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**MERGE IN TRANSIT, A DISTRIBUTION
METHOD IN THE INDUSTRIAL ENVIRONMENT**

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Summary

The rapid changes confronted by the world economy in the last years have had a notable impact on the procedures adopted for the commercial business on a global basis. The ever-growing competitiveness drives companies to adopt a supply chain prospective where each member of the chain takes part in the process of maximising customer service and minimising costs.

The design of the distribution channel is a key factor which determines supply chain performance. A detailed description regarding the most important distribution structures (central and local warehouses, centralised distribution centres, direct delivery, cross-docking) is presented.

The process of continuous performances improvement drives to a new delivery model: Merge in transit (MIT). The characteristics of this approach are presented: what it provides, the delivery process phases, the implications within the organisation.

The effects of this model are analysed from a cost, service, quality prospective as well as the drivers of these effects. Some key concepts correlated to them are then provided (separation of order and goods flow, postponement, elimination of activities, scale economies). The comparison between MIT and the approach with central and local warehouses is focused on the two key characteristics of MIT: the centralisation/elimination of inventory and the order and goods flow control. Beside this, the motivation which drives each actor within the supply chain to adopt this approach is explained.

Moreover, a pragmatic model to analyse the feasibility of MIT is provided to clarify the most important steps that must be done for a successful implementation. After constructing the scenario (fixing products characteristics, market environment, supplier and logistics service provider capabilities), the evaluation of such scenario takes place from an economical prospective. A successful implementation implies a flexible organisation and a sophisticated information system. Both issues are deeply analysed and two solutions for the information exchange (EDI-technology and product centric information management) are presented. Because of the complexity of the whole system some actors which can support MIT implementation are introduced.

Key Words

Supply chain, distribution channel, customer service, merge-in-transit, merge points, product centric information management

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1 Introduction

The rapid changes confronted by the world economy in the last years have had a notable impact on the procedures adopted for the commercial business on a global basis. The increased number of sales transactions arising from internationalisation and globalisation processes is requiring a greater attention to the logistics services procedures.

Flexibility requirements within production and distribution processes are increasing due to the market internationalisation, delocalisation and third-party allocation of production to low-cost countries, enabling further savings arising from materials and components procurement where purchasing is more convenient (global sourcing) [1].

Geopolitical events and advances in technology have broken the old rules of “local for local” manufacturing; allowing global sourcing and supply. Today’s market place can be considered a “global village”, characterized by rising competition and excess of supply over demand. In the deflationary market minimisation of price, agility and responsiveness are key issues [2].

This high pressure drives each actor in the supply chain to match the “order winning criteria” required by the market through a supply chain prospect. Taking strategic decisions focusing on a sub-optimisation prospect is not enough to reach success.

“Supply chains compete, not companies”. We must avoid situations where something that could mean a cost saving to one company, might mean increased costs to the supply chain as a whole. For example the implementation of “just-in-time” delivery enables a reduction of the inventory level for the factory but causes increased inventory and transportation costs for the suppliers. So, low-cost off-shore sourcing means high-cost supply chain outcomes due to the greater distances covered, the extension in lead-times, the complications in coordinating activities [2].

Not only the quality of the product is perceived as a value by customers but it is deemed to be of the greatest importance also the whole service offered by the suppliers including different aspects of the order fulfilment such as on-time delivery, timeliness, accuracy and completeness of shipments.

This has implied an improving development of logistics chains on an international basis redesigning the distribution networks and the relevant management activities.

The challenges, the supply chains have to face nowadays and the ever-growing competitiveness urge companies to look for new solutions able to consider change drivers and grant the greatest benefits [1]. For this reason a holistic prospect to supply chain management should be used.

The choice of suppliers and the selection of distribution channels are driven by a “joined-up thinking” approach whose aim is to enact the defined business and marketing strategy [2]. Only companies that cooperate with other companies in the chain can succeed identifying appropriate supply chain solutions for each product/market.

The objective of the supply chain concept is to synchronise the service requirements of the customer with the flow of materials from supplier such that apparent contradictory situation of conflicting goals of high customer service, low inventory investment and low operating costs may be balanced (or optimised). It follows that the design and operation of an effective supply chain is of fundamental importance.

Gattorna and Walters [3]

The structure of distribution channels determines the transportation and marketing efforts required to meet customer needs or, in other words, affects the service offered on the market. In fact the distribution channels are defined:

The structure of intracompany organisational units and extracompany agents and dealers, wholesale and retail, through which a commodity, product or service is marketed.

Baker [4]

1.1 Problem area

Distribution deals with the handling and storage of goods from the supplier to the customer within the supply chain.

The selection of proper supply chain strategies determines the business profitability. The problem is how to individuate the right distribution channel to meet customer needs and maximise the profitability of the companies.

The distribution network adopted is structured in order to meet only specific objectives. It is not necessary to reach the highest level of performance in every area. Customers who can tolerate a long response-time and thus few locations, allow firms to increase the capacity of each location while customers who expected short response time, demand for locations closed to them, with low capacity and many facilities [5].

Products and markets have different characteristics and needs, always changing and companies are searching methods to increase the value added of their offer.

Thus, it's hard to determine the right configuration, since a lot of variables are involved. The reasons that drive me to write this thesis is to give a clearer idea regarding the distribution models that could be adopted and the benefits they involved.

Customer service and costs are the two dimensions of the problem and the key drivers of the constant development within distribution field.

Because of the process of continuous improvement aiming at increasing value while lowering costs, basic distribution channels models based on central and local warehouses, centralised distribution centre and direct delivery are overcome by further new model: Merge in Transit (MIT).

MIT offers an innovative approach which minimises delivery costs and obsolescence risk while maximising customer service level for small-size orders formed by products provided by several suppliers.

It is a new delivery model in which goods shipped from several supply locations are consolidated into one final customer delivery as illustrated in figure 1. The company needs to coordinate shipments so that they arrive simultaneously and goods can be bundled and shipped immediately to the final customer for arrival on due date [6].

The separation of order and goods flow enables a centralised monitoring and the consequent reduction of administration activities and, at the same time, an elimination of inventory and the adoption of merge points. Thus, inventory costs, storage time and warehousing costs are reduced while product variety, delivery completeness to end consumer, accuracy, timeliness are improved.

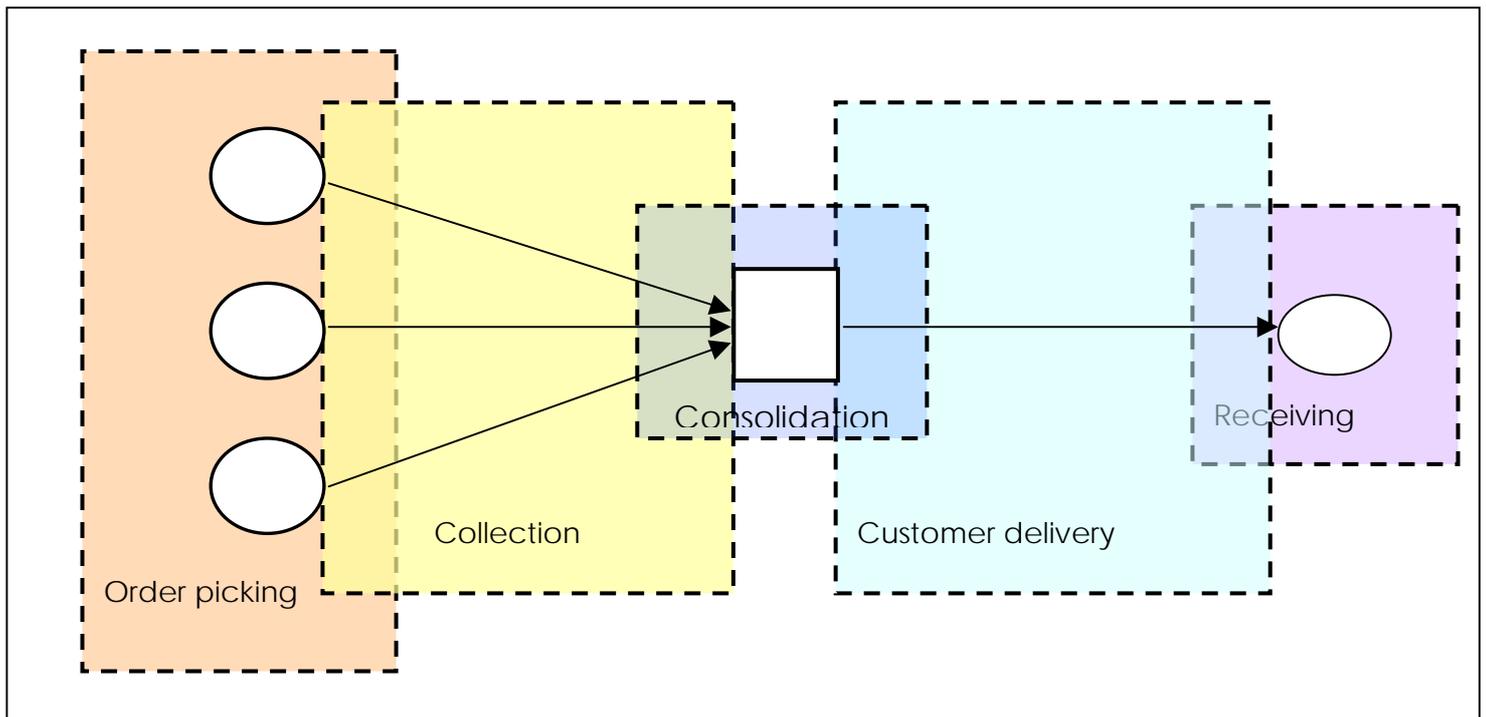


Figure 1. Merge in transit structure (from [6])

1.2 Purpose

The purpose of this thesis is to analyse a new solution in supply chain, named MIT, design to solve trade-offs between management cost cutting and higher customer service level within markets characterised by an increasing globalisation. A deep literature review has been conducted about delivery channels and in particular MIT. A clear description of the characteristics and the phases of such model is provided. Focusing on product/process characteristics, market environment as well as costs, the applicability of MIT within a specific business is assessed. Organisation flexibility, cooperation, activities complexity and information sharing would be addressed within the implementation process of MIT. More specifically, the analysis will deal with the following points:

- Distribution channels
- MIT definition
- Business suitability
- Organisation requirements

- Further suggestions

1.3 Delimits

MIT is a distribution model whose aim is to provide cost saving and value to the end customer when a wide variety of products is offered and small order size is requested. Because of it the system becomes more complex especially from the point of view of the information systems.

This thesis does not include a deep research in the information systems field because of the continuous improvement in information technology and the vastness of such argument. This thesis briefly analyses the characteristics of the two main approaches: EDI technology and product centric system without providing a deep cost evaluation or specific configuration solutions.

The thesis present the effects of MIT approach comparing it with other approaches. Sometimes the comparison involves only MIT and the structure with central and local warehouses because this one is the traditional distribution solution and is quite opposed to MIT characteristics. This choice was due to the fact that including further comparisons, the thesis would become too large and too congested.

1.4 Outline

First of all in the introduction (chapter 1) the actual business environment is presented underlying the key drivers of such continuous process of changes in product/customer needs. The basic market requirements take an important role in the design of distribution channels causing a constant impulse to improve performance. In this way, the problem area is defined (1.1). On this basis, the purpose of the thesis is developed (1.2). Delimits of such thesis are underlined (1.3). Then, the outline is presented (1.4).

The methodology adopted in the process of writing the thesis is clarified through a description of the sources, tools and methods used to develop it in chapter 2.

A deep literature review is conducted. The chapter 3 is the result of such research. In order to assess new solutions in the supply chain design a deep analysis regarding the distribution channels has been developed. The main forces that shape the business environment and logistics fields are used to classify these channels (3.1).

Underlying the benefits and the backwards of each solution, the continuous research to improve the delivery activity drives to the definition of an innovative model: MIT (3.2).

After indicating the main characteristics of MIT, a detailed analysis on the effects and the reasons for such effects is presented. Some key concepts behind these effects offer further hints for the analysis. The comparison between MIT and the system characterized by central and local warehouses is developed. Furthermore, the viewpoint of each member of the supply chain is considered and the motivations which drive it to implement MIT are presented (3.3).

At this point a model to assess the feasibility of MIT in a specific business field is suggested (3.4).

Then, the analysis part starts (chapter 4). A pragmatic view regarding distribution channels is provided (4.1) and the definition of MIT follows (4.2). Moreover, MIT is analysed focusing on business suitability (4.3), organisation requirements (4.4) and tools for further improvement (4.5).

Finally, the conclusion and discussion part (chapter 5) offers a summary of the most important elements, helping the reader to focus on them easily.

2 Methodology

This chapter clarifies how the research was done and the reasons why the work was done in that way: tools, method and sources are explained here below.

This thesis has been written after a deep research of the literature regarding delivery channels and MIT in particular. Books, written documents, theses, papers and articles were used to gather information relevant to the topic under examination. The key words used in order to collect information on the internet were: supply chain, delivery channels and merge in transit. Moreover information were selected in order to give an easy, pragmatic and not abstract view about the subject. Sources were from the library database (Academic Search Elite, ABI/Inform, Business Source Premier) and Google Scholar. This guaranteed the validity of such information. Moreover, articles used were published recently. This guaranteed up-to-date information. It was a central issue since the market environment is continuously changing and new researches are constantly done.

The work was done following a logical sequence. Introduction, theoretical framework and analysis guarantee a scientific approach for this research. And the scientific method fit investigation of new phenomena, such as MIT. For this reason a better approach could not be found.

Comparison among articles and documents which are focused on the same theme, helped me to have a deeper view into the subject. Different authors paid attention to different kind of details and this enabled to open up new horizons. Also case studies described in literature played an important role within the process of writing this thesis. From empirical data, general issues were assessed. In this way a more practical and pragmatic touch was given. This aspect was fundamental especially for the cost analysis. Starting from a real case study, I was able to draw out a guide model that could match different kind of business.

Papers regarding different fields (engineering, economy, management, production, marketing, information technology) were used to give a 360 degree view on this argument. Articles regarding information systems, automation, information technology, web applications had an important role especially for the implementation and the relative organisational implications MIT faced.

We have also to say that tables and figures were often used to clarify concepts and summarize arguments. Figures are colourful in order to catch the reader's attention and provide a more direct view into the subject.

3 Theoretical framework

This chapter is the result of literature review. Here the studies of several authors on distribution structures and in particular on MIT are presented. First of all, different distribution channels structures are introduced, then a pragmatic approach focused on improvement drives us to concentrate on MIT, an innovative distribution model. Effects, reasons, key concepts within MIT are presented as well as performance comparison between MIT and central and local warehouses approaches. Finally, a model to support companies in their choice of suitable distribution channel is proposed.

3.1 Distribution channels

The design of the distribution network has a strong impact on supply chain costs and service level. As suggested by Chopra in his article: “*Design the distribution network in a supply chain*” [5], the performance of a distribution network can be analysed considering two dimensions:

- the customer needs that are met or the customer service level (which impact the company’s revenue)
- the costs to assure them (which determines the company’s profitability).

The key factors that influence the customer service are [5]:

- product variety (the range of products/configurations offered to the customer),
- response time (lapse of time between the order placement and the delivery),
- product availability (the probability of having it in stock when an order arrives),
- customer experience (the ease with which customer order is filled),
- order visibility (the possibility given to the customer to track his order within the delivery process),
- returnability (the facility with which unsatisfactory merchandise is returned by a customer).

The key factors that influence the cost are [5]:

- inventory

- facilities and handling
- transportation
- information

There are several design options for a distribution network. In order to be more precise and to have a detailed classification scheme, Chopra suggests a classification based on two key decisions:

- The order is delivered to the customer location or picked up from a preordained site?
- The product flows through an intermediary

So, six different distribution models are found [5]:

- Manufacturer storage with direct shipping or drop shipping
- Manufacturer storage with direct shipping and in-transit merge
- Distributor storage with carrier delivery
- Distributor storage with last mile delivery
- Manufacturer or distributor storage with customer pickup
- Retail storage with customer pickup

Here below these distribution models are precisely described. First of all, the flow of products and orders is analysed, then the costs and benefits involved in each approach are assessed. A table provides a summary of the cost factors and the relating performance for each model.

As said before, the issues described are mainly based on the research done by Chopra [5].

3.1.1 Manufacturer storage with direct shipping or drop shipping

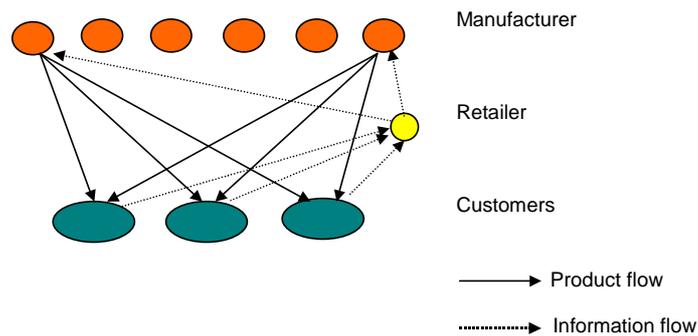


Figure 2. Manufacturer storage with direct shipping (based on [5])

The order is shipped directly from the manufacturer to the final customer without intermediaries while information flows from the customer, by the retailer and then to the manufacturer as illustrated in figure 2.

The centralised inventory at the manufacturer allows the manufacturer to aggregate demand and thus to improve product availability while allows retailers to maintain a low level of inventory. The centralisation offers the biggest advantage with products characterised by high value, low volume and unpredictable demand while the benefits of aggregation for products with predictable demand and low value are small.

Transportation costs are high because of the use of package carriers which have a higher shipping cost per unit than truckload carriers.

Moreover with drop shipping more deliveries are necessary to fulfil the customer order. But fixed costs of storage facilities are minimised due to the centralized inventory.

Handling costs are reduced due to the direct delivery.

The information infrastructure is necessary so that the customer can receive product availability information from the retailer even though inventories are centralized at the manufacturer. A good information infrastructure enables the customer to have visibility into the order processing at the manufacturer. Moreover, due to direct deliveries, the infrastructure is simple. Since the retailer has to transmit the order to the manufacturer and the distance from the centralized inventory is longer, response times are long.

Direct shipping guarantees wide range of product variety. The customer experience is generally good but it's necessary that the order is delivered partially due to the fact that it contains products from many manufacturers.

The handling of returns is difficult in the direct shipping distribution because each order could imply shipments from several manufacturers.

Due to these characteristics, direct shipping fits high value items, whose demand is low and the variety wide. Customers wait for the delivery accepting also partial shipments. Direct shipping offers the main benefits when the order is coming from few sourcing locations.

Here below table 1 summaries the performance characteristics of manufacturer storage with direct shipping network focusing on cost and service.

Cost Factor	Performance
Inventory	Low costs due to aggregation. Benefits from aggregation are very high for low volume, high value items. Benefits are very high if product customization can be postponed and carried out at the manufacturer facility
Transportation	Transportation costs are high due to longer distance and disaggregate shipping
Facilities and Handling	Thanks to aggregation, facility costs are low. There can be some savings on handling costs in case manufacturer can manage small shipments or ship from production line
Information	High since the investment in information infrastructure to integrate manufacturer and retailer is significant
Service Factor	Performance
Response time	Long response time (within 1 - 2 weeks) due to increased distance and because of two stages for order processing. Response time may be shorter or longer depending on kind of product, thus complicating receiving
Product variety	Very high variety level is easy to provide
Product availability	Easy to provide due to aggregation carried out at the manufacturer facilities
Customer experience	Good in terms of home delivery but can suffer in case order from several manufacturers is sent by partial shipments
Order visibility	More difficult but also more important from a customer service point of view
Returnability	Difficult and expensive to implement

Table 1: Performance characteristics of manufacturer storage with direct shipping network (from [5])

3.1.2 Manufacturer storage with direct shipping and in-transit merge

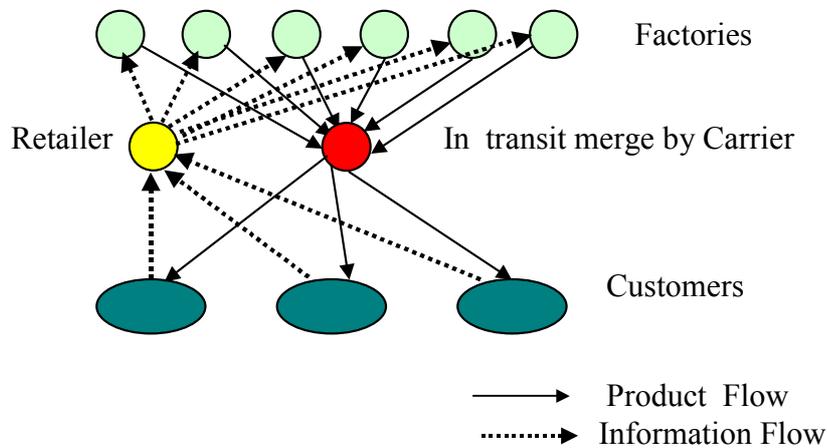


Figure 3. Manufacturer storage with merge in transit (based on [5])

It is different from the pure drop shipping because the customer receives a single delivery. Thus, each product in the order is not shipped directly to the customer, instead, there is a combination of the pieces of the order coming from different suppliers. The flow of goods and orders is illustrated in figure 3.

This approach offers the great benefits with high value product, whose demand is not predictable. In such situation the possibility to aggregate the inventories and postpone the customisation guarantees great advantage.

The transportation costs are low because single deliveries are provided. This implies also a simplified receiving process for the customer. A sophisticated information system is required. Great coordination is necessary and order visibility is fundamental. Comparing to the direct shipping, performances regarding response times, product availability and variety are improved while returnability is similar.

Lower transportation costs and higher customer service level are the main benefits of this approach that, thus, is used for low to medium order size, high value products coming from a limited number of suppliers.

Here below table 2 summaries the performance characteristics of MIT model focusing on cost and service.

Cost factor	Performance
Inventory	Similar to drop shipping
Transportation	Lower than drop shipping
Facilities and handling	High handling costs at carrier but lower receiving costs at customer
Information	High since a sophisticated information system is required
Service factor	Performance
Response time	Similar to drop shipping
Product variety	Similar to drop shipping
Product availability	Similar to drop shipping
Customer experience	Better than drop shipping since a single delivery is offered
Order visibility	Similar to drop shipping
Returnability	Similar to drop shipping

Table 2: Performance characteristics of MIT (from [5])

3.1.3 Distributor storage with package carrier delivery

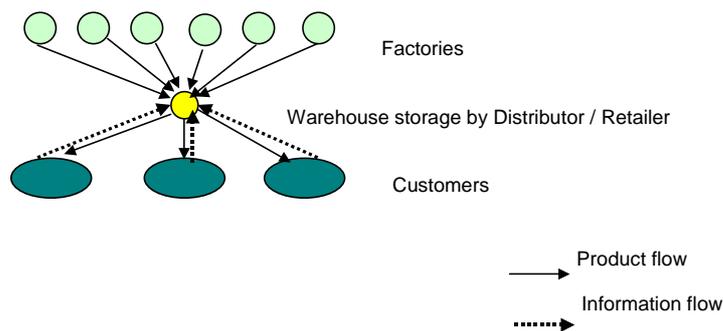


Figure 4. Distributor storage with carrier delivery (based on [5])

Inventory is held in intermediate warehouse by distributors or retailers and products are transported from intermediate location to the final customer by package carriers which undertake transport of goods from one point to another as illustrated in figure 4.

Since the demand uncertainty is aggregated by the distributor/retailer warehouse to a lower level than the manufacturer, a higher level of inventory is needed. That's why distributor storage is best suited for products characterized by higher demand.

Distributor storage has low transportation costs because of the employment of truckload, an economic mode of transportation that can be used for inbound shipments to the warehouse. Then outbound orders are bundled into a single shipment instead of having multiple shipments to go out for a single customer order as in manufacturer storage and that's allows further transportation savings.

Distributor storage has high facility costs because the level of aggregation is lower.

The information infrastructure is less sophisticated than the one necessary for the manufacturer storage. The presence of a distributor warehouse between the manufacturer and the customer reduces the need of coordination. In fact only real time visibility between customer and warehouse must be guaranteed, not the real time visibility between customer and manufacturer and that is provided at a lower cost.

The response time with distributor storage is better than drop shipping thanks to the fact that warehouse is located closer to customers and here the order is aggregated.

The disadvantage is that warehouse storage limit the range of product offered. With the distributor storage the customer convenience is high due to the fact that the customer receives a single shipment for his order. The order visibility is easier because customer receives a single shipment from the warehouse so, only one stage of the supply chain is involved in the process.

Handling returns is much easier since the returns are processed at the warehouse stage.

Distributor storage with carrier delivery is best suited for medium-fast moving items, for situations where the customer expects a faster delivery than manufacturer storage and a narrower level of variety compared to manufacturer storage but a higher than the one offered by a chain of retail store.

Here below table 3 summaries the performance characteristics of distributor storage with carrier delivery model focusing on cost and service.

Cost Factor	Performance
Inventory	Higher than drop shipping
Transportation	Low especially for faster moving items
Facilities and Handling	High especially for slow moving items
Information	Low since the infrastructure required is simple
Service Factor	Performance
Response time	Faster than drop shipping
Product variety	High since it is easy to provide
Product availability	Difficult to provide
Customer experience	Better than drop shipping
Order visibility	Easy to provide
Returnability	Not expensive and easy to provide

Table 3: Performance characteristics of distributor storage with carrier delivery (from [5])

3.1.4 Distributor storage with last mile delivery

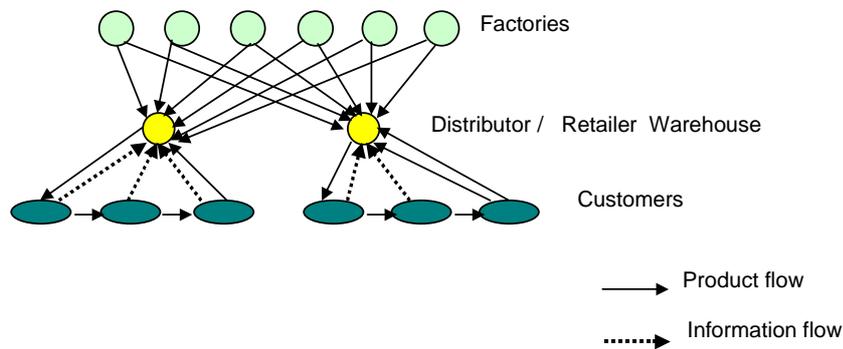


Figure 5. Distributor storage with last mile delivery (based on [5])

The distributor/retailer delivers the product directly to customer's home without using any package carrier. Warehouse is located much closer to the customer than the package carrier delivery and a high number of warehouses are necessary. The flow of goods and orders is illustrated in figure 5.

The level of inventory is high because of the lower level of aggregation it adopts. That's why this approach best fit fast moving items for which disaggregating demand doesn't imply increased inventory.

Transportation costs are high because of the loss in economies of scale.

Since a large number of facilities are necessary, the facility and processing costs are high. Facility costs are lower than the retail stores but higher than distributor storage with package carrier delivery or manufacturer storage while processing costs are much higher than retail stores because customers don't take part in the process.

The information infrastructure is similar to the one adopted for the distributor storage with package carrier delivery but it needs also the additional capability of scheduling delivery.

Response times are better than those offered by the package carriers.

The product variety is lower and guaranteeing product availability is very expensive, the cost is higher than any other option except retail stores.

The customer experience is good especially for items which are bulky and hard to be carried.

Last mile delivery gives the best returnability since trucks which make the delivery can also pick up the returns from the customer even though the returns at a retail store have lower costs because the customer can bring the product back.

Distributor storage with last mile delivery makes sense if orders are large enough and customer is willing to pay for the convenience of receiving the order at home. The efficiency can be improved if last mile delivery is coupled with an existing network; in this way economies of scale could be exploited and the utilisation could be improved.

Here below table 4 summaries the performance characteristics of distributor storage with last mile delivery model focusing on cost and service.

Cost Factor	Performance
Inventory	Higher than distributor storage with package carrier delivery
Transportation	Very high because scale economies can't be exploited
Facilities and Handling	Medium
Information	Low since the infrastructure required is simple
Service Factor	Performance
Response time	Fast since the delivery is carried out on the same day or on the following day
Product variety	Medium
Product availability	Difficult
Customer experience	Very good, in particular in relation to bulky items
Order visibility	Easy to implement
Returnability	Easy to implement

Table 4: Performance characteristics of distributor storage with last mile delivery (from [5])

3.1.5 Manufacturer or distributor storage with customer pickup

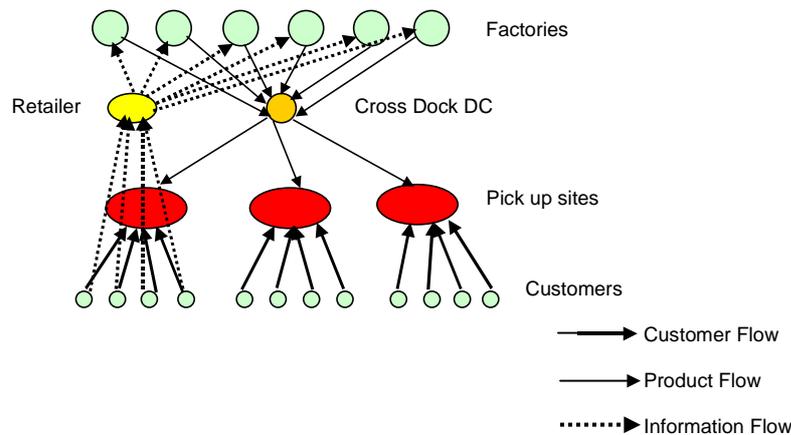


Figure 6. Manufacturer or distributor warehouse storage with consumer pickup (based on [5])

Manufacturer or distributor warehouse hold inventory but customers place their orders on the phone or online and come to indicated pickup points to get their orders which are shipped there from the storage site as illustrated in figure 6.

Aggregation enables lower inventory cost than manufacturer or distributor storage and lower transportation cost than any other solution which involves package carriers. Orders are delivered to a pickup site using truckload or less-than-truckload carriers.

Facility cost depends on the situation: if new pickup sites must be built, the cost is high while if they already exist, the cost gets lower.

Processing costs at the manufacturer or the warehouse are similar to other solutions while at the pickup site they are higher due to the fact that when the order arrives, it must be matched with the proper customer. High processing cost is the main disadvantage of this approach.

A complex information infrastructure is necessary to ensure order visibility and a very good coordination between retailer, storage location and pickup site.

The response time performance is comparable with the one reached through package carriers.

Product variety and product availability are comparable to the use of manufacturer or distributor storage approaches. Since the customer has to pick up their orders, the customer experience reaches not high levels but this allows customers who don't want to pay online to pay by cash there.

Order visibility has a key role in this approach since customers must be informed regarding the arrival of their orders and such orders must be identified. It implies a strong integration within the supply chain.

Customers can easily return the order to the pickup site from which it is transported using delivery trucks. So the returnability is good.

Delivery costs are lower, so a wider range of products could be sold and a larger number of customers could be served.

The downside effect is that the handling cost at the pickup location increases.

The effectiveness can be reached if existing locations like convenience or grocery stores are used as pickup locations even though such sites are designed to enable the customer to pick up the order thus capability of picking customer specific order must be developed [7].

Here below table 5 summaries the performance characteristics of network with customer pickup sites model focusing on cost and service.

Cost Factor	Performance
Inventory	Medium
Transportation	Low, in particular when utilising an existing delivery network
Facilities and Handling	High if new facilities must be built. In case of already existing facilities costs are lower. High can be the cost for handling activities at the pick up site
Information	High since notable investments are necessary to improve infrastructure
Service Factor	Performance
Response time	Fast
Product variety	Medium
Product availability	Easy to provide
Customer experience	Not good because of the lack of home delivery. In high population density areas loss of convenience can be small
Order visibility	Difficult but essential.
Returnability	Easy because returns can be easily handled by pick up locations

Table 5: Performance characteristics of network with customer pickup sites (from [5])

3.1.6 Retail storage with customer pickup

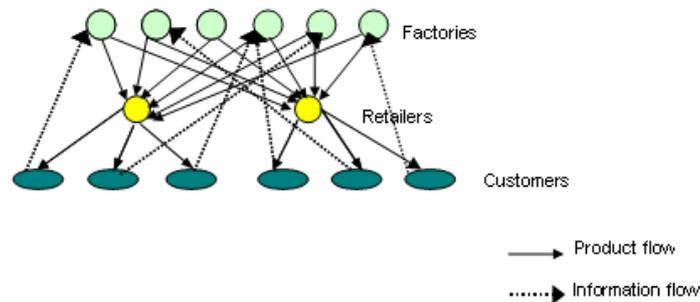


Figure 7. Retail storage with customer pickup (based on [5])

Customer walks to the retailer store or place the order on the phone or online and pick it up at the retailer store where the inventory is hold. The flow of goods and orders is illustrated in figure 7.

Inventory costs are high due to the lack of aggregation because of the local storage. That's why this approach is used for fast moving items.

Transportation costs are low thanks to the inexpensive modes of transport used for the replenishment at the retailer store.

On the other hand, facility costs are high because of the large number of facilities required.

The information infrastructure is simple if customers walk to the store while it's a bit more sophisticated for online orders which need visibility.

Response time is very good thanks to the local storage that however reduces the product variety.

A high level of product availability is so expensive with this approach.

Order visibility is a key issue especially for orders placed on line or on phone.

Returnability is good because it can be handled at the pickup location.

Summarizing, the main benefit of this option is that it keeps delivery cost low and it provides faster response comparing with other solutions. On the other side, inventory and facility costs are higher. That's why this solution best fit fast moving items or situations where customer expects a rapid response [5].

Here below table 6 summaries the performance characteristics of local storage at consumer pickup sites model focusing on cost and service.

Cost factor	Performance
Inventory	Higher than other options
Transportation	Lower than other options
Facility and handling	Higher than other options
Information	High only in case of online and phone orders because investment in infrastructure is necessary
Service factor	Performance
Response time	Fast only for items stored at pickup site
Product variety	Lower than all options
Product availability	More difficult than other options
Customer experience	Good or bad, depends on cases
Order visibility	Important and difficult for online and phone orders while easy for in store orders
Returnability	Easy, it is handled by the pickup location

Table 6: Performance characteristics of local storage at consumer pickup sites (from [5])

3.2 Process improvement within distribution channels

Differently from Chopra, Ala-Risku at al. [6], used a different prospective to categorize the distribution channels.

They insert them in the continuous process of improvement of delivery structures. In their opinion, the traditional distribution model based on holding the products in local warehouses is expensive and doesn't enable a wide offering.

Direct deliveries where the order is delivered by the supplier directly to the customer, are adopted in order to decrease inventory costs. This solution enables a wider range of products but higher inbound costs for the customer.

That's why innovative distribution methods based on consolidation are introduced. With cross-docking approach, distribution centres receive batches optimised to minimise process and product costs (the flow of goods is consolidated in distribution centres) while customers receive loads with an optimised mix of products daily. So, only one delivery to the end customer is necessary. Moreover, these authors underline that such approach fits fast-moving products with high volume demand, easily predictable.

For products with low order frequency, small volumes demand and large number of customers they suggest a different approach, MIT. The emerging distribution structure MIT is a further development of the cross-docking concept.

Useful is the definition given by Norelius [7] in his thesis: "*Merge in transit, a non-stock distribution structure*".

"Merge in Transit is the centralised co-ordination of customer orders where goods are delivered from several dispatch units consolidated into single customer deliveries at merge points, free of inventory"

As said by Ala-Risku et al. [6], both cross-docking and MIT share the same idea of consolidating deliveries from several suppliers to gain cost saving. But the main difference between the two structures is that in MIT volumes are much smaller while in cross-docking full pallets are used. Cross-docking focuses on process efficiency since the incoming shipments to terminal are forwarded with the next delivery without paying attention on the order they belong to. Operational efficiency reached by MIT approach is lower than cross-docking but it becomes an economical solution with infrequent orders of a wide range of products and a large customer-base.

Ala-Risku et al. [6] said that high-tech industry fits MIT approach. In such situation, inventory carrying costs are very high and the variety of products demanded is wide. With MIT, components coming from different supplier are consolidated into one final delivery without any inventory. This allows to postpone assembly activities and thus the necessity to store several configurations in warehouses is reduced.

A more detailed research regarding the effects that the adoption of MIT causes is done by Ala-Risku [6] and Norelius [7].

3.3 MIT effects, reasons, performance comparison

Here below the effects, the reasons of such effects, some key concepts of MIT and performance comparisons between MIT and central and local warehouse models are provided.

3.3.1 Effects of MIT

Costs	Service	Others
Reduced inventory costs	Complete deliveries to customer premises	Increase range of products and suppliers
Reduced warehousing cost	Increased customer order lead time for accessible products	Increased complexity of the organisation
Reduced administration cost		Reduced storage time
Increased or reduced transport cost		

Table 10: Effects of MIT compared with a structure with central and local warehousing

There are several benefits that can be achieved through a MIT distribution structure compared to a structure with central and local warehousing as illustrated in table 10 [6]:

- Reduced inventory and warehousing costs: the centralisation of inventories upstream enable a reduction of the safety stock level required and the elimination of stock keeping activities.
- Reduced or increased transportation costs: consolidation and shorter distance substantially compensate the increased transportation costs due to smaller shipment sizes
- Complete deliveries to customer premises
- Increased customer order lead time for accessible products (product which are accessible for customers at local inventories): the additional activities involved in the process increased lead time comparing to an approach where customer pick-up the order from stores.

- Improved customer service: thanks to the elimination of inventory and the increased flexibility, customer has the chance to choose among a wider variety of products and a larger pool of suppliers
- Increased complexity of the organisation: the flow of order and material must be well coordinated
- Reduced administration costs: economies of scale and economies of scope are exploited because of the MIT choice of central administration for monitoring and control the flow of order and goods, and some administrative activities related to stock keeping are eliminated.

Going deeper into the subject, interesting is the analysis done by Norelius [7] in his thesis where he described the drivers of the effects of MIT.

3.3.2 Drivers of the effects of MIT

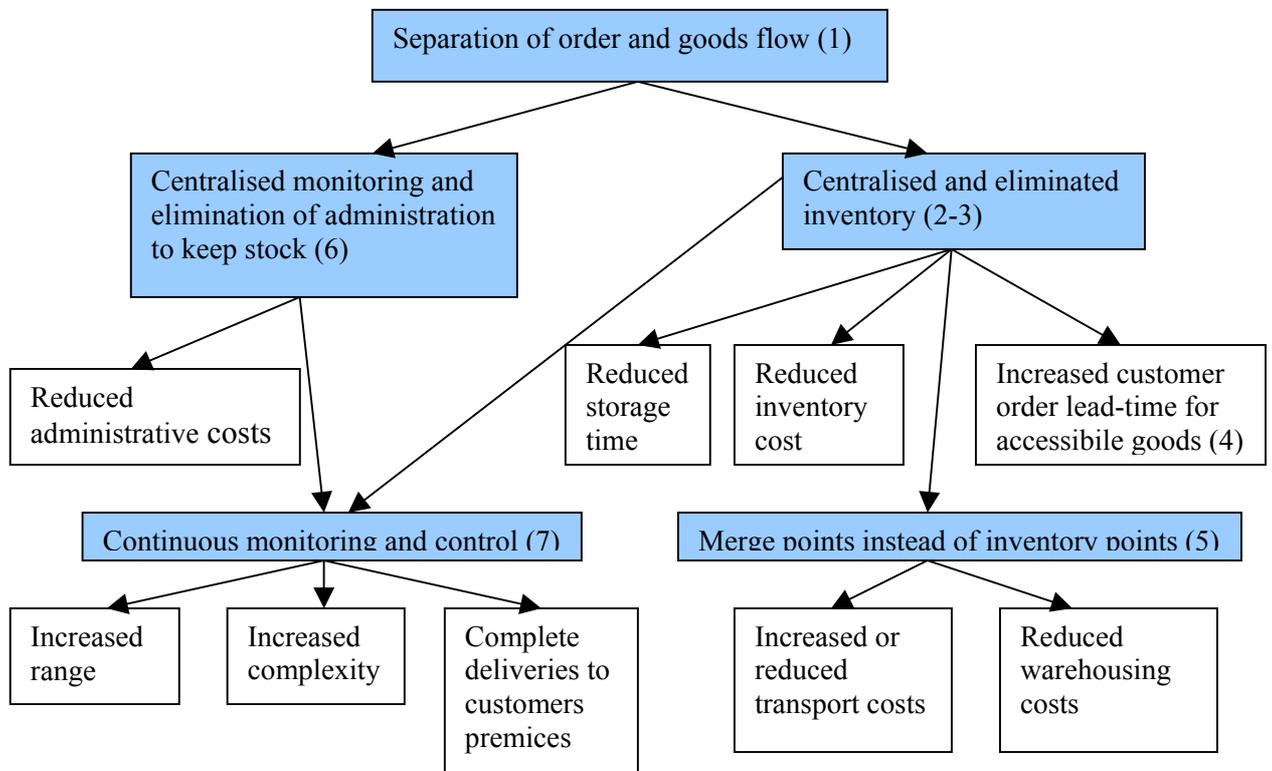


Figure 8. Relationships between reasons (blue boxes) and effects (white boxes) of MIT (from [7])

The effects above mentioned can be related to specific factors as illustrated in figure 8. The blue boxes show the reasons while the white boxes show the effects of MIT model.

The reasons that cause these effects can be summarized as follow [7]:

1. Separation of order and good flow: the separation of order and good flow enables a redesign in the information and goods flow improving the utilisation of resources and allowing the specialisation of the activities: local inventories points are replaced with a net of distribution points and local monitoring and control system driven by forecast is replaced with central system driven by customer order. In this way MIT solution increase service and reduce costs.

2. Centralised and eliminated inventory: in MIT the inventory is centralised at producer or at central warehouses without any local inventory. Through the introduction of postponement principle, the uncertainty, thus the need of inventory, is reduced.
3. Moreover, centralisation of stock points enables the exploitation of economies of scale since the resources used for storage are centralised. Then, centralizing stock allows a reduction of the safety stock since the randomly varying demands are aggregated and the standard deviations do not increase in direct proportion. In this way, also elimination of stock keeping activities is possible.
4. Unfortunately the elimination of local inventory the customer causes an increased order lead time since he has no direct access to the products.
5. Merge points instead of inventory points: replacing inventory points with merge points reduces warehousing costs and can increase or decrease transport costs depending on situations. In fact frequent-small volume deliveries from supplier to customer and the consequent decreased filling rate, increase transport costs. The filling rate is reduced since the delivery volume per delivery address decreases. In this way we have a loss of economies of scale. In fact transport means are indivisible resources that are not fully utilised. On the other hand, shorter distance reduces transport costs. In fact, with MIT the order reaches the customer more directly than other distribution solutions which involve several warehouses.
6. Centralised monitoring and elimination of administration to keep stock: administrative costs are reduced since the administrative tasks related to stock keeping are eliminated. Instead of storage activities, transfer activities take place and MIT uses a central administration for monitoring and control the flow of order and goods from manufacturers to customers, exploiting economies of scale.
7. Continuous monitoring and control: the high degree of coordination needed in a MIT approach drives to an increased complexity but at the same time to higher delivery service. In order to guarantee complete deliveries, the flow of the orders must be co-ordinated to avoid, detect and correct mistakes that could be made. The elimination of local inventory enables manufacturers to offer a wider range of standard or customised products.

Here below table 11 show how the effects and the reasons are correlated.

Effects	Reasons
Reduced administrative costs	Elimination of activities Use of scale economies Centralisation of monitoring
Reduced inventory costs	Postponement in time Postponement in form Sharing information Elimination activities Use of scale economies Trade off between storage and transport costs Centralisation of security stock Elimination of local turnover stock Postponement of assembly
Reduced storage time	Postponement in time Elimination of activities Specialisation Centralisation of security stock Elimination of local turnover stock Postponement of assembly
Reduced warehousing costs	Elimination of activities Use of scale economies Postponement in time Trade off between storage and transport costs Elimination and centralisation of equipment to keep stock

Increased or reduced transport costs	Trade off between storage and transport costs Use of scale economies Smaller shipment sizes Shorter distances
Reduced cost for forecast calculation	Sharing information
Increased range	Production of customer specific products and offers from increased number of producers
Increased customer order lead time for accessible products	Elimination of local inventory which leads to additional activities in the customer order cycle
Complete deliveries to customers' premises	Co-ordination of order and goods flow
Increased complexity	Co-ordination of order and good flows
Reduced uncertainty	Postponement in time Postponement in form

Table 11: Reasons for the effects (based on [7])

Behind the effects and the drivers of such effects, Norelius [7] issued also some concepts.

3.3.3 Key concepts within MIT

- Separation of goods and order flow: it is a way of increasing specialisation in activities. Merge point are specialised in handling goods while centralised monitoring and control system is specialised in coordinating the flow of orders and goods.
- Postponement in time and form: uncertainty causes costs and it is related to time, this means that moving the differentiation of the product or the geographical dispersion of inventories closer to the time of purchase (when the demand is more stable) can reduce uncertainty-related costs.

The principle of postponement proposes that the time of shipment and the location of the final product processing in the distribution of a product should be delayed until the customer order is received.

Zinn and Bowersox [8]

Eliminating local inventory and partly central inventory, MIT enables the postponement of geographical dispersion (time postponement). This means that goods are moved geographically when it is necessary, i.e. the delivery activity is postponed until the customer decides to place the order.

Then, the uncertainty in demand is reduced also by the postponement of differentiation of the product (Form postponement). Some activities that differentiate the form of the product within the process of value creation are postponed (labelling, packaging, assembling and manufacturing).

The reasons for increase and decrease of costs because of both time and form postponement are summarised in tables 7 and 8.

Inventory costs	Decrease	When differentiation takes place in the warehouse instead of in the production plant, the number of product variants can be reduced. Since the number of products that need to be stocked is reduced, the inventory costs also are reduced.
Processing costs	Increase	Decentralisation of the activities postponed results in loss of scale economies, increasing the processing costs.
Transportation costs	Decrease	Since unassembled products typically have better density ratios than assembled ones, a reduction in transport costs is reached.
Cost of lost sales	Increase	The increased delivery time to customers can cause lost sales.

Table 7: Form postponement: Reasons for increase and decrease of costs (from [7])

Inventory costs	Decrease	Centralised inventory enables a reduction of the level of stock needed
Transportation costs	Increase	The use of less-than-truckload LTL shipments increases transportation cost
Cost of lost sales	Increase	The longer delivery time caused by postponed shipment increases the possibility of lost sales

Table 8: Time postponement: reasons for increase and decrease of costs (from [7])

- Elimination of activities: since activities consume resources, eliminating activities is the most efficient way to improve system efficiency. In MIT approach administrative and turnover stock activities as well as stock keeping activities are eliminated.
- Use of scale economies: they decrease the average cost per unit.

Economies of scale may be defined initially as those that result when the increased size of a single operating unit producing or distributing a single product reduces the unit cost of production or distribution.

Chandler [9]

Centralisation allows a reduction of the security stock, outsourcing enables a more efficient use of indivisible resources

- Trade off between transport and storage activities: the adoption of merge points without inventory reduces inventory costs but the frequency of the shipments increases transport costs.

After clarifying effects, drivers and other key concepts, Norelius [7] provided also a comparison between MIT and the model characterised by central and local warehouses. In this way he was able to highlight the differences in costs and services of these approaches.

3.3.4 Comparison between MIT and central and local warehouses approaches from a different prospective

Above we have already presented the benefits of MIT adoption compared to central and local warehouses structure but it's interesting to make a comparison using another prospective.

MIT is characterized by two main issues: centralised or eliminated inventory between producer and customer and centralised monitoring and control of order and goods flow. On this basis differences in performance between MIT and distribution system with central and local warehousing can be understood [7]. A summary of it is provided by tables 12 and 13.

Centralisation or elimination of inventory enables a reduction in keeping stock costs while increasing or decreasing transportation costs from the manufacturer to the customer. The storage time is reduced while the customer order lead time for accessible products increases because additional activities must be performed to guarantee the accessibility of the products. The range of product offered is larger since the elimination of inventory enables an increasing number of manufacturers to offer standard and customised products.

Differences in costs and service between MIT and a structure with central and local warehousing	Main explanations of the reasons for the differences in costs and services (theoretical explanations)
Reduced inventory and warehousing costs in MIT	Elimination of local inventory (postponement or scale economies)
Increased or reduced transport costs through smaller shipments sizes and shorter distances	Smaller shipment sizes (scale economies and the trade off between storage and transport costs), Shorter distances due to more direct deliveries from producers to customers
Increased customer order lead time for accessible goods in MIT	Elimination of local inventory which leads to additional activities in the customer order cycle must be performed to make the products accessible for the customer
Increased range in MIT	Elimination of local inventory in combination with monitoring of flows which leads to increased number of producers offering standard and specific products.

Table 12: The main explanations of the reasons for the differences in costs and services between MIT and a structure with central and local warehousing, caused by centralised or eliminated inventory between producer and customer.

Centralised monitoring and control of order and goods flow decrease administrative costs while increasing customer service because of complete deliveries. The scale economies have a key role in the reduction of the administrative costs while the flexibility reached through a good coordination is a fundamental factor for the service. Since the coordination of goods and order flow demands a lot of information, a complex information system is necessary.

Differences in costs and service between MIT and a structure with central and local warehousing	Main explanations of the reasons for the differences in costs and services (theoretical explanations)
Reduced administrative costs in MIT	Centralisation and elimination of administrative activities (scale economies or eliminated activities)
Complete deliveries to customers premises in MIT	Coordination of order and goods flows due to flexible timing of transfer
Increased complexity in MIT	Co-ordination of order and goods flows which require a lot of information and timely transfer

Table 13: The main explanations of the reasons for the differences in costs and services between MIT and a structure with central and local warehousing, caused by monitoring and control of order and goods flows.

3.3.5 Motivation

After deeply analysing the effects of the MIT approach, it's useful to focus on the motivations that drive each actor within the supply chain to take part in it. Ala-Risku et al. [6] explain the motivations of the main actors within the supply chain: suppliers, logistics service provider, distributors and customers.

- Supplier's point of view: suppliers which adopt MIT approach, improve their operational performance since the number of delivery addresses is reduced. The consignment is shipped to the distributor so that for the supplier it is possible to rationalize its delivery activities. Moreover, consolidating deliveries to the distributor enables the supplier to reduce transportation costs and shipping tasks. Suppliers are induced to adopt MIT because of the competitive advantage that they can gain. Since the service level is improved because of the complete deliveries, customer may decide to increase purchases. On the other hand, MIT encourages more frequent small-size orders so that customers don't need large orders to minimise transportation costs and this can cause increased outbound logistic costs.
- Logistics service provider's point of view: even though moving from a direct delivery approach to MIT approach could mean a reduction in the total number of shipments, the increased coordination of shipments leads improvements in capacity utilisation. Then, MIT needs a single logistics service provider while direct deliveries allow supplier to freely choose the service provider who takes care of the deliveries. So potentially the transportation volumes can increase. However, the service provider has to pay attention to the order volumes. Since MIT needs huge investments in information system, the order volumes must be large enough to justify such fixed costs.
- Distributor's point of view: adopting MIT model, the distributor can offer a better service. It can offer complete deliveries without storing all the products itself. In this way inventory costs are reduced and a higher degree of flexibility within the supply chain is guaranteed. Moreover distributor can easily broaden the product variety offered adding suppliers to the Merge-in transit process without increasing inventory cost but always guaranteeing a complete delivery to customer. Thus the service level offered by the distributor is further improved. Since the distributor has the function of demand aggregator within MIT distribution model, it is the starting point to implement this solution. For this reason some fundamental issues must be considered. Distributor has to be aware of the technical requirements necessary for a successful MIT implementation: complex information systems and ability to manage business relations are fundamental factors. Then, distributor must be responsible for the customer delivery paying all transportation costs from the merge point onwards so it has to be able to cover these expenses.
- Customer's point of view: the range of products offered is broader. Then, the procurement process is simplified, the customer receives complete deliveries. This reduces the effort for the customer to control the order fulfilment and reduces receiving costs. But since the saving due to reduction in administrative costs, are not easily visible, it's hard to get customer to pay for value added logistics services.

3.4 A model to support companies in their choice of suitable distribution channel

In order to valuate the possibility to adopt a MIT approach instead of other distribution solution, a model to analyse feasibility of such choice is necessary. In this way a more pragmatic approach is provided. In accordance with Ala-Risku thesis [6], the model has four main parts as illustrated in figure 9 and involves concepts already explained. All the process starts when the company wonder weather MIT approach could be a better solution for the delivery chain it belongs to.

In order to assess the benefits that the adoption of MIT can bring, the scenario must be constructed. This implies to model distribution chain alternatives and to identify suitable product.

Then the scenario must be evaluated from an economical prospective. The costs elements must be identified. Costs as well as service benefits are assessed in order to determine the profitability for the company.

Since MIT needs a sophisticated information system, the implementation of such system is an important step in this analysis. Costs and benefits related to that are assessed.

The choice to adopt a product centric control or EDI connections is the last step.

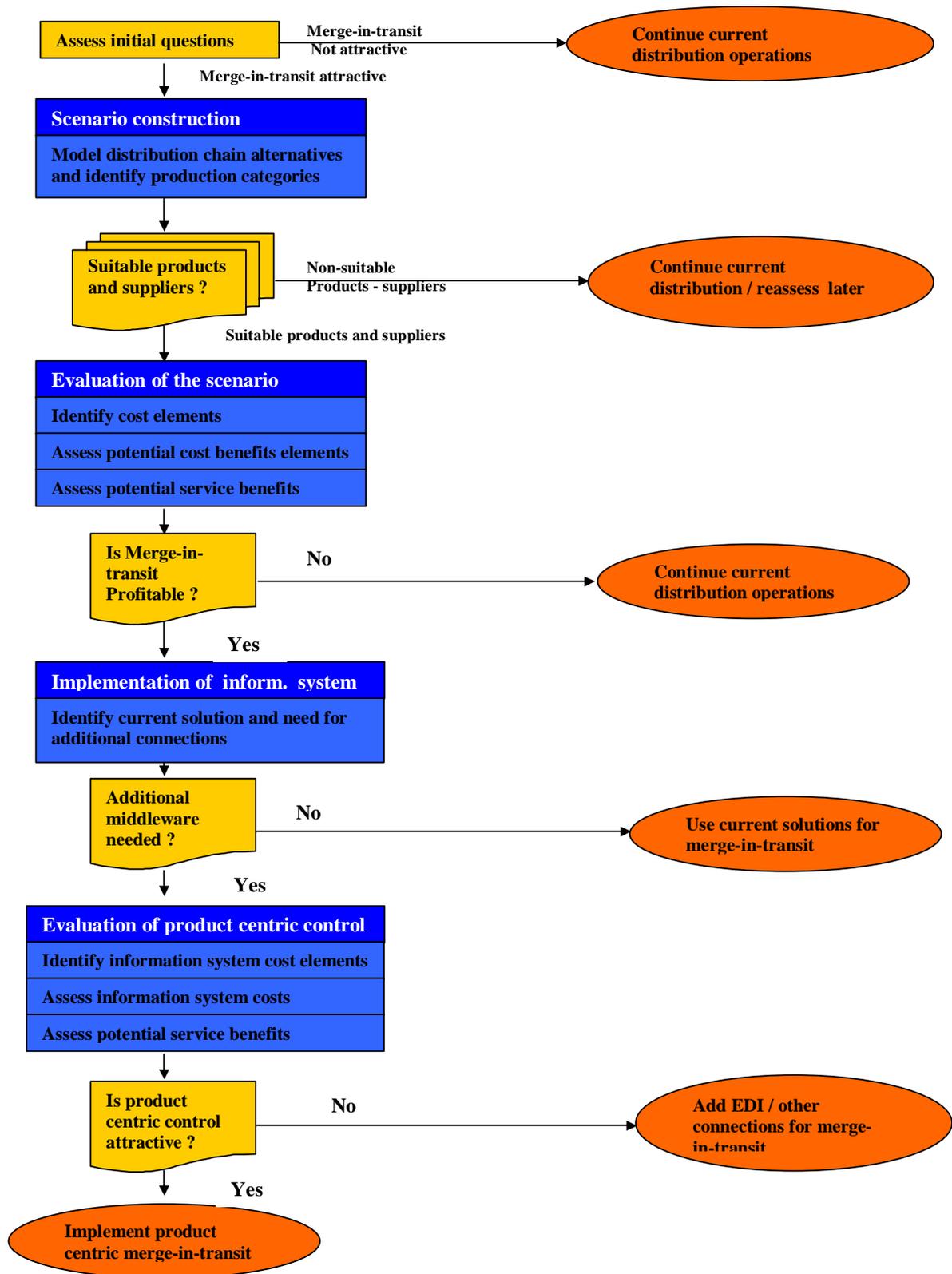


Figure 9. Illustration of the steps to be taken for the estimation of the feasibility and benefits arising from the application of the merge in transit process (from [6])

3.4.1 Scenario construction

The current model of the distribution chain is analysed and the alternative distribution model of MIT is constructed.

3.4.1.1 Modelling the distribution chain alternatives

Direct deliveries from suppliers, deliveries through warehouses and MIT deliveries are the three basic configurations for the distribution chain [6].

As said at the beginning where the distribution channels are described, direct deliveries offers the best benefits with high volume orders and bulky products while warehousing fits products whose lead time is longer than the required customer delivery times. Thus the products included in the MIT scenario must not be included in such categories.

Then, in order to construct the scenario suppliers must be identified. Their geographical location and the sale volumes are issue that must be considered. Moreover, distributor warehouses must be analysed focusing on their locations, inventory values and inventory turns. The location and the order size of the customers are also important.

Only suppliers with specific characteristics can be involved in the process of implementing MIT model. According to Ala-Risku they must be able to:

- Deliver customer order size lots
- Guarantee product availability
- Deliver the order within the lead time accepted by the customer
- Be consistent in the delivery lead time

Also the logistic service provider must match some requirements. It must:

- Provide consolidation service at reasonably located distribution centres
- Adopt a high quality delivery management that could coordinate the complex information and material flow
- Have an efficient information exchange among partners within the supply chain
- Be able to track each component delivery

Finally the scenario can be constructed.

3.4.2 Evaluation of the scenario

3.4.2.1 Identifying cost elements

The costs and benefits of MIT distribution model are evaluated. Thus, activities as well as costs of the three different distribution channels are identified.

Focusing on these three distribution channels (Direct deliveries, deliveries through warehouse and MIT deliveries) Ala-Risku [6] identifies six different activities:

- order picking at the supplier (selecting inventory for shipments)
- collection (aggregation of one or more items),
- consolidation (combination of shipments from different suppliers into one or more deliveries),
- warehousing (holding and handing goods in a warehouse),
- customer delivery (transportation of the order to customer)
- order receiving by the customer (getting the items ordered)

and eight logistics costs:

- purchasing costs (the price of the product),
- receiving order costs (costs related to the activity of handling and administrating the order when it is received),
- outbound logistics costs (costs related to the process used to pick and prepare items ordered by customers, distribution centres or other parties),
- inbound logistics costs (costs associated with activities such as receiving, storing inputs necessary to build the product or provide the service)
- transportation costs (costs related to collecting and carrying products from one location to another),
- consolidation costs (costs related to the consolidation activity),
- inventory costs (capital cost, insurance and obsolescence of the items stored),
- storage costs (costs resulting from equipment and space required to store items) .

We can assign the costs elements to the activities presented in figure 10 as follows:

Activities	Costs
Order picking	Outbound logistics costs
Collect and customer delivery	Transportation costs
Consolidation	Consolidation costs
Warehousing	Inbound and outbound logistics costs, storage and inventory holding costs
Receiving	Inbound logistics costs

Table 14: Relationship between activities and costs involved in the distribution structures (based on [6])

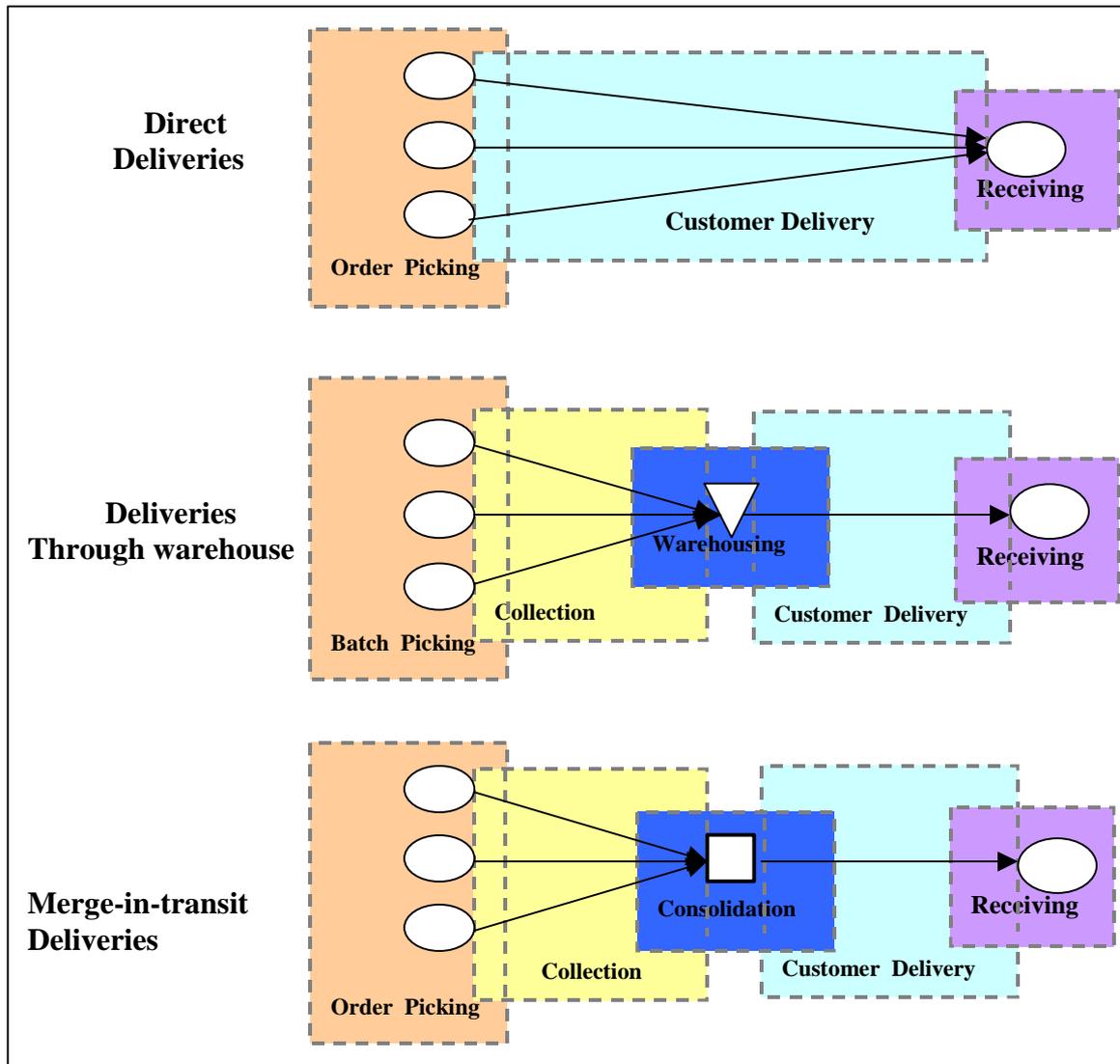


Figure 10. Activities performed in the different distribution channels (from [6])

An activity based costing is used in order to assess the costs of each delivery approach. The calculation model for delivery costs is presented in Appendix.

Direct delivery:

The cost of direct deliveries is the sum of all order-picking, delivering and receiving costs needed to provide customer with his order as illustrated in figure 11.

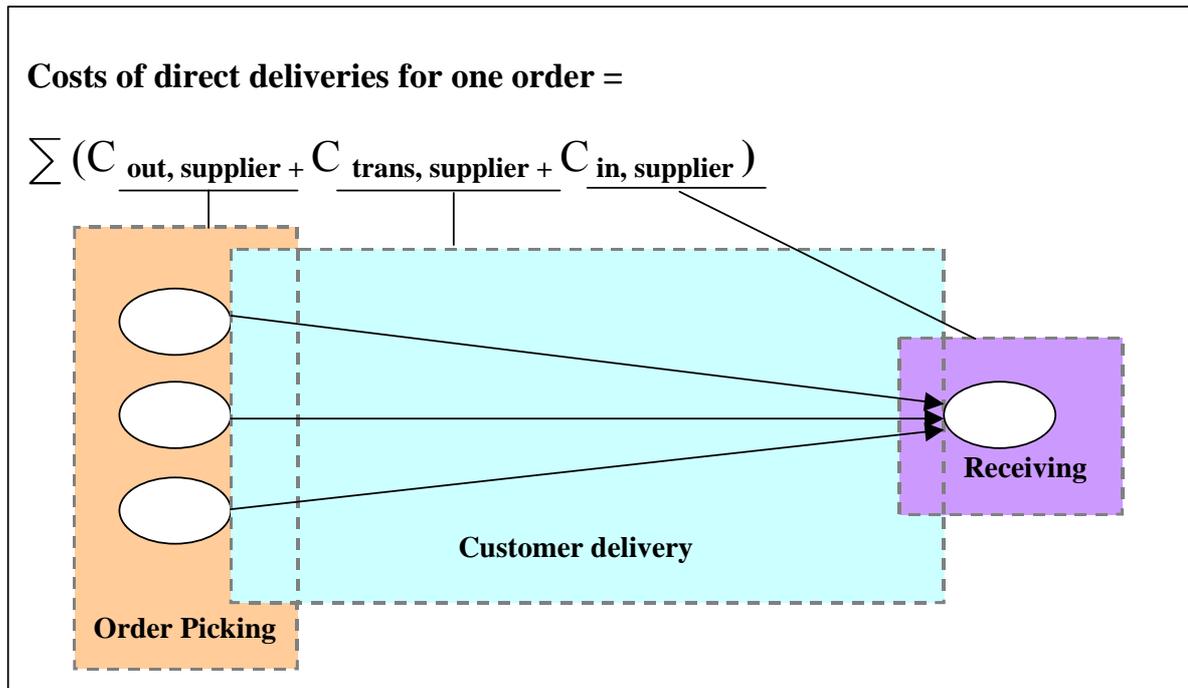


Figure 11. Costs of direct deliveries for one order (from [6])

Deliveries through warehouse:

The cost of deliveries through warehouse has three main components: the cost regarding the replenishment of the warehouse inventory, the inventory holding cost at the warehouse and the cost for customer delivery from the warehouse as illustrated in figure 12. The replenishment cost collects outbound logistics costs at supplier site, transportation costs and inbound logistics cost at the warehouse while the delivery cost collect the costs that characterised direct deliveries.

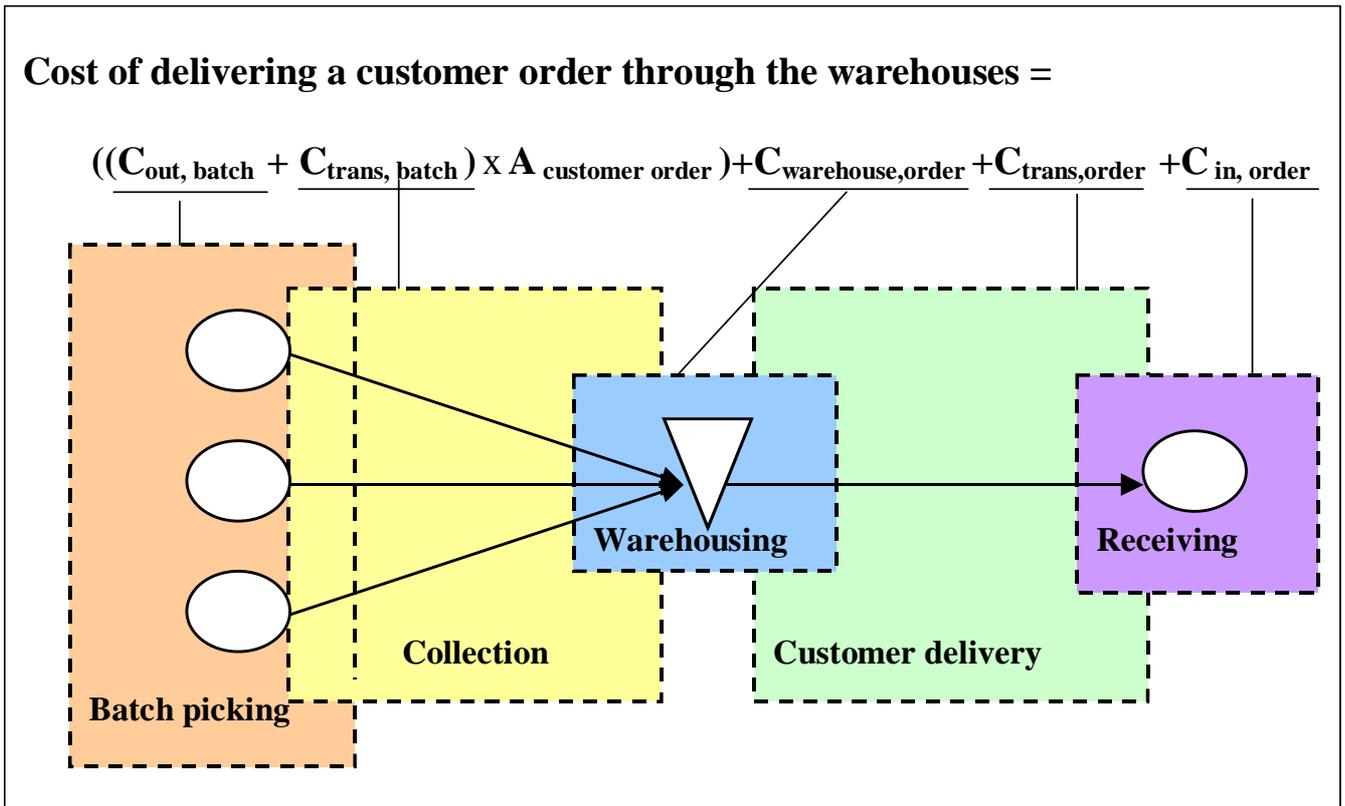


Figure 12. Costs of delivering a customer order through the warehouse (from [6])

MIT:

The cost of MIT deliveries has two main components: the cost of deliveries to the merge point (outbound logistics cost at the supplier, transportation cost and consolidation cost) and the cost of final customer delivery [10] as illustrated in figure 13.

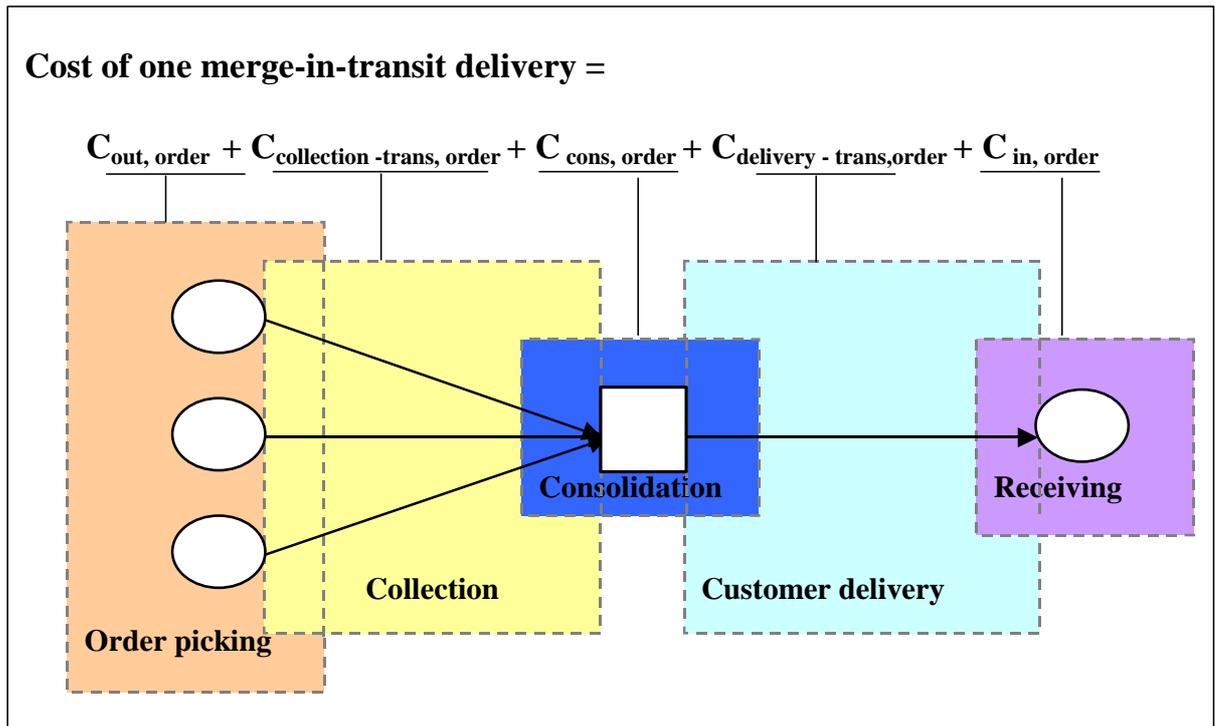


Figure 13. Costs of one merge in transit delivery(from [6])

3.4.2.2 Assessing potential cost benefits

In order to evaluate the cost benefits, the costs involved in the constructed MIT scenario are compared with those which characterise the other two deliveries approaches.

Deliveries through distributor warehouse versus MIT

Comparing the two models, the most important benefits MIT can bring is due to the reduction of the operational and the inventory carrying costs that take place in the warehouses. On the other side, the supplier has to face increased outbound logistics costs. In fact, the supplier in this case ships individual customer order (batch picking) instead of delivering aggregate demand to the warehouse. Then, a fee for the consolidation operations must be paid to the logistic service provider. Summarizing, the whole costs are quite the same. A benefit can result from customer locations because of different distances.

Direct deliveries versus MIT

The main benefits due to the adoption of MIT instead of direct deliveries are gained when the amount of products shipped directly from the suppliers to the customers are less than truckload deliveries. Thus, single deliveries reduce transportation costs as well as inbound logistics costs.

3.4.2.3 *Assessing potential service benefits of MIT operations*

Ala-Risku highlights that MIT has higher operational costs but other benefits can be gained.

From warehouse deliveries to MIT

The potential benefits of this shift are two [6]:

- Wider product assortment for the distributor (the distributor is able to offer a wide variety of products without increasing inventory costs and investing in new warehouses)
- Point of sales data for suppliers (thanks to the separation of order and material flows, the visibility in the supply chain increases and the suppliers follow the real and more stable demand.

From direct deliveries to MIT

The potential benefits of thus shift are two [6]:

- Frequent replenishment for customers (MIT enables the customer to order smaller lots more frequently and thus to reduce the stock levels and warehousing costing and to increase inventory turn since consolidating many small deliveries into a larger one lower delivery and receiving costs per item)
- Supplier shipment consolidation (several shipments can be sent at one time to the same delivery address and in this way the supplier exploits economies of scale)

3.4.3 Implementation of information system and evaluation of the product centric control

The information system required by MIT model must cover several actors, thus the information exchange must be automated. There are two approaches that guarantee the connection of the business applications between the members of the supply chain:

- Point-to-point system

- Product centric system

Point-to-point system: traditional systems are based on point-to point solution where messages are sent from one application at one company to another application to another company. But there are a lot of disadvantages with such system. Increasing the number of connections between applications, the web becomes more complex and often changes in the source system and target systems are required in order to ensure that the data are forwarded understandable by the middleware. This limits the flexibility of the network, reducing the ability to react to changes in the business environment.

Electronic Data Interchange (EDI) technology is the best-known communication model among the alternatives available. It is considered the key technology for integrating supply chain. Even though it is an old technology, improvements have been achieved and now it offers a robust solution.

The process that makes the application related data available to the middleware is formed by some steps. When an order is input, an event of requiring data transfer occurs and the application must provide an output message related to this. EDI translator software accepts this message and converts it to a standard EDI message. Then, middleware guarantees the communication link through a database-oriented approach. So the agent accesses the database of the application which takes part in the communication, modifying the data without converting any output message.

Product centric system: with the aim to make the information process straightforward, different approaches as “product centric information management” have been suggested to establish web-based platforms for the information exchange and management in a network of companies [11]. In parallel, besides managing information necessary to schedule goods arrivals at the merge point and shipments, it is essential to keep products status under control inside the supply chain [12].

It is easier with a product centric approach instead of transactional company centric view where companies maintain proprietary identity scheme for materials flow. The product centric system control deliveries focusing on material flow while traditional system is based on inter-links between the applications of centralised companies focused on transaction processing.

Product centric control is based on the use of objects to transfer information. These objects have an identity on the internet to which relevant information about them are linked forming a virtual counterpart for the objects themselves. Each member knows the virtual identity of the object and can have access to its data over the internet.

Two fundamental characteristics for the identification system are requested: uniformity and uniqueness. Uniformity guarantees that all members present an identity using the same structure and uniqueness guarantees that two identities are not the same.

In order to use this system in an efficient and effective way, two requirements are needed:

- The identification system must be uniform for all the shipments
- All actors must be able to access the data on the internet

To solve this problem, some projects were founded whose aim is to develop distributed software that can be used within a supply chain and to implement it successfully [6].

However, several are the potential service benefits provided by this centric system approach.

Product centric solution enables a quicker updating of information allowing an easier tracking of the shipments. When a parcel is identified, its agent is able to update the database about the current location.

On the contrary point-to-point system needs additional application in order to keep actors informed about the location of each shipment. Moreover, the obsolete information in the delivery chain is reduced.

The shipment's agent, through which the delivery information of shipments is accessed, guarantees that only one copy of such information exists (there is a single virtual database). Thus costs related to re-entering or duplicating data are avoided.

Then, product centric approach enables more flexibility regarding the changes of location for the consolidation operations. In fact all delivery information is provided with the deliveries themselves.

4 Analysis

After a brief summary regarding the distribution channels already presented in the theoretical framework, MIT is focused. Its characteristics are explained. Business suitability is developed through an analysis of product/process characteristics, market scenario and expenditures implications. Organisations requirements such as organisation flexibility, cooperation and information sharing are fundamental concepts within MIT because of the increased complexity of the activities performed. On account of that, further suggestions are provided.

4.1 Distribution channels

Starting from the classification suggested by Chopra [5] and Ala-Risku et al. [6], we can identify three main kinds of delivery channels:

- Central and local warehouse
- Direct delivery
- Consolidation

Central and local warehouses	Direct delivery	Consolidation
<ul style="list-style-type: none"> • Distributor storage with carrier delivery • Distributor storage with last mile delivery • Retail storage with customer pick-up 	<ul style="list-style-type: none"> • Manufacturer storage with direct shipping 	<ul style="list-style-type: none"> • Manufacturer storage with direct shipping and MIT • Manufacturer storage with customer pickup

Table 15: Classification of distribution channels

The need to reduce costs and improve service drives to different approaches: the model with central and local warehouses (deliveries through local warehouses) can be replaced by a direct delivery approach where the order is directly delivered from the manufacturer to the customer. In this way expenses due to the great number of product variants held in inventory are cut. But in order to increase customer value and lowering costs at the same time, consolidation points are used. In fact direct deliveries can reduce the need for warehouse but this implies a worst service since the orders are received with several shipments. Offering a wide range of products and delivering them in one drop-off is a value for the customer and this is the aim of consolidation practice [13].

Two models are based on the consolidation activity:

- Cross-docking
- MIT

As said before, the emerging distribution structure called MIT is a further development of the cross-docking concept aimed at fitting nowadays market requirements characterized by unpredictable demand, smaller volumes, infrequent orders. That's the reason why this thesis focuses its attention on MIT.

4.2 Merge in Transit: definition of the model

The MIT model is a distribution model providing (see figure 14):

- Procurement of items listed in one-customer order coming from different sources (international warehouses, suppliers, and so on);
- Consolidation of order at a merge point (within a brief lapse of time);
- Direct one-customer order delivery (covering the items listed in all order lines)

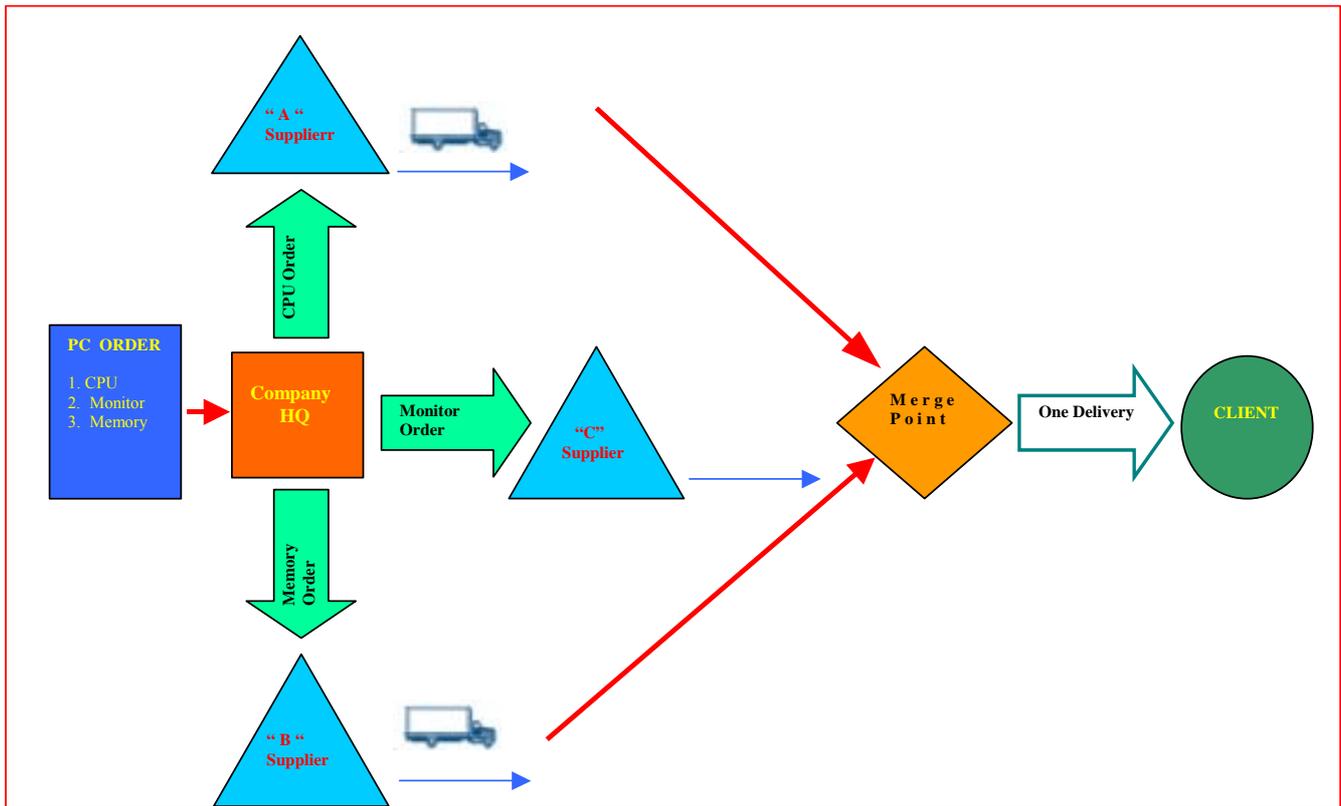


Figure 14. Merge procedures and delivery

By analysing the difficulties in synchronising shipments arrivals at the merge point, it is advisable to underline that items required in one-customer order, originating from different dispatch locations, can be shipped through various transportation modes to the merge point: by air, by sea or by road.

Since supply lead time requirements are quite different, considering both distance / location of distribution centre and the means of transport used, the best thing to do for the MIT implementation is planning the different shipments from the point of origin.

It has to be assured that the shipments arrive on time at consolidation centre, where various activities such as assembling, kitting, finishing of products (following a postponement approach [14]) are carried out, in order to make one-customer delivery according to the agreed terms.

By analysing in details the order management in accordance with MIT procedures, it is possible to distinct a timely sequence consisting in three main phases as shown in figure 15:

- The order received by the customer is split among different warehouses;

- Items belonging to the order are provided according to the means of transport to be used, for instance items to be shipped by road originating from long distance dispatch points will be the first ones to be provided, while items supposed to arrive by air, will be the last ones to be fulfilled (due to the short delivery lead time);
- Once items are synchronously shipped to the merge point, order consolidation operations (including assembling and postponement activities if necessary) are carried out and at last there is the final delivery to customer in a single shipment.

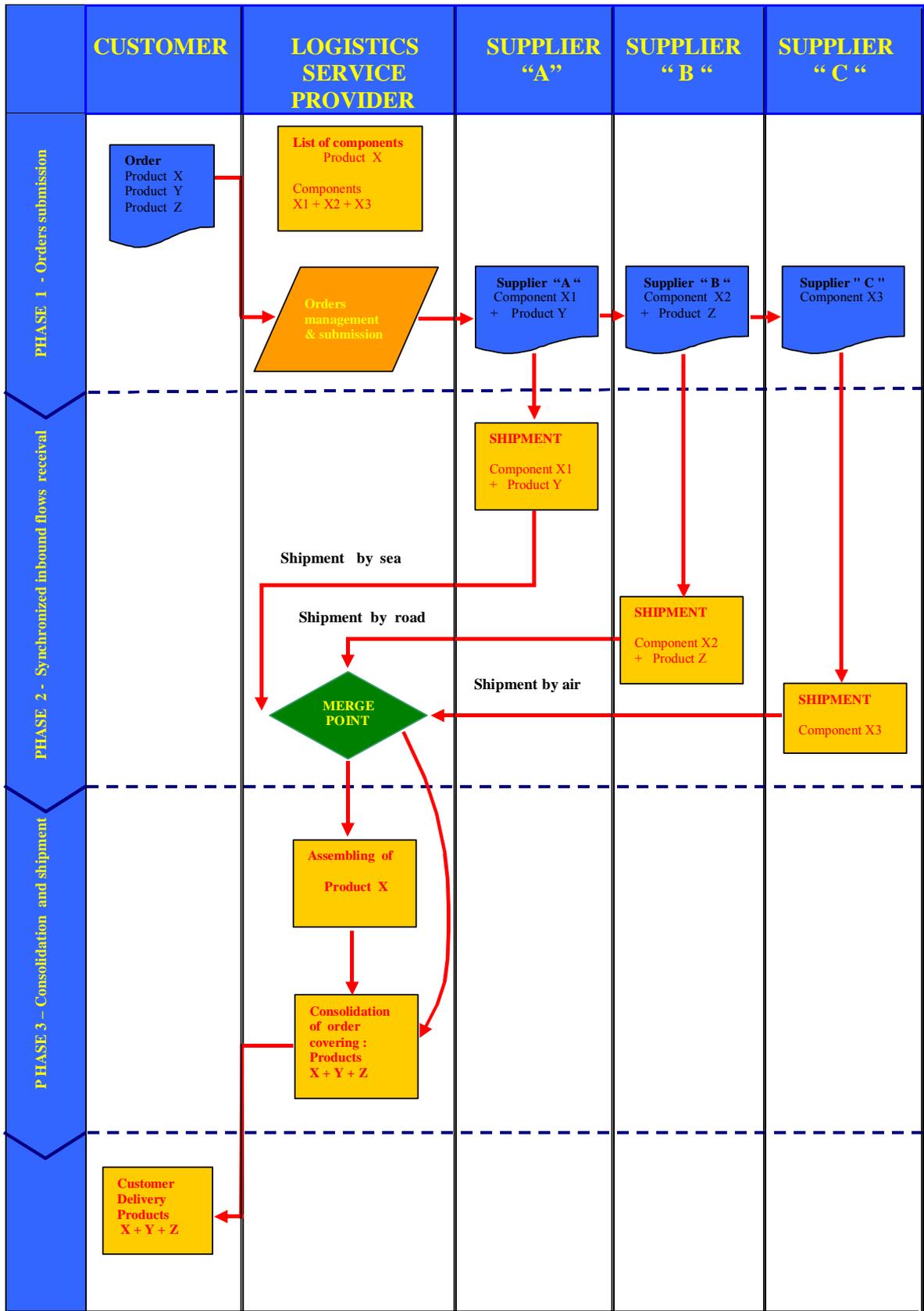


Figure 15. Order management in MIT approach

In figure 15 the flow of orders is presented.

During the first phase, the customer place an order composed by three products: product X, product Y, product Z. Product X has 3 components: X1, X2, X3. The logistic service provider sends a message to the suppliers of such products and components. IN thus case, supplier A provides component X1 and product Y, supplier B provides component X2 and product Z and supplier C provides component X2.

Then, the second phase starts. Supplier A ships the order by sea, supplier B ships the order by road, supplier C ships the order by air; all the shipments reach the merge point.

In the third phase, product X is assembled. Finally the order of products X, Y, Z is consolidated and ready to be sent with a single delivery to the customer.

The merge of individual deliveries in distribution centres while they are in transit takes place in a lapse of time lasting a few days. It mainly depends on the transit time of the different incoming items flows, according the sort of materials to be received and the transportation mode used for delivering every single partial delivery of goods covered by the original order.

The transit time influences the choice of the areas, where logistics activities have to be performed and the selection of the equipment necessary for material handling, so as to reduce or even remove inventory and lower costs related to plants and operation activities carried out in a traditional warehouse.

Therefore, the efficient management of incoming items flows is a critical element granting the success of the correct implementation of the MIT model.

Coordination and synchronicity of inbound material flows allow on one side to have a low stock level in a few networks points, reducing inventory costs arising from the need to have a double inventory at dispatching locations of distribution networks of those critical high value or obsolescent-risk components, on the other side to avoid double deliveries to final customers and therefore the related administration activities. If it could not be possible to grant the compliance with the shipments arrival schedule, taking into consideration that the delivery has to be carried out on time, distribution costs related to activities to be performed starting from the merge point to the final customer would be increased, therefore reducing the efficiency of distribution systems and running the risk of lowering the performance of services rendered.

However, in order to fully implement the MIT model and gain benefits related to the less need for space, it is necessary that the (suppliers') production lead time and the (customers') demand variability compensate the availability of a suitable stock at the dispatching locations, especially for those critical products which customer consider to be as high-value products.

It would be advisable to have a larger stock of low-value and low-obsolescence components (especially when sources are distant) for which it is advisable to optimise transportation modes using Full Container Load [15]. On the contrary for high-value and high-obsolescence components it is justified to increase the number of shipments and afford higher inbound costs. In this way it is possible to utilize a combination of different transportation modes so as to achieve the maximum benefits, to serve the specific demands (from express air delivery of a single parcel to the sea-shipment of a un full container load), granting the full availability of the items covered by the order.

Compliance with the arrivals schedule and the correct management of shipments according to the MIT model allow to carry out a high customer-delivery service providing on-time deliveries and an easier management of order splits.

4.3 Business suitability

With the aim to define the business environments where the MIT model can be efficiently implemented, it is necessary to consider its basic characteristics from the organisation, logistics and management point of view and the factors which justify the use of MIT distribution procedures.

The MIT operations model does not suit any configuration of distribution network and supply chain but is suitable for business networks involving specific kind of product and specific logistics chains.

It is possible to classify the business environments where MIT implementation is advisable according to product/process characteristics and the competitive market scenario.

In particular, as regards the first group (product/process characteristics), the following aspects are evidenced:

- Finished multi-component product, whose parts come from different sources (factories) internationally located: through the synchronicity of receipts at the merge point, where consolidation of components originating from different sources takes place, the MIT model procedures allow to meet the requirement for the availability of products to be delivered and are able to offer different combinations of services, reducing costs arising from these needs.
- High-value products and/or components: the MIT model is considered to be a winning solution since it reduces warehousing and the relevant inventory;

- High obsolescence of the finished products and of its components: as evidenced the MIT model allows to keep smaller inventory at the consolidation points and therefore reducing obsolescence risks and costs arising from the storage of components.
- High costs related to intermediate inventory beyond the value of stored products: by reducing the needs for inventory MIT model allows to lower the costs related to handling operations personnel, materials handling equipment and systems.
- Materials flows originated by customers upon delivery orders (pull approach): in this case the MIT model allows to properly master the management of the orders, which are considered as single orders, through an optimised logistics process.

Taking into consideration the characteristics of the competitive market scenario, it is possible to evidence the following remarks:

- Request for orders covering mixed products coming from different sources (factories): similarly to what happens for multi-component products, the MIT model allows an optimised management also for materials listed on orders with several order lines, granting high availability of goods and a large combination of services;
- High added value perceived by the customer for single delivery: costs arising from partial receipts of an order are lowered thanks to one-customer delivery as added value service
- High costs related to final delivery (for instance in case of express intercontinental deliveries or city-deliveries with admittance restrictions) : one-customer delivery cuts down the number of shipments necessary to completely fulfil the order and reduces delivery costs arising in these situations requiring expensive operations;
- Possibility to enter into partnership with key suppliers: the needs for great reliability of supply lead time and for the availability of stored products (in order to synchronise receipts for order consolidation), allow companies to establish strict cooperation relations with suppliers providing key components.

Besides the qualitative estimations connected to the basic MIT model characteristics, in addition to the typology of product under examination and the market involved and with the aim to check the efficiency of its concrete implementation, it is necessary to evaluate costs implications, which depend on the possible network configuration options in comparison with other distribution models.

A way to estimate the different distribution alternatives including the MIT practice, is to construct a model according to an activity based approach, in order to simulate the costs arising from the use of different distributions operations so as to achieve a great accuracy in evidencing in details the impact of the different distribution modes and possible solutions on costs related to the single activities to be performed. In particular, the ultimate goal of the model is to lower the single order fulfilment costs (should the orders be not-repeatable orders) i.e. the reduction of costs related to a specific supply relation or distribution channel, in compliance with the lead-time limit allowed by the market requirements.

In order to have a better view regarding the expenditure and the savings that result from merging at the consolidation point, some other elements must be considered: the strategic and operation impact relevant to the postponement of possible working and assembling activities, the removal of inventory, the benefits achievable by the correct management of deliveries obtainable by the final customer and to transportation of goods by means of vehicles potentially very different from those provided by a traditional distribution model.

4.4 Organisation requirements

After having analysed in details the MIT distribution model and the related operations procedures, now we investigate the organisation activities to be carried out for the correct implementation of this distribution practice.

It is advisable to underline that the implementation of the MIT model requires essential changes in the traditional procedures involving a higher complexity in managing the different activities since it is necessary to coordinate different actors (producers, suppliers, logistics service providers) and provide postponement assembly activities if required, i.e. from the simple packaging of different load units to the assembly of some components and pre-delivery inspections. Such elements require not only a certain flexibility in the organisational structure but also a large cooperation and transparency in the information sharing among the actors, even as regards the coordination of purchases and order submission.

Because of the need to manage, coordinate and synchronize material flows originating from geographically distant sources and involving different transportations modes, information sharing process becomes more complex. In particular, it is important for actors to share information regarding shipments plans.

Fundamental requirements for the information exchange are accuracy, availability and timeliness. Accuracy is related to how much available information are closed to the actual status, availability is defined as the ability to access and update information and timeliness is related to the period of time needed between when an activity occurs and when such activity is visible.

Different solutions have been suggested to better manage information sharing, so as to get the MIT model functioning cost efficiently providing savings and added value to customer. The ultimate goal of developing a reliable information exchange system suitable for the MIT model is mainly to keep the different playing actors informed about all operations. That's why the logistics information system that connects a large number of companies must be based on automated information exchange. Automation is provided by software, named middleware, which is able to connect the business applications of several companies.

EDI technology-based solutions offer significant integration performances and investments are required to make logistics software packages and hardware available for this purpose. Therefore, with the aim to make the information process straightforward, different approaches as "product centric information management" have been suggested to establish web-based platforms for the information exchange and management in a network of Companies. In parallel, besides managing information necessary to schedule goods arrivals at the merge point and shipments, it is essential to keep products status under control inside the supply chain.

4.5 Further suggestions

As you can notice, implications connected to organisation and management activities and to information exchange needs require an in-depth analysis to estimate the MIT model implementation feasibility in different business situations.

For the above reasons and due to the large number of transportation flows from origin to destination a high-level expertise is required to coordinate, synchronise and constantly control each single factor involved in this distribution process.

Where specific experts are not available to perform the activities necessary for the MIT implementation, the most suitable people able to integrate the services offered by more actors (such as logistics service providers, freight forwarders, forwarding agents and carriers) are the so-called 4PL (fourth party logistics service provider).

The 4PL [16] acts as integrators in the supply chain by managing the whole logistics network of the customer and integrating the capabilities of the different business partners (logistics service providers, shipping companies, carriers, shipping agents and air brokers). In this way they are able to potentially grant savings to their customers by gaining benefits from transportation and management synergies, turning to multi-customer warehousing, providing savings from the consolidation of more shipments to long-distance destinations (*groupage*) and at the end, carrying out distribution and machining (if need be) at the merge point.

In addition to the fact that they provide savings on logistics costs, the 4PL offer the medium-small size companies the possibility to benefit from the geographic expansion of their supply chain, which could not otherwise be managed by them due to the lack of adequate instruments.

5 Conclusions and discussions

In this section, some conclusions of what presented and some consideration about that are proposed. Customers that can benefit from MIT adoption are defined, then, the effects that MIT brings are explained as well as the drivers of such effects. Finally, a summary of the model for evaluating the implementation of MIT is presented.

A new solution in the supply chain design is assessed in depth. MIT approach is a new model which provides competitive advantages in today's fast moving market, in particular when customers:

- place infrequently small size orders
- demand a wide variety of products, often high value items, affected by obsolescence risk
- order products which are coming from different sources (suppliers, internationally distributed warehouses)
- require high service level in terms of single deliveries and order visibility

In the thesis all details regarding this distribution model are investigated from a supply chain prospective. The main phases of the delivery process within MIT are explained (order placing, order splitting among warehouses, transportation means choice, synchronised shipping to the merge point, consolidation, final delivery). The effects it implies within the supply chain are:

- reduced inventory costs
- reduced storage time
- reduced warehousing costs
- reduced administrative costs
- increased/reduced transportation costs (it depends case by case)
- reduced cost for forecast calculation
- increased range
- increased order lead time for accessible products
- complete deliveries to customer

- increased complexity
- reduced uncertainty

The drivers of such effects are:

- Centralised or eliminated inventory
- Merge points instead of inventory points
- Separation of order and goods flows
- Centralised monitoring and elimination of administration activities to keep stock
- Continuous monitoring and control

A deeper analysis into the subject has shown that some other concepts were behind these effects. In particular we have:

- Postponement practise
- Scale economies
- Elimination of activities

Assuming the viewpoint of each actor within the supply chain, these issues are catalogued providing motivations to adopt this method.

Moreover, a practical model for evaluating the implementation of MIT results from the previous consideration. The main steps are:

- Scenario construction
- Evaluation of scenario
- Implementation and evaluation of the information system

In this way the thesis fulfil the purpose for which it has been written: analysis of a new solution in supply chain, named MIT. The results achieved in this thesis fit thoughts reported in others articles related to this subject. The fast moving business environment is the subject of several studies regarding economy and trade. The supply chain concept is a basic key for succeeding in market competition. As D. A. Taylor [17] said: “ the nature of business competition is changing in a fundamental way, and the repercussions for IT are profound. The classic model of company vs. company is starting to give way to a new model: supply chain vs. supply chain. In the 21st century, being the best at producing or selling a superior product is no longer enough. Success now depends on assembling a team of companies that can rise above the win/lose negotiations of conventional trading relationships and work together to deliver the best products at the best price. Excellence in manufacturing is just the admission fee to be a player in the larger game of supply chain competition”.

Information technology is constantly advancing and enables a more efficient information exchange, fundamental issue for the implementation of MIT model. This is assessed also by Cole et al. [18] in his article “Optimal design of MIT distribution networks”.

Furthermore, postponement practice benefits several market segments. Many companies have adopted it (Cambridge University survey) [19]: Sony, IKEA, Dell, Hewlett Packard HP are some examples and it’s not a coincidence that these firms use MIT model for the distribution of their products.

The success of these firms shows the great value of this advanced delivery approach.

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7 Appendix: calculation model for delivery costs

The calculation model used to assess the delivery costs through an activity based approach consists of five main elements as illustrated in figure 10. These elements are calculated as follow:

7.1 Order picking

Order picking affects the outbound costs which can be estimated for one shipment with two cost components [20]:

- Cost for delivery specific
- Cost for each order line of the shipment.

It follows that:

$$C_{out} = C_{shipment, out} + N_{orderline} \times C_{orderline, out}$$

Where:

C_{out} = total outbound logistics costs per shipment

$C_{shipment, out}$ = outbound logistics costs per shipment independent of order size

$N_{orderline}$ = number of order lines in a shipment

$C_{orderline, out}$ = outbound logistics cost of handling one order line of the shipment

The total outbound logistics cost for the delivery of one *customer order* involves all the shipping costs to fulfil the order (products can be provided by several suppliers).

$$C_{out,order} = N_s \times C_{shipment, out} + N_o \times C_{orderline, out}$$

Where:

N_s = number of suppliers for the customer order

N_o = number of order lines in the order

In order to replenish warehouses batch are used. When calculating the batch picking cost, only a portion of the suppliers' picking costs must be allocated to an individual customer delivery. This portion is calculated as follows:

$$A_{\text{customer order}} = N_{\text{customer order}} / N_{\text{replenishment order}}$$

Where:

$A_{\text{customer order}}$ = customer order allocation factor for replenishment activities

$N_{\text{customer order}}$ = number of products in the customer order

$N_{\text{replenishment order}}$ = number of products in the replenishment order

7.2 Transportation

Transportation involves the activities of collection and customer delivery. The cost is calculated using the logistics service provider's pricing table and it is a function of the weight and the distance.

$$C_{\text{trans}} = f_{\text{trans}}(w, d)$$

Where:

C_{trans} = transportation cost of a delivery

$f_{\text{trans}}()$ = pricing function of the logistics service provider for transportation

w = weight of the shipment

d = transportation distance

It follows that, the total transportation cost of one customer order is the sum of the costs of all individual deliveries to fulfil the order.

$$C_{\text{trans, order}} = \sum_{i=1}^{N_{\text{trans}}} f_{\text{trans}}(w_i, d_i)$$

i = indexes the individual deliveries

7.3 Consolidation

The consolidation cost is calculated using the pricing table for consolidation operations of the logistics service provider and it is based on the weight of each shipment to be merged.

$$C_{\text{cons}} = f_{\text{cons}}(w)$$

Where:

C_{cons} = consolidation cost for a shipment

$f_{\text{cons}}()$ = pricing function of the logistics service provider for consolidation

w = weight of the shipment

So, the total consolidation costs for one order are calculated as the sum of all costs associated with each consolidated lot, depending on their individual weight:

$$C_{\text{cons, order}} = \sum_{i=1}^{N_{\text{trans}}} f_{\text{cons}}(w_i)$$

i = indexes the individual shipments to be consolidated for the order

7.4 Order receiving

The costs for receiving an order result from inbound logistics costs which can be calculated estimating two components [21]:

- Cost for delivery specific (independent of the amount of order lines)
- Cost for each order line of the delivery

$$C_{\text{in}} = C_{\text{shipment, in}} + N_{\text{orderline}} \times C_{\text{orderline, in}}$$

Where:

C_{in} = total inbound logistics cost per shipment

$C_{\text{shipment, in}}$ = inbound logistics cost per order independent of shipment size

$N_{\text{orderline}}$ = number of order lines in a shipment

$C_{\text{orderline, in}}$ = inbound logistics cost of handling one order line in the shipment

If there are several deliveries for one order (in case of direct delivery), the total inbound logistics costs for one customer delivery are the sum of all the costs associated with the deliveries:

$$C_{\text{in, order}} = N_{\text{d}} \times C_{\text{shipment, in}} + N_{\text{o}} \times C_{\text{orderline, in}}$$

Where:

N_{d} = number of deliveries for one customer order

N_{o} = number of order lines in one customer order

7.5 Warehousing

Warehousing consists of three main elements [22]:

- Handling costs
- Fixed storage costs
- Inventory holding costs

Handling costs can be calculated with the outbound and inbound logistics cost models presented above.

Fixed storage costs resulting from the equipment and space are allocated to the order as percentage of sales.

Inventory holding costs consist of capital cost, insurance and obsolescence.

It follows that:

$$C_{\text{warehouse, order}} = \sum_{i=1}^{N_o} (C_{\text{in, } i} + (P_{\text{storage, SKU}} + P_{\text{inventory, SKU}}) \times V_i) + C_{\text{out, order}}$$

Where:

$C_{\text{warehouse, order}}$ = warehousing costs for a delivered order

i = index for order lines up to N_o

$C_{\text{in, } i}$ = inbound logistics costs of the order line as a part of a replenishment delivery

$P_{\text{storage, SKU}}$ = storage logistics costs of the order line as a part of a replenishment delivery

$P_{\text{inventory, SKU}}$ = inventory holding costs as percentage of sales for the SKU of the order line

V_i = sales value of the order line

$C_{\text{out, order}}$ = outbound logistics costs for the order