics to be useful when making supply chain decisions:

1. **Information must be accurate.** Without information that gives the true picture of the state of the supply chain, it is very difficult to make good decisions. That is not to say all information must be 100 percent correct, but rather that the data available paint a picture of reality that is at least directionally correct.
2. **Information must be accessible in a timely manner.** Often accurate information exists, but by the time it is available, either it is out of date or if it is current, it is not in an accessible form. To make good decisions, a manager needs to have up to date information that is easily accessible.

3. **Information must be of the right kind.** Decision makers need information that they can use. Often companies will have large amounts of data that are not helpful with decision making. Companies must think about what information should be recorded so that valuable resources are not wasted collecting meaningless data while important data go unrecorded.

- When managers have good information, they have supply chain visibility, enabling them to take a global scope.
- With this global scope, they are able to make the best decisions for the supply chain.
- Therefore, information is a key to supply chain success, as captured in the Figure.
Use of Information in the Supply Chain

- Information is used when making decisions about inventories, transportation facilities within a supply chain:
  - 1. Inventory. Setting optimal inventory policies requires information that includes demand patterns, cost of carrying inventory, costs of stocking out, and costs of ordering.
  - 2. Transportation. Deciding on transportation networks, routings, modes, shipments and vendors all requires information including costs, customer locations, shipment sizes to make good decisions.
  - 3. Facility. Determining the location, capacity, and schedules of a facility requires information on the trade-offs between efficiency and flexibility, demand, exchange rates, taxes, and so on.

- Information is most important when it is used across all stages and drivers of a supply chain.
- This allows decisions to be made that maximise total supply chain profitability.
Information Technology: The Information Enabler

- IT systems play a significant role in every stage of the supply chain by enabling companies to gather and analyse information.
- IT systems can be segmented according to the stages in the supply chain on which they focus and the phase of supply chain decisions for which they are used.
- These two segmentations can be used to create a matrix upon which any IT system used in the supply chain can be mapped.

The Supply Chain IT Map

- Strategic
- Planning
- Operational

| Supplier | Manufacturer | Distributor | Retailer | Consumer |
The horizontal axis corresponds to the stages in the supply chain and the vertical axis corresponds to the level of functionality that the systems perform.

The horizontal axis defines the scope of an IT system.

There are IT systems throughout the entire supply chain, all the way from raw material suppliers to the customer.

Some focus on only one stage or a function within a stage, whereas others cross multiple stages and give a broader scope.

For instance, there are IT systems with a narrow scope that provide inventory levels for products in a particular warehouse or that provide manufacturing schedules for a particular plant.

In contrast, there are IT systems that look at demand, inventory levels, and plant schedules across an entire network to determine what should be scheduled for production based on orders and inventories far downstream.

The vertical axis defines the decision phase within a supply chain for which an IT system is used.

IT systems have different levels of functionality that can capture and display information, analyse it to solve short-term problems, or analyse it to solve long-term problems.

IT systems can be used to make strategic, planning, or operational decisions within a supply chain.
All three decision-making phases and IT system levels are essential for each stage in a supply chain.

These two dimensions - the scope of the supply chain that is covered by the IT system and the system's level of functionality - give a manager an understanding of where each type of IT system should be applied and what type of problems it can solve.

The Past - Legacy Systems

Legacy systems are older IT systems based on mainframe technology that usually work at an operational level on only one stage or even one function within a stage of the supply chain.

"Legacy system" is a very broad label and applies to a wide variety of systems with applications that can range from order entry to manufacturing scheduling to delivery.

Although these functions are very different, they are all called legacy systems because of the older technology involved and because these systems continue to exist past their intended life span through numerous updates of the original code.
Many legacy systems have lasted much longer than originally intended and are continually modified as requirements change. This continuous modification process can make them very cumbersome to work with, especially when considering that they were not very user-friendly in the first place. They can also become very complex after years of adding layer after layer of code. Two important characteristics of legacy systems are the very narrow scope across which they have visibility and the operational nature of the tasks they perform.

Placing Legacy Systems on the Supply Chain Information Technology Map

A Typical Legacy Systems Mapping
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Strategic  Planning  Operational

Supplier  Manufacturer  Distributor  Retailer  Consumer

A Typical Legacy Systems Mapping

Strategic  Planning  Operational

Supplier  Manufacturer  Distributor  Retailer  Consumer

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A Typical Legacy Systems Mapping

Strategic  Planning  Operational

Supplier  Manufacturer  Distributor  Retailer  Consumer
On the vertical axis measuring levels of functionality, legacy systems have little analytical capability and tend to look only at operational transactions that occur in the function on which they are focused.

They rarely venture into the planning realm and virtually never attempt any sort of strategic supply chain decisions.

Legacy systems exist at every horizontal stage in the supply chain.

Advantages

- Legacy systems tend to be able to get the operation done. They may not be very efficient and they may be slow, but because legacy systems have often been up and running for more than a decade, they do work.
- Legacy systems sometimes take less incremental investment to run than installing new applications because legacy systems already exist. The complex layers of code, however, make modifications very difficult.

Disadvantages

1. Legacy systems focus on only a small part of a stage within the supply chain.

- Legacy systems usually have only transactional capabilities, which relegates them to an operational rather than a planning or strategic role.
- Legacy systems are usually based on mainframe technology that is difficult to modify and takes a long time to run when situations change.
Enterprise resource planning (ERP) systems are operational IT systems that gather information from across all of a company’s functions, resulting in the entire enterprise having a broader scope.

ERP systems monitor material, orders, schedules, finished goods inventory, and other information throughout the entire organisation.

ERP systems’ main advantage over legacy systems is the clearly superior scope they provide to make better supply chain decisions.

ERP systems are good at monitoring transactions but generally lack the analytical capability to determine what transactions ought to happen.

Therefore, they reside more in the operational area of the IT map than in the planning or strategic areas.

This is beginning to change with ERP providers including some analytical modules in their systems.

Although vertically limited, the ERP scope is obviously much broader than the typical legacy systems discussed previously.
This breadth of scope is one of the features that make ERP systems as popular as they are.

Their scope allows ERP systems to track orders through the entire company from procurement to delivery.

The ability to keep track of orders and have broad visibility in general has become more important as supply chains become more global and more complex.

Today’s trend of using a product-based instead of a function-based organisational structure has also helped make ERP systems more attractive, because this structure increases the importance of the cross-functional scope that ERP systems provide.

ERP systems typically have many modules, each covering different functions within a company.

These modules are linked together so that users in each function can see what is happening in other areas of the company.

There are several key modules to an ERP system, each of which can be installed on its own or with a combination of other modules:

1. **Finance.** This module tracks financial information such as revenue and cost data through various areas within the company.

2. **Logistics.** This module is often broken into several sub modules covering different logistics functions such as transportation, inventory management, and warehouse management.

3. **Manufacturing.** This module tracks the flow of products through the manufacturing process, co-ordinating what is done to what part at what time.
4. **Order fulfilment.** This module monitors the entire order fulfilment cycle, keeping track of the progress the company has made in satisfying demand.

5. **Human Resources.** This module handles all sorts of human resources tasks, such as the scheduling of workers.

6. **Supplier Management.** This module monitors supplier performance and tracks the delivery of supplier’s products.

- EPP systems not only allow a company to track items throughout the system, they also allow a company to automate processes.
- By automating processes, companies are often able to increase efficiency and reduce errors.
- This combination can result in significant cost savings if executed properly.
- It is important to keep in mind, however, that automating poor processes only guarantees that they will be executed poorly each time.

**Placing Enterprise Resource Planning Systems on the Supply Chain Information Technology Map.**
 ERP systems were developed to provide an integrated view of information across functions within a company and with the potential to go across companies.

- The enlarged scope of visibility along the horizontal axis is what chiefly differentiates ERP from legacy systems and is the main reason why the ERP industry was so successful during the mid and late 1990s.

- Within a company, an ERP system will provide visibility of both incoming supplies and orders so that manufacturing managers can be sure when they schedule production that demand will be met and that appropriate materials will arrive on time.

 Sales people can view production schedules and warehouse inventory levels in order to determine when a product might be delivered to a customer.

- ERP systems can also create opportunity to share data across firms so that managers have visibility across the entire supply chain, although few companies have reached this stage of implementation.

- Nonetheless, the enlarged scope of visibility is the largest benefit that ERP systems offer, because it allows company and supply chain managers to make much better decisions.

 In terms of the vertical axis, ERP systems tend to focus on the operating level and do not have much analytical capability to help with decisions in the planning and strategic phases.

- ERP systems are weak when it comes to determining how much inventory there should be to meet a certain service level.

- As an example, most ERP systems can develop a production schedule that attempts to find the best schedule possible.

- However, given the relatively unsophisticated optimisation techniques used (such as material requirements planning (MRP), they tend to arrive at a feasible their rather than an optimal solution.
ERP systems have problems trying to optimise over multiple types of constraints (such as capacity and material constraints) and multiple plants.

Recently analytical capability has been added to ERP in the form of add-on modules that bolt onto existing ERP systems.

The focus on the analytics will improve ERP systems and move them into the planning and potentially even strategic levels of functionality.

On the IT map, ERP systems generally span all of the functions of a particular stage in the supply chain and have limited visibility into stages directly interacting with the ERP system.

In addition, ERP systems have the potential to cross organisations and broaden scope even further, although this has not happened with much frequency.

On the vertical axis, they solidly cover the operational area and have moved up into some of the planning arena, although they are not as well developed there.

An ERP System’s Mapping

Strategic
Planning
Operational

Supplier
Manufacturer
Distributor
Retailer
Consumer
Advantages

1. ERP systems provide a wider scope to managers of supply chains. With an ERP system in place, managers have much broader information availability with which to make decisions that increase total supply chain profits.

2. ERP systems are fairly good at giving real-time information so there is little delay communicating information about changes in one part of the supply chain to other parts of the chain.

3. ERP systems are also better than legacy systems at using enabling technologies like the Internet to share information.

Disadvantages

1. ERP systems still have relatively weak analytical capabilities because their focus is at an operational level. The ERP players are trying to move upward on the IT map, but it is a difficult move to make because software for the planning level requires quite a large amount of expertise to develop.

2. ERP systems have a reputation for being very expensive and difficult to implement. This can be especially true when the standard modules must be customised to accommodate different business processes.
The Enterprise Resource Planning Players

**SAP**
- The clear ERP market leader with around a 30 percent share of the market, SAP has its roots writing software for manufacturing environments.
- The firm has a strong tradition of building capabilities in-house, and they are expanding their product offerings vertically by developing more analytical functions to be used in supply chain planning.

**ORACLE**
- The second largest player with about half the share of SAP, Oracle is the only one of the Big Five ERP players that is not solely an ERP firm.
- Oracle also writes database software, which led it to begin creating ERP systems.
- Oracle initially added financial applications to its database programs and eventually grew to be a full ERP provider.
- Oracle has had the most success with consumer packaged goods companies, although they have successfully expanded into other industries.
Peoplesoft

- Whereas SAP started with manufacturing applications and Oracle with finance, Peoplesoft started with human resources applications.
- It has acquired an analytical software firm in the supply chain (Red Pepper) in order to push its products up the vertical scale of the IT map.

J. D. Edwards

- This firm started out building cross-functional systems that were targeted toward midsize firms, generally those with around $1 billion in sales.
- J. D. Edwards has purchased Numetrix, a supply chain software company, in an effort to increase its offering in the analytical applications realm.

Baan

- Baan, like J. D. Edwards, began with the entire integrated view in mind rather than a specific function as is the case with the three leaders.
- Baan also focuses on midsize companies.
- Baan tends to perform better in manufacturing environment although they have attempted to break out of this vertical industry.
- In order to improve its supply chain analytics, Baan has purchased CAPS Logistics.
Whereas an ERP system's greatest advantage is the broad scope it provides, an analytical application's advantage lies in the fact that it can be used for both planning and strategic decisions. Analytical systems are not focused at an operating level but rather on planning and strategic decisions. They analyse information supplied to them by legacy or ERP systems in order to help supply chain managers make good decisions.

Analytical applications rely on sophisticated algorithms including linear programming, mixed integer programming, genetic algorithms, theory of constraints, and have many types of heuristics. These algorithms are most often proprietary to the software company, and large amounts of R&D go into developing them. Due to the level of sophistication, this technology is relatively hard to develop if a firm has not had much experience in this area.
Analytical applications are generally not as broad as ERP applications in their horizontal scope.

In fact, many analytical applications focus only on a particular function within a supply chain stage, similar to the way legacy systems perform.

However, they excel in their analytical capability, which gives them higher levels of functionality than either legacy or ERP systems.

On the IT map, analytic applications therefore exist higher up on the vertical axis. There are many different types of analytical applications that focus on various stages and vertical niches in the supply chain.

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**Analytical Applications**

**Planning Systems**

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**Procurement & Content Applications**

- Procurement and cataloguing applications focus on the relationship between a manufacturer and its suppliers and the procurement process that takes place between them.
- The basic purposes of supplier focused applications are to enable a streamlined procurement process, replace the supplier’s catalogue, and keep track of parts, specifications, prices, order processes, and the suppliers themselves.
- Supplier management systems allow analytical comparisons of supplier versus supplier and part versus part to help buyers make decisions on whom to buy from and what to buy.
Advanced Planning and Scheduling

- Advanced planning and scheduling (APS) has been one of the fastest growing areas in analytical applications.
- APS systems produce schedules for what to make, uses where and when to make it, and how to make it while taking into account material availability, plant capacity, and other business objectives.
- APS can also encompass the functions of strategic supply chain planning, inventory planning, and available to promise (ATP). These systems are highly analytical and use sophisticated algorithms.

Transportation Planning and Content Systems

- Transportation planning and content systems perform the analysis to determine how, when, where, and in what quantity materials ought to be transported.
- Comparisons of different carriers, modes, routes, and freight plans can be made using these systems.
- The planning vendors produce the engine that performs the analysis, and content vendors provide the data needed to perform the analysis, such as mileage and tariff requirements.

Demand Planning and Revenue Management

- The demand planning and revenue management application helps companies forecast their demand using proprietary analytical tools.
- These systems take as inputs historical data and any information regarding future demand and come up with models to help explain past sales and forecast future demand.
- Good systems take into account demand trends as well as seasonality along with modifications for promotions to forecast future demand.
Customer Relationship Management (CRM) and Sales Force Automation (SFA)

- The customer relationship management (CRM) and sales force automation (SFA) applications automate relations between sellers and buyers by providing product and price information.
- They also allow for detailed customer and product information to be available in real time so that salespeople can direct their efforts or customers can configure orders themselves.

Supply Chain Management

- Supply chain management (SCM) systems are a combination of many of the preceding applications and are used to span the stages in the supply chain.
- They are delivered as a suite of different supply chain applications that are tightly integrated.
- SCM systems allow for a more global scope because they can span many supply chain stages with their different modules.

Analytical Applications

Operational Systems
Inventory Management Systems

- These systems observe demand patterns; take inputs on forecasting, costs, margins, and service levels; and then produce a recommended stocking policy.
- They are best used to achieve an optimal balance between inventory costs and stockout costs.

Manufacturing Execution System

- A manufacturing execution system (MES) is less analytical than an APS system and is similar to the operationally focused ERP system, except that it concentrates only on executing production in a manufacturing facility.
- An MES generally produces short-term schedules and allocates resources with their analytical capabilities.
- The leading MES modules are from the ERP companies and a number of smaller players.

Transportation Execution

- Similar to an MES with respect to APS, transportation execution systems make transportation plans work.
- They are less analytical than their planning counterparts but serve as an operational link to the planning tools.
Warehouse Management System

- Like transportation execution systems, warehouse management systems (WMSS) execute inventory planning commands and run the day-to-day operations of a warehouse.
- These systems also keep track of inventories in a warehouse.

Placing Analytical Applications on the Supply Chain Information Technology Map.

- On the IT map, analytical applications generally reside within various stages of the supply chain at the planning level.
- Some planning applications have operational counterparts.
- SCM stretches across supply chain stages.
- Note that some applications, such as the transportation applications, can exist between any two stages in the supply chain, and not simply where they are shown in the figure.
Advantages

1. Analytical applications have very sophisticated analytical capabilities and generate solutions that are far superior to what could be arrived at without them. Therefore, these applications can potentially increase the users’ profitability. This can be seen by analytic applications’ penetration up the vertical scale of the IT map.

2. Analytical applications generally can respond in real time to problems and emergencies. For example, schedules can be instantly rerun if a machine goes down, thereby quickly shifting production.

Disadvantages

- Analytical applications have one downfall in terms of the IT map: The biggest problem with analytical applications is that they do not have the broad scope of an ERP system.
- They must rely on data from either legacy or ERP systems, and when supply chain wide data are not available, they must resort to estimates or default to local optimisations,
- In any case, integrating the analytical application with a good data system is essential.
The Analytical Application
Players

i2 Technologies
- i2 is the market leader in the SCM realm.
- i2’s strength began with its powerful APS systems used for discrete manufacturers.
- i2 is particularly strong in the high-tech industry, although it now has a very broad base of customers.

Manugistics
- The number-two player in SCM is Manugistics.
- Manugistics’ systems are best at demand planning and working with distribution-intensive products such as consumer goods.
ERP players

- Some of the ERP players are also developing SCM capabilities using three different approaches.
- SAP is developing its capabilities in-house, Oracle has leaned toward partnering with existing SCM players (although it has developed an in-house supply chain solution as well), and Peoplesoft, J. D. Edwards, and Baan have acquired SCM companies and are incorporating their products into the ERP suites.

Summary

- It is important to understand the interaction between ERP systems and analytical applications.
- Although they are sometimes viewed as competitors, they also rely on each other. The full value of an ERP system cannot be realised without the problem-solving ability of analytical solutions.
- Conversely, for analytic solutions to be productive, they need accurate data from a variety of functions.
- One of the best ways to obtain these data is through an EPP system.