Contribution to Integrated Design of Logistic Systems for Online Business

Von der Fakultät für Ingenieurwissenschaften, Abteilung Maschinenbau und Verfahrenstechnik der

Universität Duisburg-Essen

zur Erlangung des akademischen Grades

eines

Doktors der Ingenieurwissenschaften

Dr.-Ing.

genehmigte Dissertation

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Tag der mündlichen Prüfung: 10.04.2019

Abstract

What Bill Gates predicted in the last century, turns into reality today. Borderless, timeless, low cost and highly efficient, e-commerce has developed into the dominant of this market in this century. In principle, B2C and B2B are the main business models in e-commerce and therefore the research object of this dissertation.

With the rapid development of electronic commerce, logistics service also put forward higher request. A well-designed logistics system has become a key to success for e-commerce. To this end, the emergence of innovative technologies and strategies makes the logistics industry comprehensive revolution.

In this research work, based on the practical operation and understanding of B2C and B2B e-commerce, the corresponding logistics concept is designed and a corresponding system is developed in a different business phase in order to maximize the benefit from the market. A constant and gradual business adjustment is made during the development of e-commerce to extend the business model.

The emergence of 3PL makes many companies worldwide turn to logistics outsourcing as a way to increase profitability. The cooperation between involved companies and 3PL happens mostly on transportation and the operation aspect turns to focus on the warehouse design and management, among which order picking system is the key part, due to the most investment on personnel and capital. The optimization of this system improves the efficiency of the complete logistics chain and enhances the company competitiveness, which includes the layout design of the order picking system, position adjustment of products in shelves, picking strategy etc. In different scenarios, the order picking routes are calculated and compared in order to make sure that the order picking system is optimized.

In this research work, many theoretic picking strategies are explained and furthermore, in practice, a business structure is built based on the calculation and profits from the suitable picking strategy. Some formulas from the reference are proved and one of them is adjusted through this research work.

Based on the customer orders, a strategic simulation model is proposed to evaluation different batching building scenarios. The purpose of the simulation is to recreate the physical material flow network and to analyze “what if” scenarios. In difference to material flow simulation model, a strategic simulation model emphasizes the determination of strategies. In this case, a system model is built based on order processing performance and the batch order is reorganized in different batch size.

Keywords: e-commerce, logistics planning, warehouse design, order picking strategy, logistic system design, strategic simulation model.

Acknowledgements

First, I would like to express my sincere gratitude to Prof. Dr. Ing. Bernd Noche for his guidance and support. I thank him also for providing me an opportunity to do a PhD. His supports helped me a lot not only in every phase of my research work, but also provided valuable advices in my business.

I am very grateful to my family – my wife Sibel Sezgin, whose support and encouragements give me a constant motivation to finish my research. Also to my elder daughter Emine Eslem Sezgin and my little daughter Ümmü Seleme Sezgin, for their patience and understanding. I express my sincerest love and gratitude.

I wish to express my appreciation to my beloved colleagues in my company, who spent a lot of precious time with me. Their selfless supports always inspire me to keep forward and it is a very pleasant experience working with such people, I would like to say sincere thank you.

Last but not least, I would like to express my appreciation to my partner Yilmaz Uyumaz, whose friendship, support and encouragement have helped me a lot through over ten years of business operation.

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Terminology

3PL	Third Party Logistics
A2A	Administration to Administration
A2B	Administration to Business
A2C	Administration to Consumer/Citizen
AS/RS	Automated Storage and Retrieval System
B2A	Business to Administration
B2B	Business to Business
B2C	Business to Consumer
B2G	Business to Government
C2A	Consumer to Administration
C2B	Consumer to Business
C2C	Consumer to Consumer
EDI	Electronic Data Interchange
FCL	Full Container Load
FMEA	Failure Modes and Effects Analysis
FTE	Full-Time Equivalent
KPI	Key Performance Indicator
LCL	Less Than Container Load
MTO	Make to Order
MTS	Make to Stock
OCF	Operating Cash Flow
P2P	Peer to Peer
PDAs	Personal Digital Assistants
PxI	Probability multiply Impact
SC	Supply Chain
SCM	Supply Chain Management
SKU	Stock Keeping Unit
VMI	Vendor Managed Inventory
WMS	Warehouse Management System

Chapter 1 Introduction of online business research

We have entered the era of information and network where people converse through instant messages, get information from websites and download music from the internet. The way we buy and sell goods has also been changed. More and more people use the internet to conduct business and buy and sells goods and services over the Internet. The name of this activity is e-commerce. Even though e-commerce has a short history its development is fast and ongoing.

At the same time, internet has significantly changed the way that information and cash flow passes through the entire logistics system.

1.1 Research background

1.1.1 Global spreaded e-commerce

As the development of World Wide Web and internet browser, e-commerce became possible in 1991 when the internet was opened to commercial use, from then on, the more secure protocols (HTTP) and DSL enabled the rapid connection to the internet. By the end of 2000, a great number of companies from Europe and America offered online services through the World Wide Web, even though the internet bubble burst at the end of 2000, it already brought around $700 billion in transactions by the end of 2001[11].

At the present stage, it is worth nothing that the United States is the world's single biggest e-commerce market, followed by the United Kingdom and Japan, with annual growth rates expected to remain in the 10-15% range in the foreseeable future. In Asia, China is becoming the most potential e-commerce market. With a growing rate of 130% in e-commerce sales in 2011[MAN 15].

The concept of e-commerce nowadays differs from what it has been and spreads into many different branches. The trading connections of the individual customers or marketplace – B2C to wholesale business partners – B2B, and further cooperations with governments, so called B2G, which cover a series of business scopes, from raw material to high technology devices e-commerce, not merely a selling website, are becoming a platform for business revolutions. It makes business possible globally with relatively small investment and rapid react that had been difficult for traditional stores. As developed information technology, e-commerce has advanced possibilities. Internet plays not only the role of an information board, but provides more and more practical functions, for example, e-bill and e-banking transferring money within seconds, which in principle, speed up the transaction and furthers the material flow in supply chain.

There is potential for electronic business wherever there is an electronic device. Business through mobile devices will be widely spreaded when cellphones are no longer a luxury toy for users. The recent e-commerce revolution starts with M (mobile) and F (Facebook). Today, more and more consumers use mobile devices equipped with many applications searching products and executing the purchase, which make electronic transaction more portable and flexible. Derived from e-commerce, F-commerce is using social networking to accomplish the product publication and

transaction, the word F-commerce is originated from Facebook, which is the most popular social network platform [KEM 13]. The diffusion spreads widely in the desired customer group and the notice is duplicated from one point to its related network.

1.1.2 Logistics facing new challenges

As all things evolve, the concept of logistics gradually develops to meet the need of this era and gives more meanings. While the six "Rights" still explain the core of logistics, the course of operation has been totally changed.

Logistic product is described as the 6+1 "rights" of logistics, which the right object, in the right quantity, in the right place, at the right time, at the right cost of the right quality and environmentally compatible [SWM 10]. This definition emphasizes the spatial and temporal dimension of logistic. It indicates that the "right" is the most important and not the sooner the better or the less cost the better. It is very important to balance between transportation, cost, customer service and other activities based on the trade-off between them as every essential activity of logistics is interrelated to each other. It is no doubt that optimizing one individual activity is likely to cause the opposite effect on other activities or the total performance. It should be an important goal in logistical operations to create an optimum balance of every activity and improve total logistic performances.

The more we can understand the logic of how material flows through the system, the better we manage the production. From Just-in-Time to Lean Production, we tend to achieve the same objectives as before or even higher accomplishment with less material and time consumption. The logistic strategy also handles the information flow, when and what kind of message should be sent to which parties. This strategy guarantees the inventory level is real time controlled and supplied by the vendor. The logistic procedure can be finished within seconds and without any influence of other factors through prompt information exchange.

Besides these modern logistic management strategies, the recent innovative technologies apparently promote the progress of logistic development and make logistic procedure fast, precise, reliable and even environmentally friendly. As we know, the logistic procedure is getting more and more complicated and involved in many industry parties, especially in huge enterprises, the logistic relationship is indicated as a network connected with supplier, production, warehousing, distribution and other services.

1.2 Research motivation and objectives

For online trading companies, a simple concept is to buy and to sell products through internet trading platforms. It is no longer a secret; many private sellers have already bought or sold used products online, thanks to online trading platforms, which deliver the trading service for the internet users.

On the other hand, not everyone can be successful in online trading, even for professionals the job is not done even when the money is transferred to the account. Because what we not see behind the trading, is a complete business structure, which is different from other businesses, but is also not totally new. In particular, in its challenge to the logistic system.

Many are dedicated to the research of the successful business model, after the boom of online businesses from the last century. It is incontrovertible, that the antecessors explore a different road for trading in contrast to the aid of the virtual network. But the virtual business cannot be built on nothing, the profits are made online, and the materials are as always transferred offline. Therefore, in a sense, the logistic system for online business is similar to the traditional trading shops in some aspects, but the internet interface accelerates the trading processes and forces the material and information flow to move even faster and more individual, weakens the function of local shops and strengthens the function of central warehouse.

For this reason, this research based on the know-how of traditional logistic systems and recent developments explores an integrated design of logistic systems for online business, along each developing phases. For small and medium enterprises in online business, a suitable logistic system could save time and labour, increase the efficiency of order processing and improve customer satisfaction and therefore, strengthening the competitiveness on the market.

Besides the theoretic guideline, a practical business model is created to replenish the research vacancy which makes this research a complete operation handbook in both theoretic and practical aspects.

1.3 Research problem description

An obvious difference is where the transaction between seller and buyer is completed. For traditional business, the transaction takes place at a local shop during opening time. For online business, the transaction can happen any time with any customer in the world who has an internet connection. In a traditional business when an item is sold the sale is finished. For online businesses, the transaction is normally a contract. If an online transaction is finished, it means, the buyer has an obligation to pay the seller, and the seller has an obligation to deliver the product to the customer. In regards to materials, the products are pushed to the local shop in the traditional business, where in the online business, the customers pull the product they want from the distribution center. Therefore, in comparison to traditional businesses, online businesses have to confront the challenge with smaller and more frequent order and timely delivery. A suitable and effective logistic system should be ranked above all other difficulties in the logistic aspect.

A suitable and effective logistic system always depends on the scale and operation activities of the e-business. This does not mean that the higher the automation the more effective the logistic system. Above all, a comprehensive product analysis leads the trends of logistic system and this involves storage, transport, order picking and shipping. Along the supply chain of the trading products, each individual decision should take into consideration the inventory level, transport volume, customer group, product life cycle, financial balance, etc. Therefore, there is no standard solution for every e-business and based on the development of e-business, a rational logistic system planning in different phases that reassesses different factors that affect the business effectiveness. Among these factors, some KPIs play a critical role on the business strategies.

For online business, as well as offline business, some KPIs are especially sensitive to the success of business. For instance, inventory turnover has become the typical measurement of the warehouse effectiveness, but from the online business point of view, the traffic volume is more meaningful. Based on the browsing traffic, the profit margin is a measuring scale for the effectiveness. Therefore, some KPIs involve customer rate of traffic, average order value, and return rate of customer.

Customer rate of traffic – It indicates how many customers who have browsed the online shop are willing to buy something.
Average order value – It indicates how much money the customers would like to spend in an online shop.
Return rate of customer – It indicates how many times the customers come back and makes an order.

It is important to control and manage the factors of the logistic system. First of all, the technical figures must reflect the real status of the logistic system. Some commonly used analysis methods are helpful to detect the problems or the developing trends, for example, ABC and XYZ analysis, but the figures change dynamically with the product structure. This amplifies the complexity managing the important factors in the logistic system. In practice, not total figures are observed, but attention should be paid to some critical turning points, for instance, when the sales record goes down or the product return rate goes up.

Every person lives in a society and, in the same way, the enterprise exists in the market. The better you know the market, the better the chance you can survive in the competition. Especially for online businesses, the developing steps go further than we had expected in the past decade, with more convenient communication devices, real time information exchange apps, reliable and secure paying methods, timely and value-added services and modern and multimedia website design push the online business to update faster and more attractively. On the other hand, the cooperation between different departments in the online business is closer in regards to the material flow, information flow and financial flow. A steadily and gradually increased business value needs an integrated logistic system with product analysis, supply chain management, intra-logistic solution, distribution, reverse management, financial management, risk management, order picking system and customer service.

1.4 Structure of the thesis

The thesis is organized as follows.

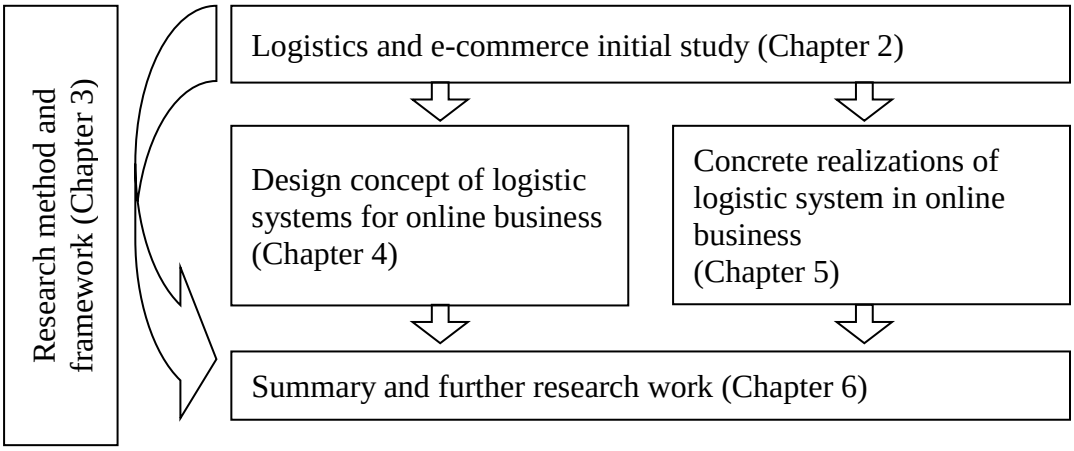


Figure 1-1 Structure of the thesis

Chapter One outlines the objectives of this research and gives an overview of the dissertation. **Chapter Two** provides a detailed literature review concerning logistics, supply chain management and e-commerce as well as the relationship among them. In **Chapter Three** the methodology of logistic system design is presented and a process framework is developed. **Chapter Four** demonstrates the design concept of a logistic system in various aspects. From a logistic, financial, management point of view, this research dedicates to build up a thorough blueprint for online business handlers from each business phases. Based on these theoretical researches, In **Chapter Five**, a concrete realization of online business is founded to validate the researches demonstrated in Chapter 4. **Chapter Six** summarizes the whole research and illustrates the future research work.

Chapter 2 Literature review

2.1 Electronic commerce (e-commerce)

2.1.1 Introduction of e-commerce

Definition of e-commerce
Commerce is basically a transfer of goods and services between buyers and sellers in a specific space and time. E-commerce makes the transaction possible without the restriction of time and space. The information is exchanged automatically without showing up personally in most commercial activities. The revolution of e-commerce is not only the technical solution for modern business, but also the change of our lifestyles.

Over the last quarter of the 20th century communication and information technology has rapidly developed. In January 2009, there were over 625 million internet hosts in over 245 countries and this is up from just 70 million in 2000 [LT 10]. Most definitions assume that e-commerce is enabled by the development and implementation of electronic media such as the internet, whereby it is not uniform in how far "old" electronic media, like telephone, telex and television, are included [MAR 03]. Based on telecommunications network or the internet, e-commerce evolves a lot of convenient tools such as E-mail, smart cards, electronic data interchange, bar code and other tools.

Literally, the definition of e-commerce can be explained as "doing business electronically" [MAR 03], whereas Gartner Group's definition (1999) "e-commerce is a dynamic set of technologies, applications and business processes that link corporations, consumers and communities" is too narrowly focused on the transactional aspect. This focus is more explicitly followed by Timmers [TIM 98] who defines e-commerce as "any form of business transaction in which the parties interact electronically rather than by physical exchange or direct "physical contact".

Development of e-commerce
In 1994, e-commerce as we now know it did not exist. In 2009, just 15 years later, around 123 million American consumers were expected to spend about $228 billion, and businesses over $3.36 trillion, purchasing goods and services on the Internet's World Wide Web [LT 10]. E-commerce is an economic solvent. It dissolves old business models and changes the cost structure, and rearranges links among buyers, sellers, and everyone in between [KR 01].

E-commerce has gone through three stages: innovation, consolidation and reinvention (see Table 2-1).

Table 2-1 Summary of e-commerce in each period [LT 10]

Evolution of e-commerce		
1995-2000 Innovation	2001-2006 Consolidation	2006-Present Re-Invention
Technology driven	Business driven	Audience, customer, and community driven
Revenue growth emphasis	Earnings and profits emphasis	Audience and social network growth emphasis
Venture capital financing	Traditional financing	Smaller VC investments; early small-firm buyouts by large online players
Ungoverned	Stronger regulation and governance	Extensive government surveillance
Entrepreneurial	Large traditional firms	Large pure web-based firms
Disintermediation	Strengthening intermediaries	Proliferation of small online intermediaries renting business processes of larger firms
Perfect markets	Imperfect markets, brands, and network effects	Continuation of online market imperfections; commodity competition in selected markets
Pure online strategies	Mixed “bricks-and-clicks” strategies	Return of pure online strategies in new markets; extension of bricks and clicks in traditional retail markets
First-mover advantages	Strategic-follower strength; complimentary assets	First-mover advantages return in new markets as traditional web players catch up
Low-complexity retail products	High-complexity retail products	Services

In fact, we are in the middle of yet another transition that is a new and vibrant service-based model of e-commerce growing up alongside the more traditional e-commerce retail sales model. This is perfectly exemplified by Amazon. Businesses such as Facebook, MySpace, Twitter, YouTube, and Photobucket that enable users to distribute their own content (such as videos, music, photos, personal information, blogs, and software applications) have rocketed to prominence [LT 10].

All of these developments indicates that more and more people and businesses are using the internet to conduct commerce. Smaller, local firms, are learning how to take advantage of the web. The e-commerce channel is deepening as more products and services come online. More industries are being transformed by e-commerce, including all forms of traditional media, software, education, and finance. Internet technology will continue to drive these changes as broadband telecommunications spreads to more households and more people purchase internet-enabled smartphones [LT 10].

2.1.2 Classification of e-commerce

In regards to e-commerce, as mentioned, most people will immediately be reminded of Ebay, Amazon or other websites from which they have brought their Christmas gifts. Whereas, online shopping is merely one type of e-commerce and now, we will take a look at the other types of e-commerce.

Usually, we distinguish different types of e-commerce by the nature of the market relationship in relation to who is selling to whom [LT 10]. Table 2-2 shows the three most important groups of market participants along with their possible business connections. There are two exceptions: P2P and m-commerce, which are technology-based distinctions.

Table 2-2 Various electronic business relationships [MS 09]

		Service Consumer		
		Consumer	**Business**	**Administration**
Service Provider	**Consumer**	**Consumer-to-Consumer (C2C)** e.g. classified ad on a personal homepage	**Consumer-to-Business (C2B)** e.g. web page with personal ability profile	**Consumer/Citizen-to-Administration (C2A)** e.g. citizen evaluates public environment project
	Business	**Business-to-Consumer (B2C)** e.g. products and services in one e-shop	**Business-to-Business (B2B)** e.g. order with suppliers (supply chain)	**Business-to-Administration (B2A)** e.g. electronic services for public administration
	Administration	**Administration-to-Consumer/Citizen (A2C)** e.g. possibility of electronic elections	**Administration-to-Business (A2B)** e.g. public advertisement of project plans	**Administration-to-Administration (A2A)** e.g. forms of cooperation in virtual communities

Business-to-Business (B2B) e-commerce:
B2B e-commerce is simply defined as e-commerce between companies. This is the type of e-commerce that deals with relationships between and among businesses. B2B e-commerce covers a broad range of applications that enables an enterprise or business to form electronic relationships with their distributors, resellers and suppliers, and other partners [TLKC 00]. There are two primary business models used within the B2B arena and these are net marketplaces and private industrial networks. Net Marketplaces include e-distributors, e-procurement companies, exchanges and industry consortia. Private industrial networks include single firm networks and industry-wide networks [LT 10].

Business-to-Consumer (B2C) e-commerce:
Business-to-consumer e-commerce, in other words commerce between companies and consumers, involves customers gathering information, purchasing physical goods (i.e.,

tangibles such as books or consumer products), information goods (or goods of electronic material or digitized content, such as software, or e-books) and, for information goods, receiving products over an electronic network [MOH 12]. There are many different types of business models within the B2C category. These are portals, online retailers, content providers, transaction brokers, service providers, and community providers [LT 10]. Thus, the more common B2C business models are the online retailing companies exemplified by Amazon.com, Drugstore.com, Beyond.com, Barnes and Noble and Toys R us. Other B2C examples that involve information goods are e-trade and Travelocity.

Business-to-Government (B2G) e-commerce:
Business-to-government e-commerce or business-to-administration (B2A) is generally defined as commerce between companies and the public sector. It refers to the use of the internet for public procurement, licensing procedures, and other government-related operations [MOH 12].

Web-based purchasing policies increase the transparency of the procurement process and reduce the risk of irregularities. However, today, the size of the B2G e-commerce market as a component of total e-commerce is insignificant as government e-procurement systems remain undeveloped [MOH 12].

Consumer–to-Consumer (C2C) e-commerce:
Consumer-to-consumer e-commerce or C2C is the simplest business model in which the transaction is accomplished between individual private consumers. It provides a way for consumers to sell to each other with the help of an online market maker such as the auction site eBay or the classifieds site Craigslist. Given that in 2008, eBay generated more than $60 billion in gross merchandise volume around the world, it is probably safe to estimate that the size of the global C2C market in 2008 is over $70 billion [LT 09].

This type of e-commerce is characterized by the growth of electronic marketplaces and online auctions, particularly in vertical industries where firm or businesses can bid for what they want from multiple suppliers. It perhaps, has the greatest potential for developing new markets [MOH 12].

Peer-to-Peer (P2P) e-commerce:
Peer-to-Peer technology enables internet users to share files and computer resources directly without having to go through a central web server. P2P network programs account for between 50%-70% of all internet traffic worldwide depending on the region-a startling figure [1].

Mobile commerce (M-commerce):
M-commerce is the buying and selling of goods and services through mobile technologies. The business relationships take place by means of mobile devices such as portable computers, like notebooks, cell phones or personal digital assistants (PDAs). Andreas Meier and Henrik Stormer [MS 09] indicated that “Over 80% of all Europeans possess a cell phone. Even PDAs have an ever-growing number of buyers.”

As content delivery over mobile devices becomes faster, more secure, and more scalable, the applications of mobile devices will become larger and larger. Currently the main mobile applications include:

- Mobile Payment: Mobile payment or mPayment is regarded by many experts as the most important application of mobile devices.
- Mobile Ticketing
- Mobile Web Sites

2.1.3 B2B e-commerce versus B2C e-commerce

The research that we focus on in e-commerce primarily involves B2B and B2C, which are the most common and the mostly used types. As an e-commerce model, B2B and B2C both accomplish the transaction through network. However, there are still a lot of differences. Therefore it is necessary to make comparative analysis in order to achieve a complete understanding of both business models. Table 2-3 shows the major differences between B2B and B2C.

Table 2-3 Comparison of B2B and B2C [SAM 02]

	Business to Business (B2B)	Business to Consumer (B2C)
Commerce Activities	Business-to-business encompasses many other types of activities than simply placing orders between business (e.g. joint design, development and manufacture). For these issues, there is a need to agree on platforms and/or data interchange standards. Typical activities among companies participating in B2B commerce include collaborative planning and forecasting, order fulfillment, payment execution and status tracking.	For the business-to-consumer, the business only has to be able to support communications via the internet, phone, fax and e-mail. The focus is on providing services such as product catalogs, ordering and payment and status checking.
Business Models	The business models in B2B are much more defensible than in B2C. B2B is an evolved economy. It is about transformation and evolution of business. In B2B, buyers and suppliers are made more efficient, competitive and profitable.	The B2C models are based on optimizing the ability to directly attract, manage and support the individual customer, thus eliminating the traditional middleman. In B2C, it is a case of new vs. old: it is Amazon vs. Borders. They are fighting for a share of the same customer.
Nature of Transactions	B2B order are governed by the complex business rules of the different parties (such as buyers, sellers and distributors) involved in the transaction. Each side wants visibility in the transaction from inception to completion.	B2C orders are often impulse or spot transactions with a short life span. There is more leniency in fulfillment of these orders.
Order Size	In most cases, the average order size (in value) in the B2B world is large.	In most cases, the average order size (in value) in the B2C world is small.
Flexibility to Change Relationships	The switching costs in B2B are much higher because the companies are much more tightly connected through integration in to back ERP systems. The companies must evolve trust with buyers and suppliers that goes well beyond delivering a product.	B2C relationships are very flexible. Buyers have full flexibility to change their suppliers.
Customer Relationships	Relationships are much more complex, long-term, often contractual and involve bigger dollar amount. They involve intricate procurement models, supply chain automation, engineering and planning collaboration.	B2C relationships are usually one-sided, where businesses define and control the relationship with the consumer.

Obviously, the customers of B2B and B2C e-commerce are different. One is a business (commercial), another is a consumer (personal). The main subject of B2C e-commerce is to transfer the potential customer that is interested in the website into an end buyer. To achieve this subject, an elaborated website, above all, is necessary, and then a convenient buying and paying method. Lastly, and most importantly, is a timely delivery and after sale service. The most commonly used services, such as eBay (Auction store), amazon.com (Online store), and cheaptickets.com (Online service), all

belong to this type. As B2C e-commerce is dealing with an individual buyer, which may buy from everywhere around the globe, the buying order is often limited to one book or a T-shirt, so it is unnecessary and difficult to integrate to the buyer's system.

In contrast, B2B e-commerce deals with products, services and information with other business groups. They sometimes negotiate over the unit price, delivery method and product specifications, etc. Initially it emerged from the Electronic Data Interchange (EDI), using that the business documents like invoices, orders, shipping confirmation can be exchanged from one company's computer to another. During the trading process, information and data, such as an electronic contract, product orders and delivery documents are transferred through the network, in the meantime, in order to realize the data exchange. A standard machine language is needed based on Electronic Data Interchange (EDI). The website of B2B e-commerce is often a platform which provides information and communication for other business partners rather than a sales channel. The buying order may contain over thousand items of single type as B2B e-commerce is facing companies or wholesalers. Although the establishment of a trading relationship between both sides seems to be complicated, it lasts for a long time once set up and tends to be stable and sustainable as long as the relationship is effectively maintained and supervised from both sides.

2.2 Logistics and supply chain

But not all people involved in e-commerce can make benefit, like other business forms, it requires many other auxiliary instruments, such as: manufacture plan, IT support, logistic, supply chain management and customer relationship management.

Logistics and supply chain management are the focus of our research, because a suitable logistic system may reduce the costs on transportation, warehousing and inventory, in order to profit. It can also shorten the lead time from loading and unloading processes, order picking and product transfer in order to improve service level. At the same time, it is not easy for e-companies themselves to provide their products and services faster, cheaper, and better. A cooperation with other participants in their supply chain is definitely necessary. After all, logistic and supply chain management are an indispensable weapon for the development of enterprise and to get ahead in the business competition as long as we comprehensively understand the usage.

2.2.1 Logistics: state of the art

The origins of the modern logistics concept in businesses can be traced to developments in military logistics during World War II [CBL 96]. In military operations logistics deals with the procurement, supply and maintenance of equipment, the movement, evacuation, and hospitalization of personnel, the provision of facilities and services, and with other related matters. Logistics has evolved considerably over the past several decades. The definition of logistics develops with the evolution of logistics in each epoch and the scale and significance itself is updated from time to time.

The evolution of business logistics can be divided into three phases [RCH 94]:

- Functional management (1960s-1970s)
- Internal integration (1980s)
- External integration(1990s)

Internal integration of logistical activities became widespread during the mid-1980s and the Council's following definition of logistics reflected its broadened scope:

The definition of logistics can be described as: “Logistics is the process of planning, implementing and controlling the efficient, effective flow and storage of raw materials, in-process inventory, finished goods, services and related information from point of origin to point of consumption (including inbound, outbound, internal, external movements) for the purpose of conforming to customer requirements.” (Council of logistics Management) [KLA 02].

2.2.2 Interrelated logistics and supply chain

Supply Chain (SC) Definition
“Supply chain can be defined as a strategic concept that involves understanding and managing the sequence of activities - from supplier to customer - that add value to the product and supply chain pipeline” [BT 96]. The logistics supply chain pipeline is illustrated in Figure 2-1.

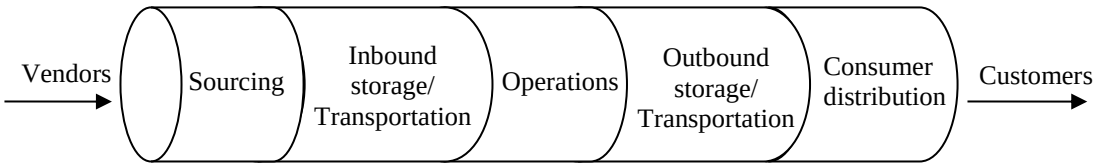


Figure 2-1 Logistics supply chain pipeline [CBL 96]

The term ‘supply chain’ is somewhat misleading in that the term ‘chain’ represents a simple series of links. What happens in practice is a supply chain pipeline can connect with several other pipelines to form a system of pipelines, which can also be called a supply network.

Christopher [CHR 05] defines the supply chain as a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.

In a broad sense a supply chain consists of two or more legally separated organizations being linked by material, information and financial flows [SK 08]. These organizations are not limited to a supplier, a manufacturer, and a distributor, but open to any firm that performs various services, including a third party financial provider, a third party logistics (3PL) provider, a market research firm, and so on [MD 01].

In a narrow sense the term supply chain is also applied to a large company with several sites often located in different countries. A supply chain in the broad sense is also called an inter-organizational supply chain, while the term intra-organizational relates to a supply chain in the narrow sense [SK 08].

Supply chain structure
A more realistic representation of the supply chain is shown in Figure 2-2, where each link can be connected with several others. A focal firm is shown at the center of many possible connections with other supplier and customer companies.

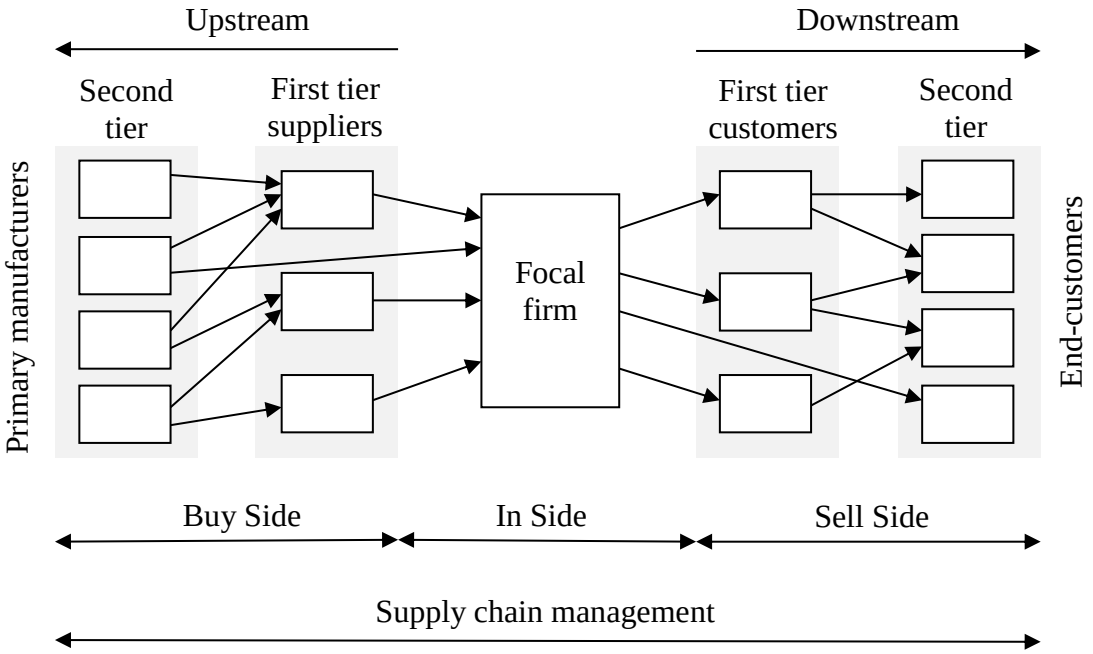


Figure 2-2 Supply network [SCHHJ 97]

The supply chain can be seen in this diagram as a number of processes that extend across organizational boundaries. The Focal firm is embedded within the chain, and its operational processes (‘inside’) must coordinate with others that are part of the same chain.

The analogy to the flow of water in a river is often used to describe organizations near the source as upstream, and those near the end-customer as downstream. Materials flow from left (upstream, or ‘buy side’) to right (downstream, or ‘supply side’).

The supply chain is tiered in that supply side and demand side can be organized into groups of partners with which we deal with [HV 08].

Push and pull supply chains
Supply chain is often described in terms of push or pull systems. In a pull (or make-to-order (MTO)) system products are manufactured in response to customer demand. In a push (or make-to-stock (MTS)) system production is forecast driven and executed in anticipation of demand. Whether a push system is more appropriate than a pull system depends on product features, manufacturing process characteristics, as well as demand volume and variability. MTO systems are more suitable whenever lead times are short, products are costly, and demand is low and highly variable [GLM 04]. Actually, it is necessary to use these two systems together in some cases.

Supply chain management (SCM)
Hartmut Stadtler [SK 08] defines the term *supply chain management* as the task of integrating organizational units along a supply chain and coordinating material, information and financial flows in order to fulfill (ultimate) customer demands with the aim of improving the competitiveness of a supply chain as a whole.

Supply chain management is considered as one of the basic management factors in the business strategies. It is one of the key components of enterprise management and is responsible for balancing demand and supply along the entire value-adding chain [CHR 05]. SCM's impact on the enterprise management can be estimated as up to 30%. From decisions on the SC configuration arise up to 80% of the total SC costs [HAR 05] and up to 75% of the operational costs in SCs [WAN 05].

Logistic and supply chain management (SCM)
In analyzing the existing research literature and empirical case studies, Dmitry Ivanov and Boris Sokolov [IS 10] concluded that logistics deals mostly with local functions for implementing the physical transition of material flows and SCM deals with the value adding chain as a whole and concentrates on the managerial links between the local functions for implementing the physical transition of inbound and outbound material flows. With the Figure 2-3 we can easily understand the interrelation of logistics and SCM as the circles are the subject of logistics and managerial (informational and financial) links between the circles are the subject of SCM. Logistics is required to optimize the realization of physical transitions throughout a supply chain. On the other hand, SCM focus in management of these external relationship and flows.

In other words, logistics takes care of providing the right goods, in the right place, at the right time, in the right volume, in the right package, in the right quality, with the right costs, and SCM takes care of balancing the supplies along the entire value-adding chain subject to the full customer satisfaction [IS 10].

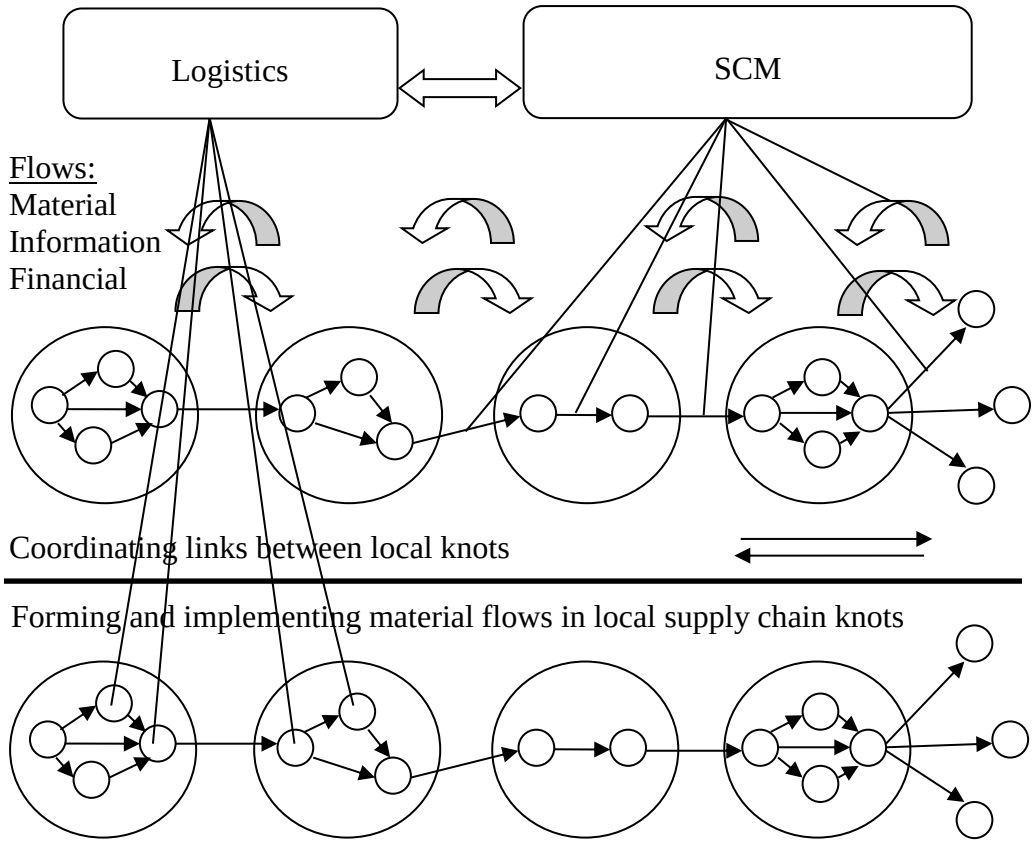


Figure 2-3 Interrelation of logistics and SCM [IS 10]

It is impossible to consider logistics and SCM in separate from each other. SCM and logistics are interconnected. SCM is a very important part of logistics. Logistics is also a very important part of SCM.

To create efficient logistics it is necessary to have both efficient and effective internal material flows and efficient and effective flows between companies.

2.2.3 Logistics system activities and components

A logistics system is made up of a set of facilities linked by transportation services [GLM 04]. Facilities can be manufacturing centers, distribution centers, warehouses, transshipment points, stores, etc., where materials are processed. Transportation services are responsible for material transfer between the various facilities.

Logistics can be regarded as an individual part of one company or an integrated flow of materials through several companies. It is often necessary to have a broader perspective of the logistics system rather than just within an individual company, since there is interdependence between customers and suppliers.

A logistics system is composed of subsystems and components, just like the supply of materials, production and distribution systems, and it has an exchange with its surroundings. The relationship between the subsystems and components, including between the system and its surroundings, take the form of co-ordination and exchange of materials and information. Through the combination and co-operation of subsystems, and components, a higher total system effect will be produced.

1) The process of logistic systems

A logistics system can be characterized as a set of linked processes which transform materials into products for distribution to the customer.

Processes can be classified in different ways. One frequent classification is to differentiate between core processes, support processes and management processes [JON 08].

Core processes: they are initiated by an event and directly contribute to customer value and are central to achieving an operative perspective. They can be divided into different types, such as supply, manufacturing, distribution, after sales and other elements.

Support processes: aim at aiding core processes so that they can be carried out in an efficient manner, such as like planning and demand forecasting process.

Management processes: they are initiated by plans and may also directly affect customer value and are central to achieving a strategic perspective. Long-term strategic and business planning are examples of these processes.

The logistic process is illustrated in the diagram below.

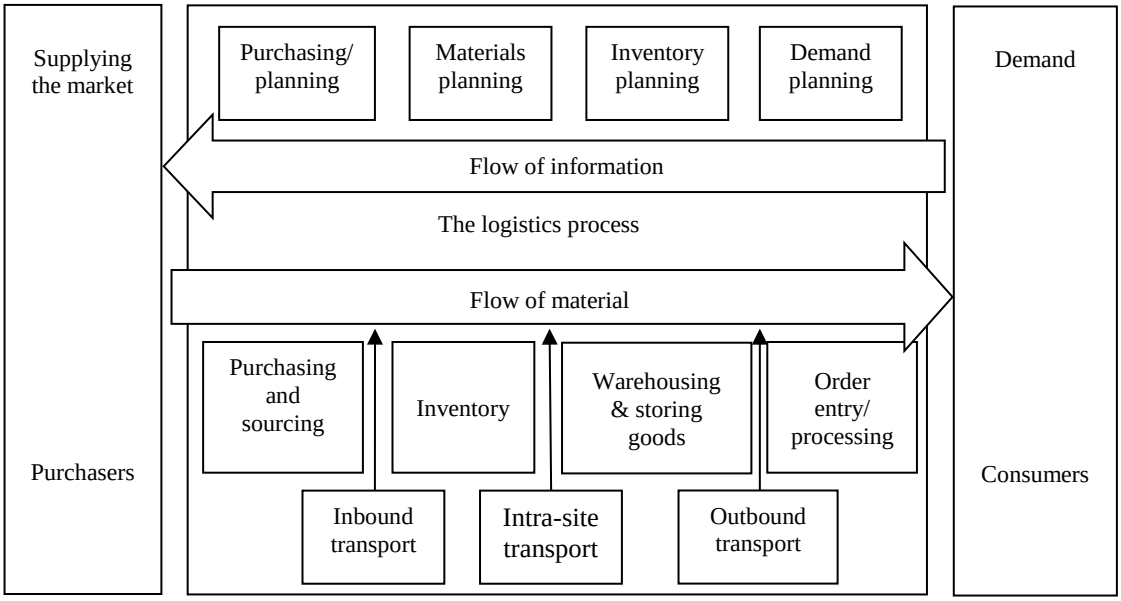


Figure 2-4 The logistic process [PAG 05]

2) The activities of logistic systems

The logistics definitions discussed earlier indicate that there are several activities associated with logistics. Logistics can be considered as the combination of a firm's order management, inventory, transportation, warehousing, materials handling, and packaging as integrated throughout a facility network [BC 07]. It is worthwhile to discuss these activities and their relationship to logistics in order to understand and manage the sequence of activities from supplier to customer. The common logistics activities are:

Transportation
Transportation is a very important part of the logistics system and has received considerable managerial attention over the years as the major focus in logistics is upon the physical movement of flow of goods.

Storage
Storage is the physical stock-keeping of goods in a store or warehouse and has a trade-off relationship with transportation. It involves two separate, but closely related activities, and these are inventory management and warehousing [CBL 96].

Figure 2-5 shows the typical functional areas and flows within warehouses. The main warehouse activities include receiving, transfer and put away, order picking/selection, accumulation/sortation, cross-docking, and shipping.

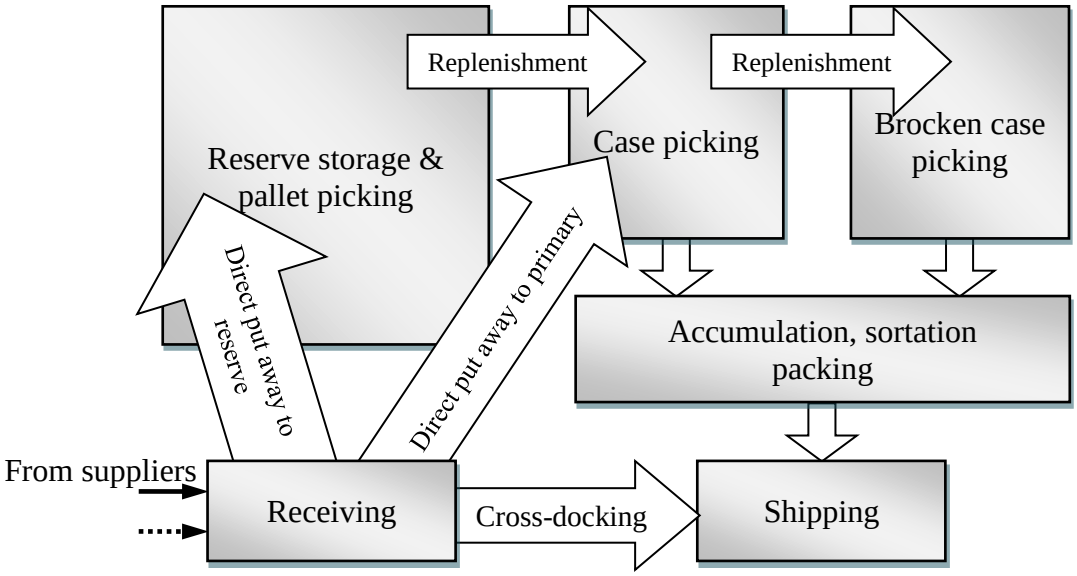


Figure 2-5 Typical warehouse functions and flows [TWBFT 03]

The *receiving* activity includes the unloading of products from the transport carrier, updating the inventory record, inspection to find if there are any quantity or quality inconsistencies. *Transfer and put away* involves the transfer of incoming products to storage locations. It may also include repackaging (e.g. full pallets to cases, or standardized bins), and physical movements (from the receiving docks to different functional areas, between these areas and from these areas to the shipping docks). The *order picking/selection* is the major activity in most warehouses. It involves the process of obtaining a right amount of the right products for a set of customer orders. The *accumulation/sortation* of picked orders into individual (customer) orders is a necessary activity if the orders have been picked in batches. In such a case the picked units have to be grouped by customer order upon completion of the pick process. After picking, orders often have to be packed and stacked on the right unit load (e.g. a pallet). *Cross-docking* is performed when the received products are transferred directly to the shipping docks (short stays or services may be required but little or no order picking is needed). Cross docking is typically employed for fast-moving products with constant demand that spends less than 24 hours on-site [MLB 08].

Packaging
As introduced by Sople in 2012, packaging can be divided into industrial packaging and consumer packaging. The purpose of industrial packaging is to protect the product during the logistical process and facilitate ease of handling [SOP 12]. Different transportation types usually have different packaging requirements and depend on their risk to be damaged. The consumer packaging, at the retail level, is usually influenced by sales. A good consumer packaging can attract customer's attention and make a sale. The size of consumer packages will affect the use of the industrial packages, thereby further affecting the transportation, material handling, and warehousing.

Materials Handling
Materials handling is a very important activity in warehouse operations as it is concerned with managing and moving goods in the warehouse. At the same time materials handling is also required for efficient loading and unloading operations in the transportation. The direct labor and capital invested in material-handling equipment are a major part of total logistics cost [BC 07]. Some mechanized and automated device for short distance movement are usually used to assist in materials handling, such as conveyors, forklift trucks, containers etc.

Order Processing
Logistic plays an extremely important role in ensuring that the customer gets the right product at the right place and time. In other words, to meet the requirement of customers is the aim of the logistic system. In most supply chains, customer requirement are transmitted in the form of orders. The processing of these orders involves all aspects of managing customer requirements, including initial order receipt, delivery, invoicing, and collection [BCC 07].

Especially, the processing of orders is an important aspect of information which is critical to logistics operations. Forecasting and communication of customer requirement are the two areas of logistical work driven by information [BCC 07].

Based on EDI, the e-commerce stores are capable of handling customer orders more quickly and accurately.

Inventory
`Inventory` is another name for materials and is any materials that a firm holds in order to satisfy customer demand (and these customers may be internal and/ or external to the firm). Figure 2-6 shows inventory locations throughout a supply chain.

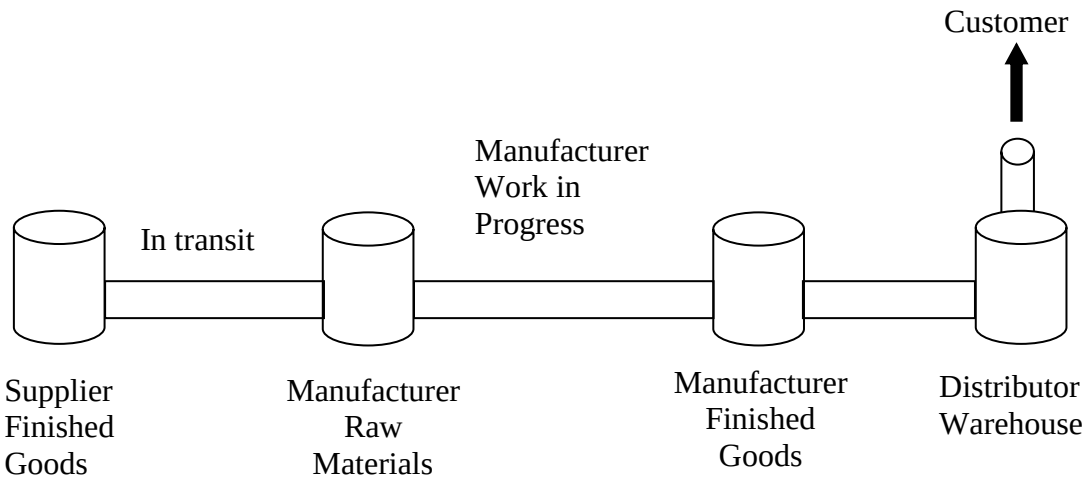


Figure 2-6 Inventory locations throughout a supply chain [MLB 08]

This illustration should give a sense of the ubiquitous nature of inventory, and the various forms in which it is held. Supply chains hold raw materials in order to convert these inputs into finished products: When the raw materials are processed, but not yet completely finished, they are called work-in-progress. They are finished goods once the product is ready for shipment. Notice also the in transit inventory in Figure 2-6. This is inventory being moved from one location to another [MLB 08].

Inventory costs money. Supply chain partners invest significant amounts of money in holding inventory in various forms. This is money that could be invested elsewhere and earn a return. Inventory ties up working capital and affects cash flow and sometimes even threatening the survival of a firm. Inventory also takes up space, and firms need to hire people to take care of inventory. Thus firms are always on the look-out for ways to reduce their inventory holding. However, inventory cannot be reduced to zero, because firms need to have raw materials, work-in-progress and finished goods in order for the firm to function. Customer orders will take unduly long to fulfill without these in place. Therefore, the goal in inventory management is to minimize inventory holding while maintaining a desired customer service level [MLB 08].

Facility Network Design

Facility network design is concerned with determining the number and location of all types of facilities and what type of inventory and how much of said inventory to stock at each facility as well as the assignment of customers. The facility network creates a structure from which logistical operations are performed. Thus, the network integrates information and transportation capabilities. Specific work tasks related to processing customer orders, warehousing inventory and materials handling are all performed within the facility network.

3) Flows in the Logistics System

There are several efficient flows which go through the whole logistics system and are associated with all activities. They are flow of information and financial flows, flow of products, material, inventory, services and so on. Among them, the flow of materials has traditionally been seen as the primary flow in logistics. The efficient flow of

information is an important condition for material flows, and then comes financial flow as a result of the materials flow.

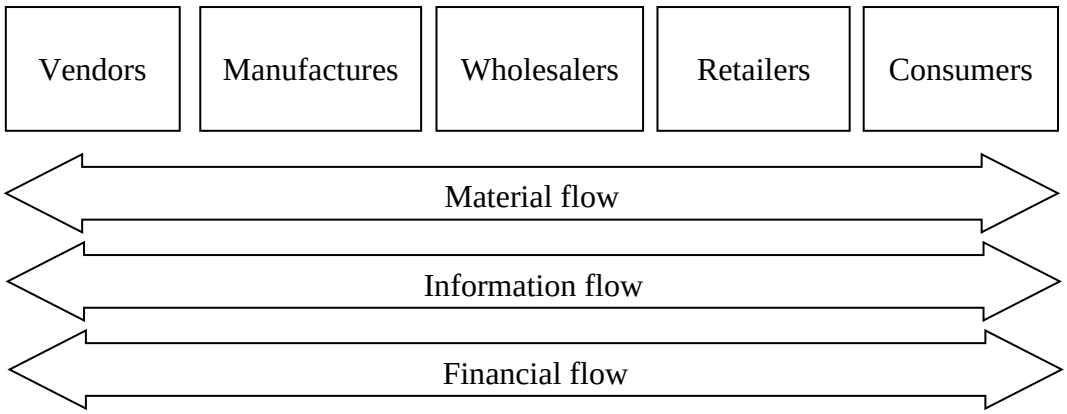


Figure 2-7 Flows in a logistics system

The three flows are explained in the following:

Materials flow
In logistic systems the flow of materials moves in two directions. The first is from the original source to the end-user. The second is in the opposite direction and from consumer to supplier or upstream through the production system and consists of returns form claims and recycling materials or products. It represents large values and has a direct impact on the environment and linked to several logistic activities like transport, materials handling, storage and packaging.

Information flow
According to Bowersox in 2007, information from and about customer flows through the enterprise in the form of sales activity, forecasts, and orders. The information flow plays a vital role in the logistics system. Prior to this concept, information only consisted of only sales data and/or demand. The information becomes available in real time to all involved logistic process with the development of information technology. It may consist of customer order information, sales information, delivery notification, order confirmation, stock balance information and others [BC 07].

Financial flow
As a result of the flow of materials from a supplier to a customer a flow of payment appears in the opposite direction. Sometimes, a reverse flow of finance from supplier to customer arises because of claims. The financial flow moves also in both directions just like materials flow and information flow.

A better synchronization of material, information, and financial flows will have a positive impact on all three flows [MS 09].

2.2.4 Third-party logistics

The emergence of companies involving third party logistics business began in the 1980's. They took over the logistics functions from other companies and then, they could completely focus on their core business and reduced the total cost. In the

meantime, the logistics resource from 3PL companies was effectively used in serving many companies. Due to the growth of 3PL companies, a wide range of logistic services are delivered by 3PL companies, and many 3PL companies also provide logistic consultancy and solution, which more seems like the domain of 4PL, and even some have evolved into 2PL, which have their own fleet. 3PL is defined as, according to council of supply chain management professionals, "a firm that provides multiple logistics services for use by customers. Preferably, these services are integrated, or bundled together, by the provider. Among the services 3PLs provide are transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding." [4] However, it is necessary for the decision makers to understand the functions of 3PL before outsourcing these functions.

A typical 3PL provider offers services including:

- Inbound freight
- Freight consolidation
- Warehousing
- Distribution
- Order fulfillment
- Outbound freight

Inbound freight is the most overlooked area for cost reduction. It involves the management and control of freight from domestic and offshore vendors, consolidation of vendor shipments, and direct shipments to retail sites and customers at home, multiple shipping points, and warehouse cross dock opportunities for retail replenishment and backorder processing [5]. An effective inbound freight management can lead to a complex executive process while maintaining a high customer service level, and thus, it is difficult to restrict the cost to a desired range.

Freight consolidation means the act of combining individual shipments into a single lot in order to reduce costs or improve transport equipment utilization. Consolidation can take a variety of forms by customer, geography, shipping land or schedule. Consolidation may occur at the shipping facility or may even be a service of a third party [2]. Here, many cargos from different companies are collected, reorganized and transshipped to desired destinations so that the shipping and inventory cost can be extremely reduced. If effectively using the existing resources, 3PL providers can bring the customer larger benefit and faster react period which for small shipments the operation can find difficult to manage.

Warehousing and distribution: First, the location of warehouse plays an important role in product reception and distribution. The service provider always prefers the warehousing close to the transport turnover point or to the customers; second, central warehousing effectively utilizes the inventory space and observes the stock quantity.

Order fulfillment is settled after the requirement of customers. The order is accepted and forwarded directly to the order reception, and further sent to the order processing department, directly in the warehouse, in order that the desired articles in the order list can be collected as soon and accurately as possible. For a big and complex order, the picking process could possibly originate from three possible configurations. The first is a full packaged unit, for instance, a full pallet. The second is a small package which is disassembled from a full package. The last is a single article which is seen as the

smallest unit for orders. The achievement of order fulfillment differs with the grade of automation, picking strategy, facilities and devices and also training skills. A research from Capgemini 2012 shows in the following paragraph that, 3PL providers dedicated to the order processing, use pick-by-light, pick-by-voice, pick-and-pack and other picking strategies to accelerate the picking process and ensure the order accuracy.

Outbound freight is another area that could reduce the total costs. Thanks to e-commerce, small and more frequently delivered package challenges the logistic solution. The distribution center from 3PL provider involves the repackaging, labeling, customer vendor control and reuse of returned products and in consequence, some value-added services, which are delivered by 3PL, ensure the high level service and consolidate the customer relationship.

Furthermore, coupling with 3PL provider requires other prerequisites. First, an integration of IT atmosphere where information exchange and synchronization sets up on an internet-based platform with preapproved protocol. Secondly, a declaration of service series where the specific logistic functions that 3PL provides should exactly meet the desire of companies. In principle, the outsourced service functions are agreed by 3PL provider in the form of a contract.

The outsourced logistic services are recognized as contract logistics and they handle the management of complex logistic functions along the supply chain. The services of contract logistics provider are delivered firstly by 2PL providers which possess the transport fleet and network. The other service functions are contracted with a third party, which were later called 3PL and this allows more focus on the core business. From then on, 3PL has become the most burgeoning business in the logistic branch coupled with the development of IT technology and warehouse management. From 2010 the total revenues of 3PL companies has reached over 500 billion US dollars and Asia-Pacific has risen to the second biggest market around the globe [LC 12].

Table 2-4 Global 3PL revenues for 2010 [LC 12]

Region	2010 Global 3PL Revenues (US$ billions)
North America	149.1
Europe	165.1
Asia-Pacific	157.6
Latin America	27.5
Other Regions	42.3
Total	541.6

3PL providers face an unprecedented chance and an unprecedented challenge with the exponential increase of e-commerce business. Differing from traditional businesses, e-commerce is based on the internet platform interacts directly with customers, where the transaction happens at any time and space, but the products transport have no shortcut in reality and, instead, the prompt response through local warehousing, vendor control, speedy order processing and distribution effectively satisfy the business environment and, in addition, thanks to the IT development there is more value-added-services that are offered by 3PL providers to attract potential customers and promote new products.

2.2.5 Logistic system design overview

A logistics system's physical structure consists of two elements. They are stationary facilities and the transportation links between those facilities [OW 03].

Transportation links design
It includes the selection of the transportation modes (whether they are road, rail, sea, air or combined multimodal transport) or transporter, route planning, load and unload planning etc.

1) Transportation modes selection
Generally the most common four transportation modes are sea, rail, road and air. It is also possible to use more than one transport mode for one consignment and this is called intermodal transportation.

Each mode of transport has its own characteristics. We have compared them in Figure 2-8.

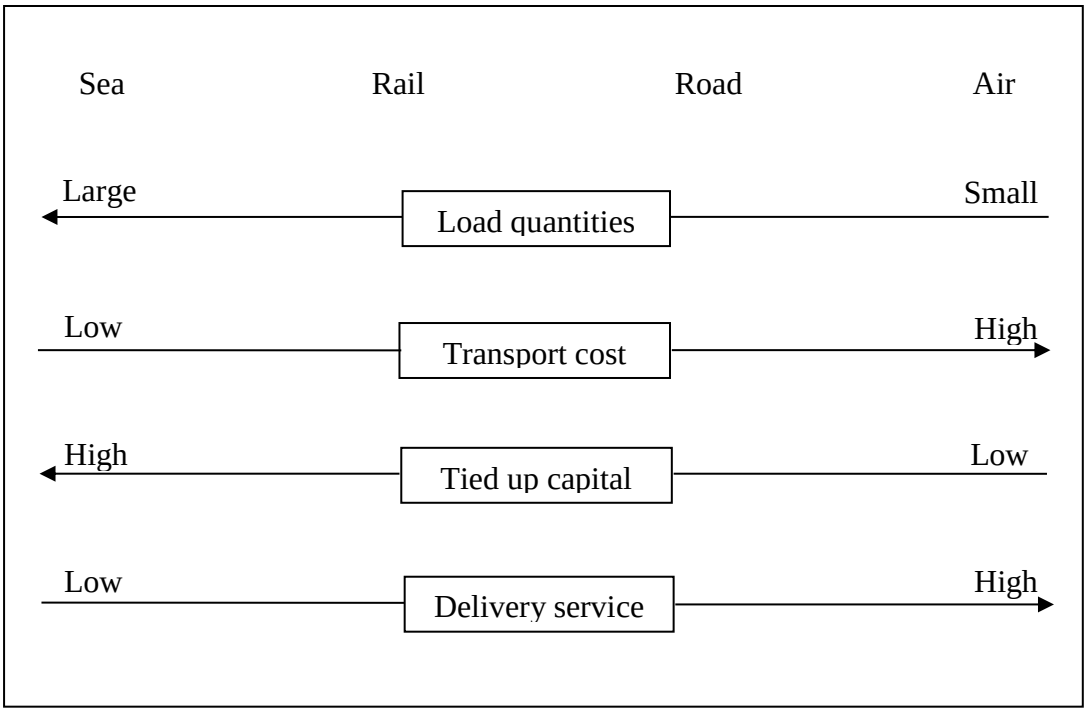


Figure 2-8 Comparisons between the four traditional traffic modes [JON 08]

Sea transport
Sea transport continues to be the main transportation form for huge containers. Low cost and large loading capacity are the greatest advantages of sea transport over other modes. Other advantages for sea transportation lie in the flexibility in transport routes and the low cost of maintaining infrastructure for transportation. On the other hand, the transit time of sea transport is generally the longest of all modes. The time is measured generally not in hours but in days compared to highway and air.

There are several types of vessels which are adapted for different goods and transport routes. We generally use containerships as they ensure a high utilization of the ships´ transport capacity and containers can be stacked on top of each other, close to each other and also on the deck. In addition to these tankers, bulk and neo-bulk carriers and

RoRo vessels are usually used for specific types of goods just like liquid, iron ores or heavy machinery and large vehicles.

Rail transport
Rail transport is common for the transportation of large quantities of high-volume goods of low value over long distances. It can be an alternative for sea transport. Almost any type of goods can be transported by rail, especially bulk commodities like ores, coal and grains.

The railway network is developed more slowly because departures by rail are less frequent than by road. Simultaneously, the low flexibility in time and geography is another disadvantage of rail transport.

Road transport
Almost any type of goods can be transported to nearly everywhere by road transport. Road transport usually carried smaller volumes of goods compared to sea and rail transport. The weight and dimensions of trucks are often established by state and local highway departments.

Flexibility is the great advantage of road transport over other transport modes. They can be loaded and be on their way faster. At the same time, if necessary, alternative routes can always be obtained.

Air transport
The major advantage of air transport is the low transit time. Air transport provides a very fast service over large geographical distances. Thus, it is usually used for time-sensitive express goods or emergency deliveries. On the other hand, this mode has the highest cost and this is considered to be the greatest disadvantage of it.

Three factors are fundamental to transportation performance from the logistical system viewpoint and these are cost, speed, and consistency [BC 07].

The cost of transport is the payment for movement between two geographical locations and expenses related to administration and maintaining in-transit inventory. *Speed* of transportation is the time required to complete a specific movement [BC 07]. Usually the faster the transportation service the higher the rates are that are charged. At the same time, the faster the transportation service, the shorter the time interval of inventory in transit. Thus, a critical aspect of selecting the most desirable method of transportation is to balance speed and cost of service.

Consistency of transportation refers to variations in time which is required to perform a specific movement over a number of shipments. If a given movement takes two days in one case and six days next time, inventory safety stocks will be required to protect against unpredictable service breakdowns and serious logistical operational problems will arise.

2) Load and unload planning
FCL: The FCL or “Full Container Load” means the load reaches its allowable maximum (or full) weight or measurement. In practice it means the whole container is intended for one consignee. Shipping goods FCL is more cost effective and safe then

using other sea freight services. In practice, the FCL in the ocean freight does not always mean packing a container to its full payload or full capacity. Container loading is a quite difficult procedure and during the loading it is necessary to pay attention in order to avoid cargo damage.

LCL: Less than container load (LCL) is a shipment that is not large enough to fill a standard cargo container.

If an exporter intends to pack a container to its full capacity or full payload with the consignments of two or more consignees for the same destination, then it is a case of LCL and the carrier will charge the LCL freight rate on each consignment.

Warehouse design

As mentioned before, the main functions of warehouse can be summarized as: Receiving-Storage-Order Picking-Shipping. In the warehouse design, a number of important decisions are related to these functions, such as, the decision of warehouse size and amount, warehouse layout designing, the selection of order picking method and so on.

Warehouse design should be committed to ensure that each function can be implemented to meet the requirements of the whole logistic system. At the same time, warehouse designers should also aim to achieve optimal output, reduce costs, excellent customer service and sound working conditions [GLSE 05].

1) Storage

SKU assignment

There are numerous ways to assign products to storage locations. The most frequently used types of storage assignment are described below and these are random storage, class-based storage and dedicated storage.

Random storage

For random storage every incoming product can be stored anywhere that is empty in the warehouse. The random assignment method results in a high space utilization (or low space requirement) at the expense of increased travel distance [IS 91]. For these reasons, the random storage policy is more practical in a computer-controlled environment.

Class-based storage

In inventory control, a classical way for dividing items into classes based on popularity is the Pareto method. This method is also the most common used strategy to group products in class-based storage, based on the assumption that e.g. 15% of the products contributes to about 85% of the turnover. The arrangement of classes based on the product's popularity would lead to the widely used ABC layout policy [DL 05]. In it, the fast moving items are generally called A-items and would take over the most convenient locations in the warehouse and these are typically close to the I/O points or outgoing shipping door. The next fastest moving products are called B-items, and take the next most convenient locations after A-items. The next class would be C-items, and so on.

Dedicated storage
Another possibility is to store each product at a fixed location and this is called dedicated storage. A disadvantage of dedicated storage is that a location is reserved even for products that are out of stock so that the space utilization is lowest among all storage policies. An advantage is that order pickers become familiar with product locations. In retail warehouses often the product-to-location assignment matches the layout of the stores [DN 01]. This can save work in the stores because the products are logically grouped. Finally, dedicated storage can be helpful if products have different weights. Heavy products have to be on the bottom of the pallet and light products on top. Dedicated storage can be applied in pick areas, with a bulk area for replenishment that may have, for example, random storage. In this way, the advantages of dedicated storage still hold, but the disadvantages are only minor because dedicated storage is applied only to a small area.

Storage layout
In the context of order picking, the layout design concerns two sub-problems and these are the layout of the facility containing the order-picking system and the layout within the order-picking system. The first problem is usually called the facility layout problem and it concerns the decision of where to locate various departments (receiving, picking, storage, sorting, and shipping, etc.). It is often carried out by taking into account the activity relationship between the departments [MAN 12]. The common objective is to minimize the handling cost, which in many cases is represented by a linear function of the travel distance. In this paper, we focus on the second sub-problem, which can also be called the internal layout design or aisle configuration problem. It concerns the determination of the number of blocks, and the number, length and width of aisles in each block of a picking area. The common goal is to find a 'best' warehouse layout with respect to a certain objective function among the layouts which fit a given set of constraints and requirements. Again, the most common objective function is the travel distance.

2) Order picking
Order picking is a warehouse function dealing with the retrieval of articles (items) from their storage location in order to satisfy a given demand specified by (internal or external) customer orders [PS 99]. On the one hand, underperformance in order picking may result in an unsatisfactory customer service (long processing and delivery times and incorrect shipments) and, on the other hand, it may lead to high costs (labor cost, cost of additional and/ or emergency shipments), since more than 50% of the total operative costs of a warehouse are related to order picking [FRA 01].

According to the order picking approach, the order picking system can be divided into manual order picking and automated picking. Manual order picking systems can further be differentiated into two categories. First, the picker-to-parts systems, in which order pickers walk or ride through the warehouse and collect the requested items, and, second, part-to-picker systems, in which automated storage and retrieval systems deliver the items to stationary order pickers [WÄS 04]. Among these, the picker-to-parts system are most common [DEK 04] and particularly suitable for small and medium enterprises.

Routing
For manual-pick order-picking systems, the travel time is an increasing function of the travel distance (see, for example, [JM 91], [HAL 93], [PET 99], [RD 01a], [RD 01b],

[PA 04]). Therefore minimizing the travel distance is considered to be the main method to improve order-picking efficiency.

Hall [HAL 93], Petersen [PER 97] and [ROO 01] distinguish several heuristic methods for routing order pickers in single-block warehouses, such as, the S-shape, return, largest gap, midpoint, composite and optimal. In this research, the easiest and most commonly used strategies are compared and discussed. According to Sadowsky, these four methods are described as follows:

Transversal/ S-shape strategy
All aisles will be traversed through the whole length. Aisles with no items to be picked are skipped. This method is the simplest and most frequently used strategy. It is very suitable for the order picking equipment which cannot easily change directions within an aisle.

The following two figures indicate two kinds of transversal/S-shape strategies for order picking, in which Figure 2-9 demonstrates picking route through every aisle no matter where the desired articles located. This kind of strategy is relatively fixed and the possible variable lies with the location of the last article. In Figure 2-10, another option of transversal/S-shape strategy is going through the aisle only where one or more articles located.

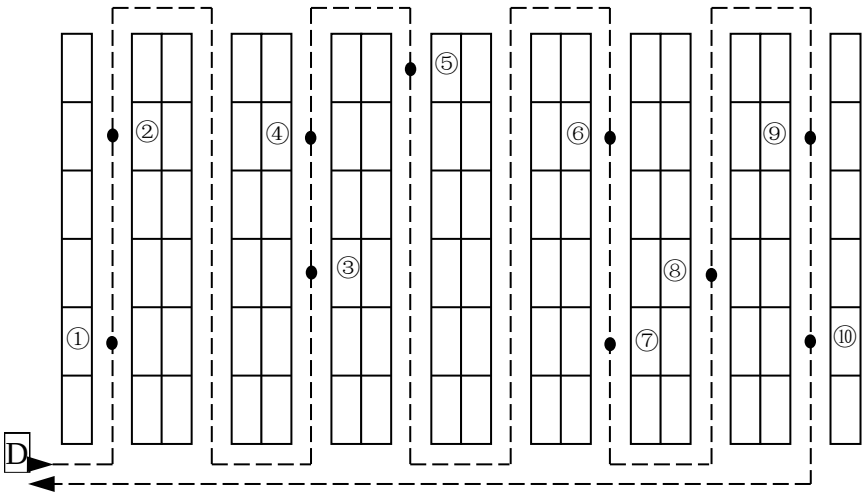


Figure 2-9 Transversal/ S-shape strategy through every aisle [SAD 07]

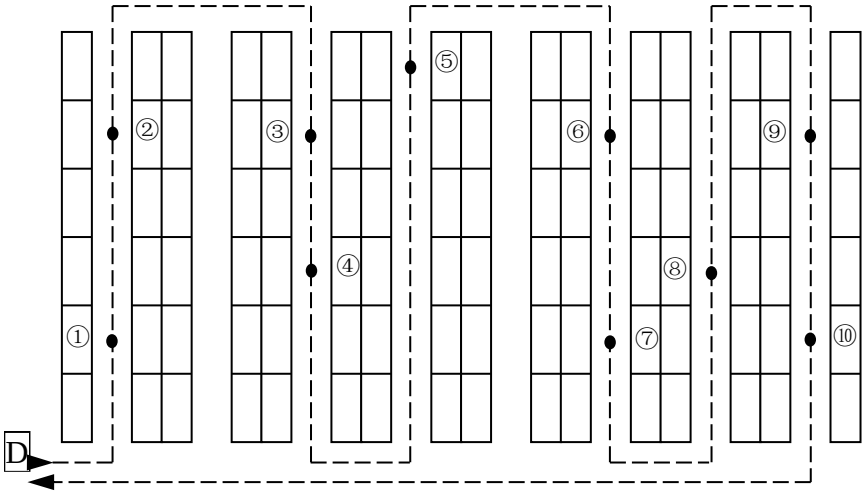


Figure 2-10 Transversal/ S-shape strategy through necessary aisles [SAD 07]

Return strategy
The aisles are entered and left after picking from the same side. This method is preferred if there is only one possibility for changing aisles in the warehouse.

The following figures indicate two return strategies with an aisle and an article each. The picking route in Figure 2-11 includes a route repeat in the same aisle where two or more articles are being located and Figure 2-12 shows an aisle-based return strategy. These two variables of return strategy have the same picking route where there is only one desired article located in one aisle.

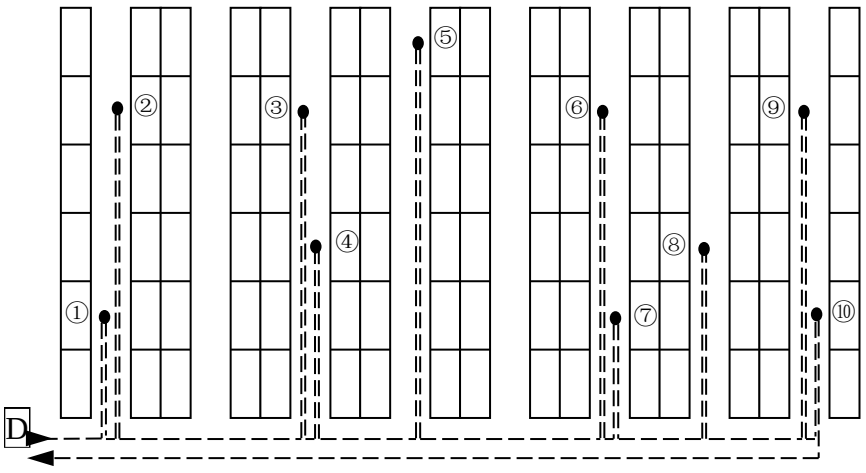


Figure 2-11 Return strategy once an article [SAD 07]

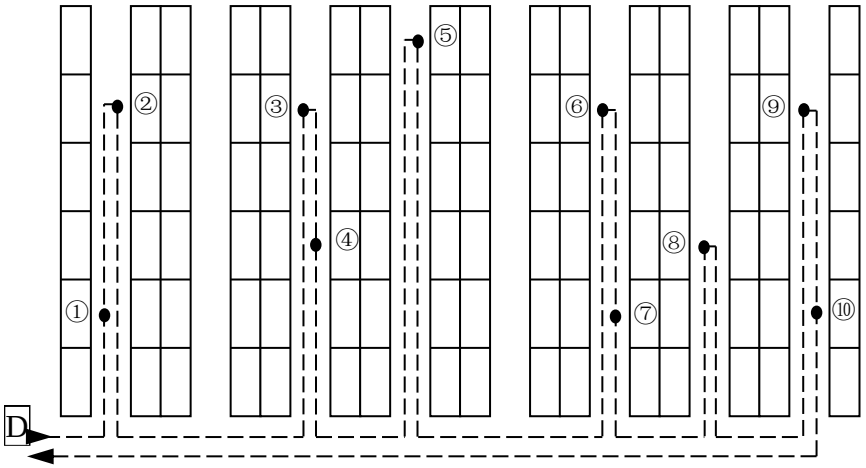


Figure 2-12 Return strategy once an aisle [SAD 07]

Midpoint strategy
This divides the warehouse into two halves. Picks in the front half are accessed from the front aisle, and picks in the back half are accessed from the back aisle. This method performs better than the S-shape method when the number of picks per aisle is small (i.e. one pick per aisle on average) [HAL 93].

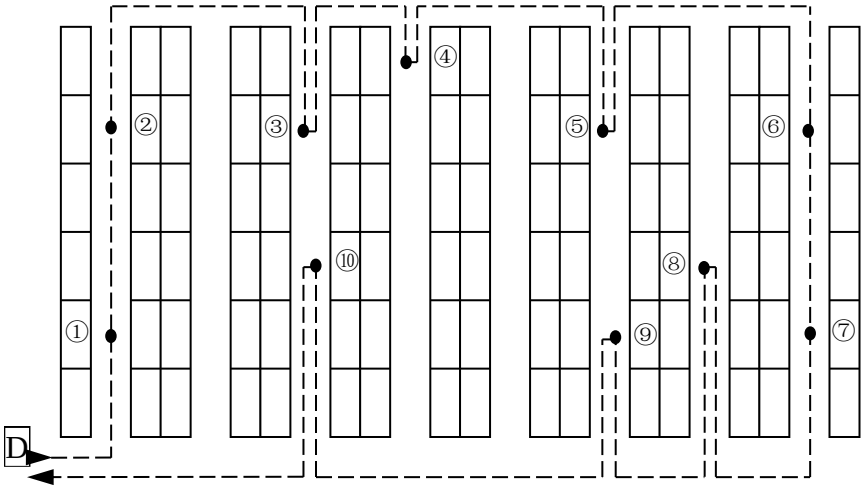


Figure 2-13 Midpoint strategy [SAD 07]

Largest Gap strategy
If the largest gap is between two adjacent picks, the picker performs a return route. The Largest Gap heuristic is especially useful when the additional time to change aisles is short and the number of picks per aisle is low.

The largest gap method always outperforms the midpoint method (see [HAL 93]).

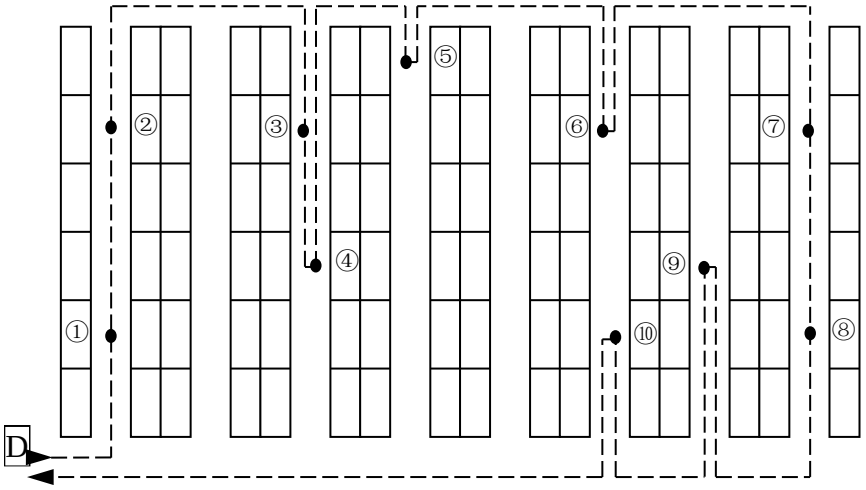


Figure 2-14 Largest gap strategy [SAD 07]

Meanwhile, in the picker-to-parts order picking system, the pickers traveling distances is also affected by other warehousing factors, such as, material handling technology, warehouse layout and SKU assignment. Therefore, these aspects are closely integrated and interact with each other in the design of the warehouse.

Batching
Each order can be picked individually (i.e. one order per picking tour) when orders are fairly large. This way of picking is often referred as the *single order picking* policy (or discrete or pick-by-order). However, when orders are small, there is a potential for reducing travel times by picking a set of orders in a single picking tour. *Order batching* is the method of grouping a set of orders into a number of subsets, each of which can then be retrieved by a single picking tour. According to Choe and Sharp [IS 91], there are basically two criteria for batching and these are the proximity of pick locations and time windows.

Zoning
The order picking area can be divided into zones as an alternative to single order picking. Each order picker is assigned to pick the part of the order that is in his assigned zone. Possible advantages of zoning include the fact that each order picker only needs to traverse a smaller area, reduced traffic congestion, and furthermore, the possibility that order pickers become familiar with the item locations in the zone. The main disadvantage of zoning is that orders are split and must be consolidated again before shipment to the customer [DLR 06].

2.3 Reverse logistics

2.3.1 Introduction of reverse logistics

What is Reverse logistics?
Traditionally, the main purpose of logistics is bringing resources (raw material, product or related information) from origin to point of consumption. Conversely, Rengel, P. and Seydl, C. [RS 02] indicated that in the case of reverse logistics, the resource goes at least one step back, e.g. from the customer to the distributor or to the manufacturer (Figure 2-15).

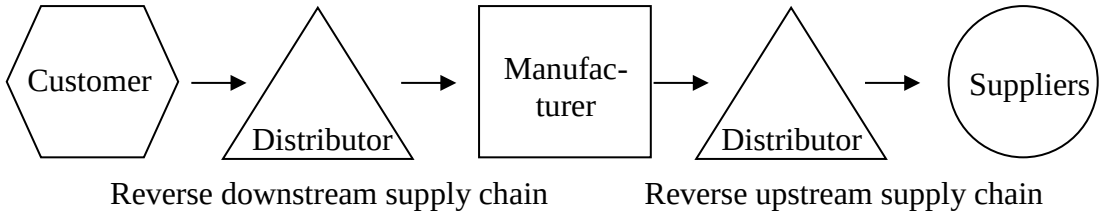


Figure 2-15 An example of a simplified reverse supply chain [RS 02]

According to Kokkinaki et al. [KDVP 01], reverse logistics stands for all operations related to the reuse of products and materials. Bichler et al. [BKKKLLL 02] state that the reverse logistics process includes the management and the sale of surplus and returned equipment and machines from the hardware leasing business.

Reverse logistics is defined as the reverse flow of goods from their typical final destination back to another point. It makes the logistics process not only bring the product to the customer, but also forms a closed loop in the whole supply chain.

Reverse logistics process
According to Marisa P. Brito and Rommert Dekker [BD 04], the reverse logistics processes.

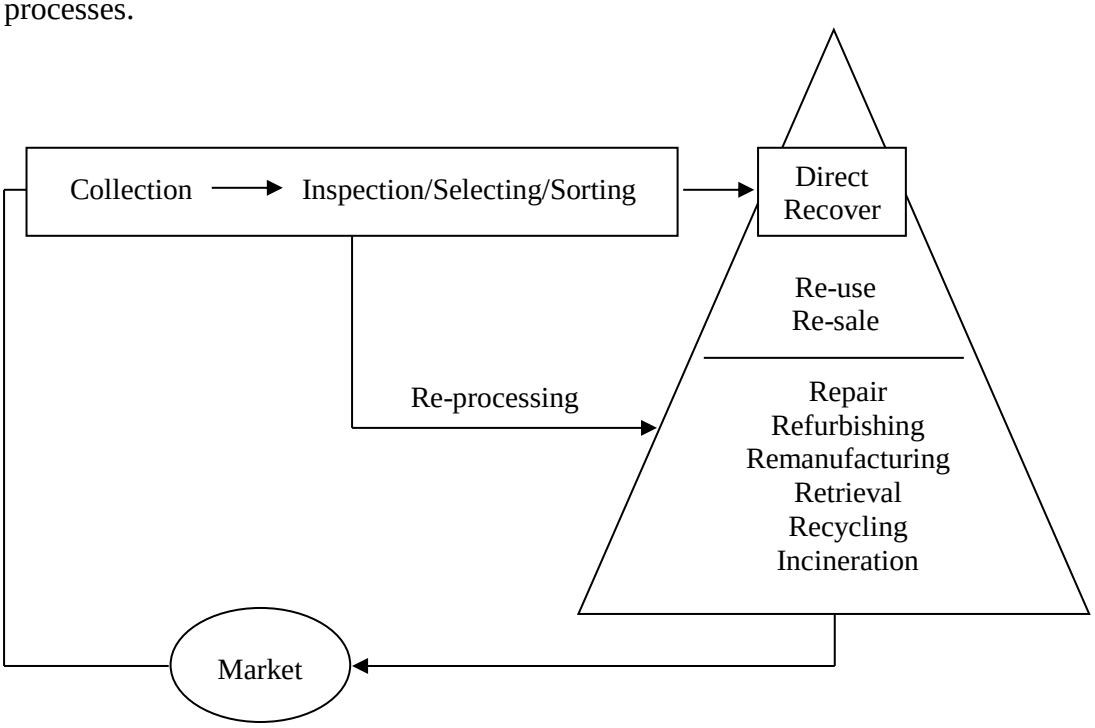


Figure 2-16 Reverse logistics processes [BD 04]

First there is the collection which refers to bringing the products from the customer to a point of recovery. Next there is the combined inspection/selection/sorting process, and, at this point, the quality of product is assessed and a decision is made on the type of recovery. Products can then be sorted and routed according to the recovery that follows. If the quality is as-good-as-new, products can be fed into the market almost immediately through reuse, resale, and redistribution. If not, another type of recovery

may be involved that now demands more action that is called, in other words, a form of reprocessing.

Importance of reverse logistics
During the last few years the rate of product return has increased significantly and companies gradually find that the management of these reverse product stream can still reduce costs, increase revenues and customer service levels. So the importance of reverse logistics has increased over time.

2.3.2 Return happens

No matter what kind of business or product return happens all the time, only the return rate is different more or less. In the offline business, Dekker and Van der Laan [DV 02] mentions that, the average return rate of products is around 10%, while in the online world, the rate is far higher than offline business. Mason [MAS 02], Nairn [NAI 03], Sharma, Wickramasinghe and Singh [SWS 05] and Vigoroso [VIG 01] figure out that, the return rate may reach from 30% to 35% or even higher to 50%, according to the recent market research from Zalando, an online business handler for mode industry.

The driving forces for this situation and rapid growing of returns will be indicated below:

Customer satisfaction
The one important objective, for almost every business, is to provide good products and services to delight customers and retain them. Therefore, allowing customers to return products for a repair, exchange or refund if they are not happy with them, initially, is a basic approach to customer satisfaction.

In recent years, customer protection legislation enacted in many countries allows customers to return products if they are not satisfied with goods ([BD 03]; [DRD 03]; [KS 02]).

Competitive reason
In the late 1980s returns started to spin out of control. This was the time, when many retailers began using returns as a competitive weapon in the battle to win market share. Consumers quickly took advantage of liberal no hassle return policies. Often, retailers were trying to return, even when they knew that the items were older than their return policy allowed. In some cases, retailers took back products that they did not even sell all in order to keep the customers happy [BAY 01].

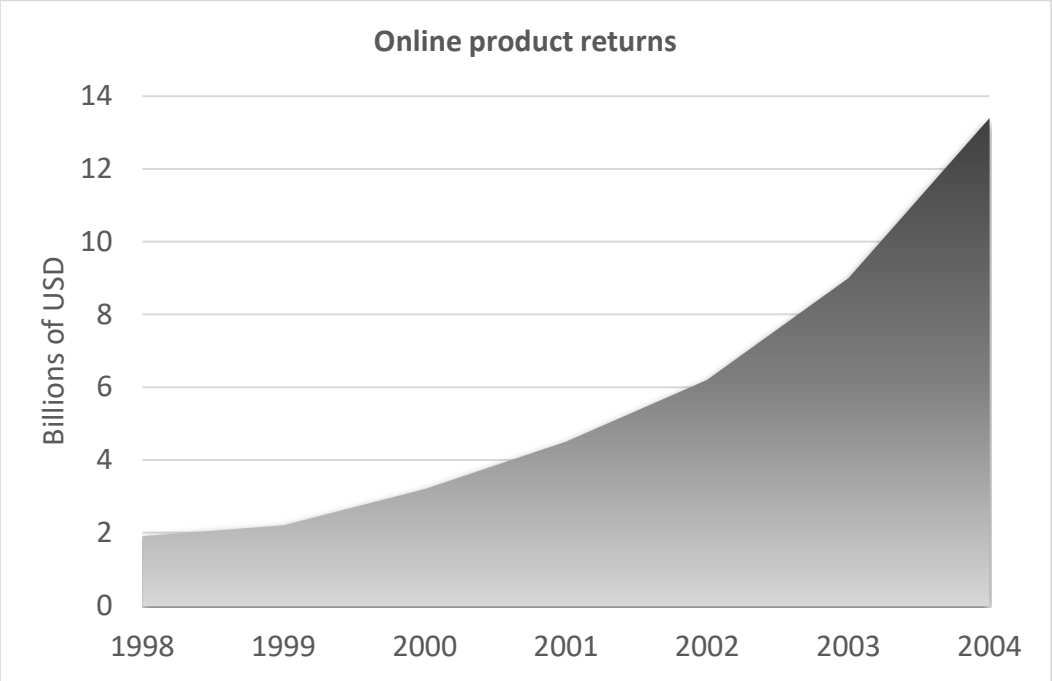


Figure 2-17 Online product returns are skyrocketing [BAY 01]

Online shopping

With the emergence of e-commerce, where customers purchase goods without trying or even seeing them, an efficient return policy is essential ([DRD 03]; [JR 05]; [SMI 05]). Although product descriptions in E-Businesses have improved in the past ([BKWY 02]; [CAG 06]), the rate of return of goods from E-Business is high ([NAI 03]; [SWS 05]).Smith, Bailey and Brynjolfsson [SBB 00] are of the opinion that efficient reverse logistics management is important to increase customer's' trust in E-Businesses. Turban et al. [TKVL 06] are of the opinion that the volume of return in E-Business will increase as sales from E-Business increase. According to Tan, Yu and Arun's [TYA 03] point of view volume of returned products can amount to 30 per cent of total products in the logistics channel of an organization. The volume of E-Business returns is predicted to further increase with the remarkable growth in E-Business sales in coming years [TKVL 06].

2.3.3 Return in e-commerce

According to industry research, return rates for online business are higher than for traditional business. In some business area, return rates may reach up to 40% and they vary significantly by different product category. Detailed return rates are outlined in Table 2-5.

Table 2-5 Selected return rates by merchandise category [BAR 03]

Product category	Return rate
Business products	<1%-5%
Hard-goods gifts	5%-9%
Home décor	5%-10%
High-tech products	5%-20%
Casual apparel	10%-20%
Shoes	10%-30%
Fitted apparel	20%-30%
High-fashion apparel	25%-40%

The return rate in the fashion business via internet is higher than in other segments. According to different online products categories the return reason is also not the same. For instance, apparel and accessories get returns frequently due to unsuitable size, color or model. In contrast, commodity products roughly get returns because of poor quality and electrical products get returns usually due to their performance or did not meet the expectation of the customers.

Although the treatment for returned products requires a lot of labor and financial investment, more and more companies are starting to offer this kind of service, especially in e-commerce. 94% of customers are influenced by an online merchant's return policy [BAY 01], because it not only represents the responsibility of the company, but also guarantees the customer enjoying online shopping without having to worry about other matters. Also, we can optimize the system and avoid serious losses as the returned products may reveal the problem in supply chain and logistic system. The processing of returned products requires cooperation of each member along the supply chain and this put more focus on the information exchange between each other.

2.4 Interaction between logistics and e-commerce

2.4.1 E-commerce promote the development of logistics

In the following table, major characteristics of the company’s e-commerce business model and initial supply chain that impose new requirements on logistics services are listed.

Table 2-6 Comparison of traditional logistics and e-commerce logistics

Logistics Component	Traditional logistics	Logistics in e-commerce
Transportation	Customer to product in the last mile	Product to customer in the last mile
Warehousing	Warehouse with shops delivery	Centralized warehouse with customer delivery service
Inventory	VMI, push strategy	Customer oriented, pull strategy
Order processing	Massive orders with specific shop delivery	Trivial orders with multitudinous delivery destination
Materials Handling	Bulk package, palleted product	Small package
Material flow	Hierarchical	Unorderly und redundancy
Information flow	Regular information exchange	Stochastic customer demand
Financial flow	Long term capital flow	Small denomination with fast circulation

1) Every product is delivered to the end customer in the last mile transportation instead of shop visiting in comparison with the traditional logistic system in retailing business.

2) Shops represent the corporation to the customer. As such they fulfill the function of selling and warehousing goods, complementary to the central warehouse but hinge on a retailing supply chain. On the other hand, the electronic interface represents the selling function where the central warehouse is in charge of the order delivery in E-business. Therefore, the inventory management in the e-branch seems more centralized and customer-oriented and from a strategic point of view, the customer pulls the product from the bottom of the supply chain by ordering the product in advance. In contrast, retailing shops push the products to the market depending on the selling prediction.

   The scale of order processing differs from traditional and e-commerce inventory management even though the basic function of warehouse is rarely different. In retailing sector, the warehouse handles shop orders and this means that it handles various products in great amounts. Correspondingly, the delivery unit is packed normally with pallet. In e-business, orders mostly originate from end customers, are relatively small amounts, specific product type and concrete delivery address, which requires the e-business handler to use a flexible packing unit and suitable delivery vehicle. Sometimes the product is delivered by another service provider such as DHL, DPD etc.

3) As the material flow goes forward through the supply chain, the information flow goes backward from the end node. In retailing business, regular vendor information is collected from the local shops and transferred directly to the warehouse. More stochastic orders and huge customer groups are the basic characteristics of e-commerce.

2.4.2 B2B logistics versus B2C logistics

B2B supply chains have less channels overall and are larger in size whereas B2C supply chains have a larger amount of smaller channels from Figure 2-18, the B2B supply chain settles the upstream until the retailers, where B2C supply chain extends further to the end customers.

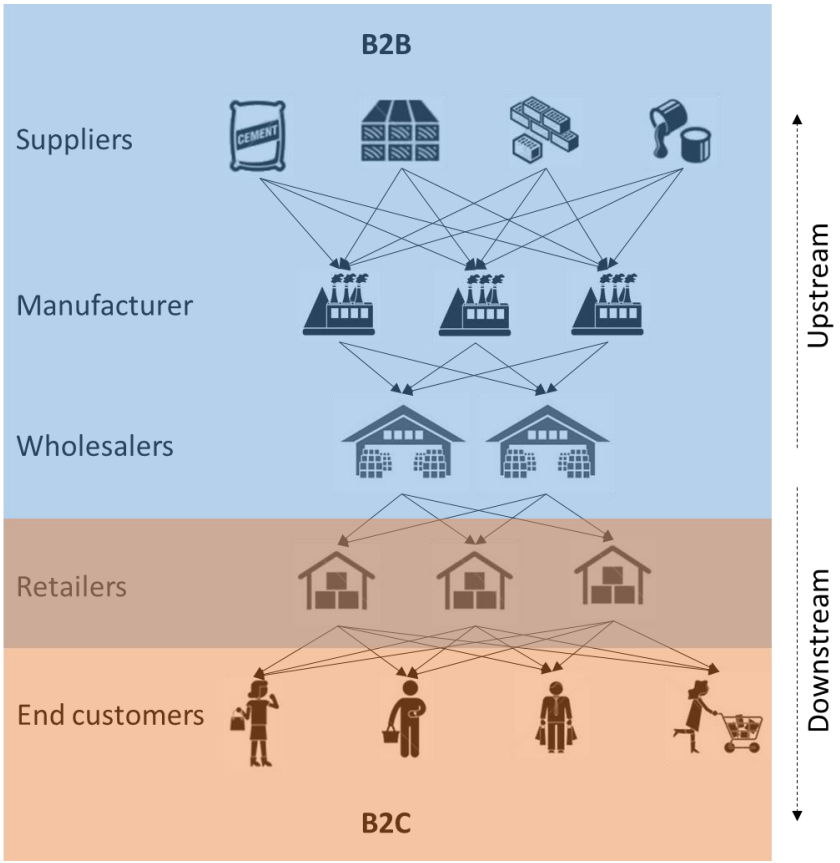


Figure 2-18 The supply chain of B2B and B2C

Chapter 3 Methodology

3.1 Research methodology

Just as no ideal logistical system is suitable for all enterprises, the method for identifying and evaluating alternative logistics strategies can vary extensively [BC 07]. However, there is a general process applicable to most logistics design and analysis situations.

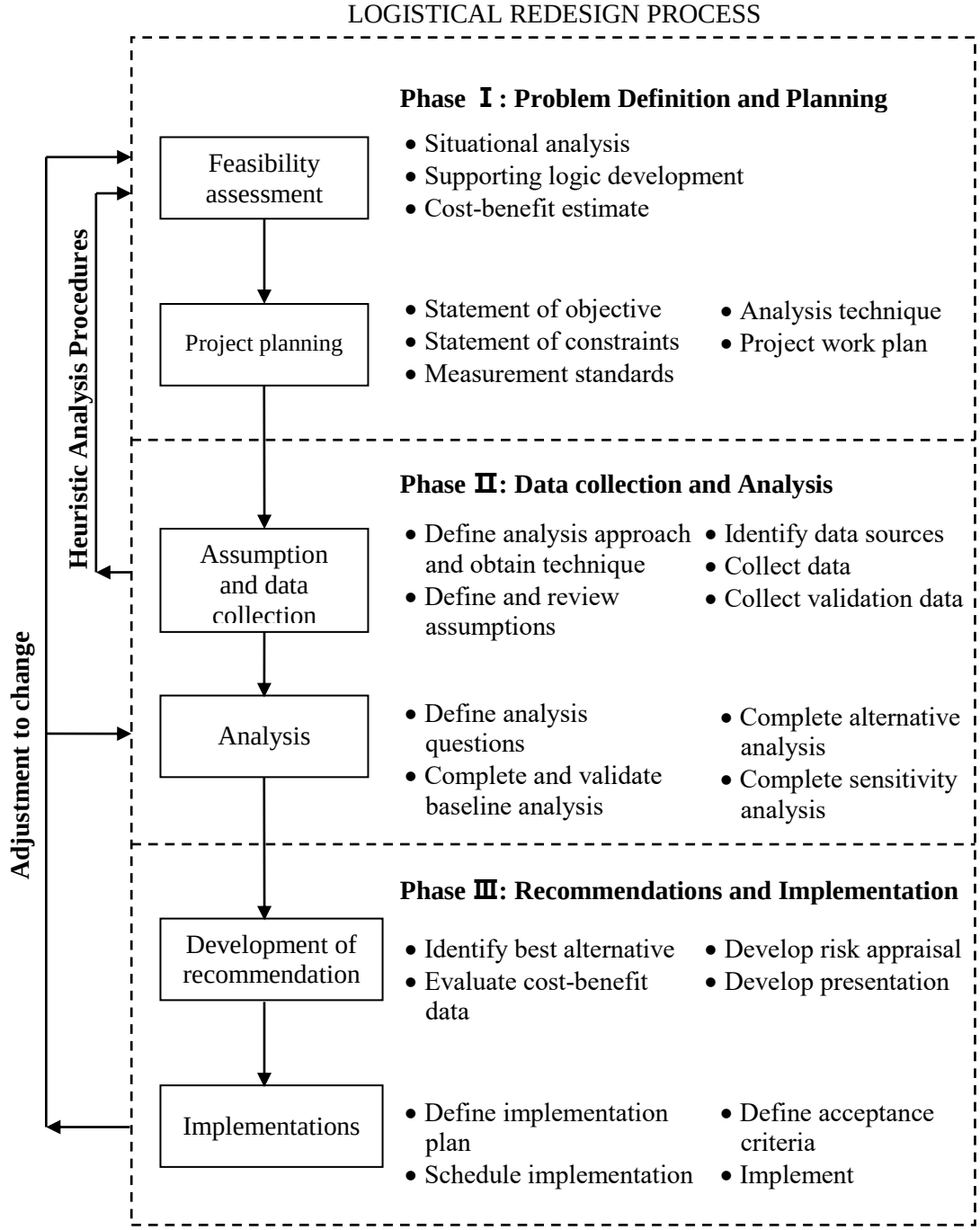


Figure 3-1 Illustrates the generalized process flow [BC 07]

3.2 Research framework

Based on this Methodology, Figure 3-2 illustrates the logistic chain design process flow which will be used.

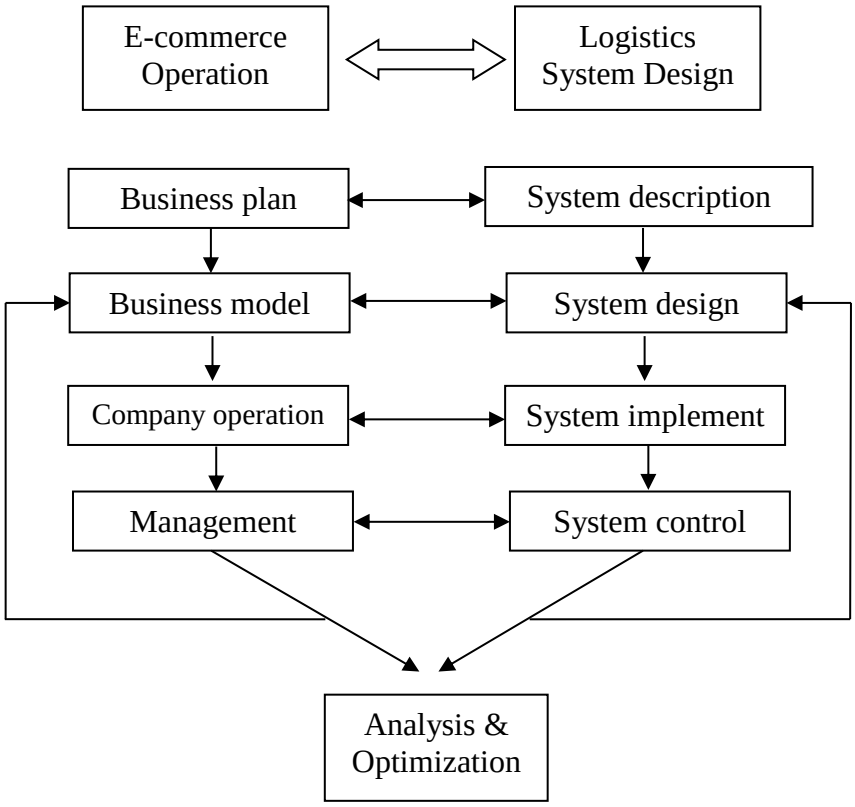


Figure 3-2 Logistic design process in relation to e-commerce operations

3.3 Analysis method

3.3.1 ABC analysis

ABC analysis, Pareto's law or "80/20 rule" are all-synonymous of the same tool which basically states that 20% of a given population represents 80% of a specific characteristic. Pareto analysis (sometimes referred to as the 80/20 rule and as ABC analysis) is a method to divide products, customers or other objects into different groups according to their relative importance.

Table 3-1 Customer service strategy for different customer groups

Customer Group	Describe	Customer service strategy
Group A	5 % of customers that make up 80% of revenue	• Big and wholesale customers, this kind of customers have stable sales record. • Strong connection or integrated in their vendor managed inventory and high priority for product supply.
Group B	15 % of customers that make up 15% of revenue	• Middle-class customers, some of them in retailing business and having their own customers. • Setting up personal relationship and regular information exchange may strength the credit.
Group C	80 % of customers that make up 5% of revenue	• Bottom and end customers, mostly receive information and trade through internet. • Routine newsletter, special offers and information update are suitable means of attractions to win these customers.

In purchasing, the basic ABC analysis is used to identify which segments represent most of the spending in a given category or portfolio. Most of the time, few segments in a portfolio constitute the largest part of the total spending. Usually,

- The A segments represents approximately 80% of the total spending within a category.
- The B segments represents the following 15% of the total spending within a category.
- The C segments are the remaining items which represent the final 5% of the total spending.

The ABC approach can also be used in other analyses such as:

- Spending per supplier in a portfolio: A few suppliers will represent most of the spending.
- Number of orders per supplier: A few suppliers will have most of the orders in a portfolio.
- Number of items bought per supplier: A few suppliers will deliver most of the articles in a portfolio.

Figure 3-3 indicates that the customers in Group A make up 80 percent of total sales but only account for 5 percent of the total number of customers. The next, approximately, 15 percent of customers account for 15 percent of total sales and will be classified as Group B. Finally, Group C is represented by the remaining 80 percent of customers and accounts for only about 5 percent of total sales. After that the customer service strategies can be made differently between groups.

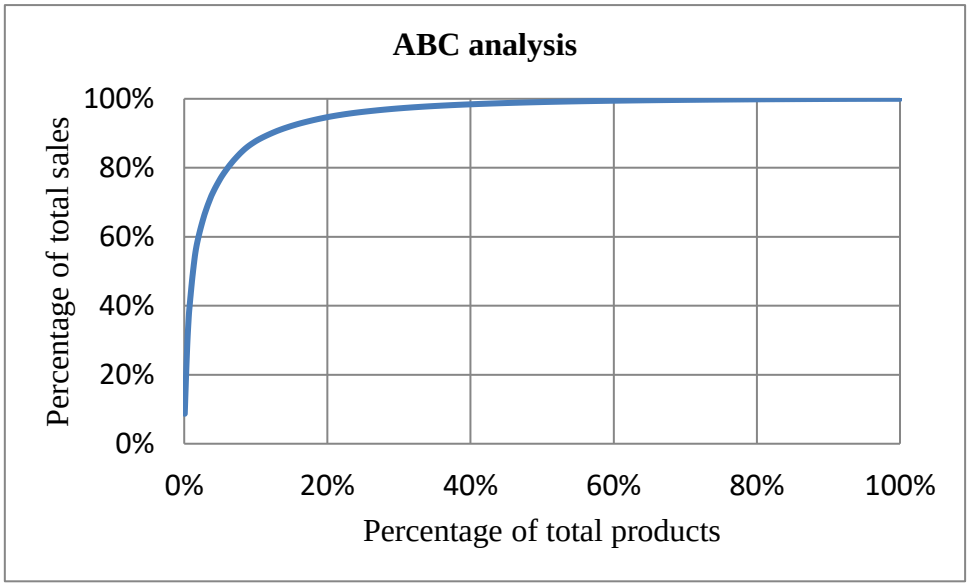


Figure 3-3 The relationship between products and total sales

3.3.2 SWOT analysis

SWOT analysis is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project or in a business venture. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve said objective. The technique is credited to Albert Humphrey and he is the man who led a convention at Stanford University in the 1960s and 1970s using data from Fortune 500 companies [6].

A SWOT analysis must first start with defining a desired end state or objective. A SWOT analysis may be incorporated into the strategic planning model. Strategic Planning, on the other hand, has been the subject of much research.

- Strengths: attributes of the person or company that are helpful to achieving the objective(s).
- Weaknesses: attributes of the person or company that are harmful to achieving the objective(s).
- Opportunities: external conditions that are helpful to achieving the objective(s).
- Threats: external conditions which could do damage to the objective(s).

Identification of SWOTs are essential because subsequent steps in the process of planning for achievement of the selected objectives can be derived from the SWOTs [6].

3.3.3 Vendor managed inventory

Apply VMI with some regular customers in order to reduce inventory. Vendor managed inventory (VMI) is more than just a software application. VMI is easy to explain. Simply put, customers, such as high street retailers, outsource their inventory management to their suppliers [MLB 08].

A holistic view of inventory levels is taken throughout the supply chain with a single point of control for the whole inventory management. A customer is effectively eliminating an echelon in the supply chain by enabling a vendor to manage stock replenishment at their facilities. As a result, upstream demand visibility is improved to reduce the impact of demand fluctuation. Hence VMI can enable the supply to be more accurate and precise in meeting the demand [DT 03].

Although VMI is today centred around an IT solution, the concept of a customer merely defining their requirements and their supplier being accountable for fulfilling them predates contemporary IT [DT 03].

3.3.4 Risk management using FMEA

By definition, the FMEA becomes a systematic technique using engineering knowledge, reliability, and organization development techniques. In other words, teams optimize the system, design, process, products and/or service [STA 03].

Not only online business but also offline business, and even other fields of industry, use FMEA as a tool to identify the risks. It becomes a systematic, proactive method for evaluating a process to identify where and how it might fail and to assess the relative impact of different failures in order to identify the parts of the process that are most in need of change [8].

In this research, a FMEA matrix is further explained by the likelihood of occurrence and impact.

3.3.4.1 Qualitative risk analysis

Once the risks are identified in the business they absolutely need to be assessed or measured in terms of a combination of:

- Likelihood - the likelihood of the risk occurring
- Impact - the consequences if said risk does occur

Using scales of likelihood and impact within a risk matrix will allow you to combine the two separate measures to generate a matrix of risk scores.

Likelihood scale
Three scales of risk likelihood are shown in the table below:

Table 3-2 Scales of risk likelihood

Scale	Likelihood
Low	Unlikely: occur occasionally
Medium	Likely: high probability
High	Almost certain: several times a year

Impact scale
The impact of a risk can be assessed in terms of its effect on:

- Time
- Cost
- Quality

A matrix is setup to match the objective (time, cost, quality) to a defined impact.

Table 3-3 Impact scale matrix

Scale	Time	Cost	Quality
Low	Delay in products delivery within 3 days	< 5% Cost increase	Quality degradation is acceptable or barely noticeable
Medium	Delay in products delivery within one week	5% - 10% Cost increase	Quality may be accepted through mitigation or agreement
High	Delay in products delivery within over one week	> 10% Cost increase	Quality does not meet the following safety aspects, constructability, operability, maintainability

3.3.4.2 Quantitative risk assessment

Step 1: Each identified risk is assessed based on its:

- Probability of occurring and is rated from 1 to 3 based on the Risk Probability Ranking table. The probability remains the same for all three objectives (cost, time and quality) of risk.
- Impact if it does occur, is rated separately for each objective (cost, time and quality) based on the Evaluating Impact of a Risk on Major Project Objectives.

The output of this exercise is, for every risk, a probability and up to three impacts corresponding to the objectives that the risk would impact.

Step 2: Create the Probability and Impact Matrix and choose which matrix layout is appropriate for each objective.

The output from Step 1 is combined to determine whether the activity is high risk (RED), medium risk (YELLOW) or low risk (GREEN) for each objective. Establish a PxI Matrix for each main objective that reflects the project stakeholders' views of what combination of probability and impact makes a risk to each objective low, medium or high.

Use the risk matrix to combine LIKELIHOOD and IMPACT ratings and values to obtain a risk score. The risk score may be used to aid decision making and help in

deciding what action to take in view of the overall risk. How the risk score is derived can be seen from the sample risk matrix and the risk score table shown below. Four levels of risk or score are shown in the matrix and table below.

Table 3-4 Sample risk determination matrix can be used to evaluate the risk when using a three level rating system.

Likelihood				
	High	Medium	High	High
	Medium	Low	Medium	High
	Low	Low	Low	Medium
		Low	Medium	High
			Impact	

3.4 Information processing and logistic system design

From the practice for the practice indicates the relationship between information collected from the logistic system and logistic plan based on this information. The information flow from every aspect, for instance, customers, suppliers or transport carriers determines the business scale and further the corresponding logistic system for physical materials in the unique phases of development for online businesses.

The information related to logistic system design can be generally categorized as follows,

- Article master data
- Customer orders
- Inbound and outbound data

The key figure behind this information can lead to different logistic system designs. For instance, the dimension, weight, and special warehousing demands determines the type of shelves and warehousing conditions. The picking positions and picking strategies must coincide with the volume of customer orders.

In the long run, the development gradually increases and the change of the logistic system is from quantitative to qualitative. The quantitative change happens all the time when the capacity is temporarily reached, and the change is slight and cannot permanently affect the logistic system, but an extension of the existing logistic system. The limits are reached when the geographical or labour resources are no longer able to expand and this triggers the qualitative change of the logistic system. The period of quantitative change repeats from the beginning until the next qualitative change as the new logistic system is online. The quantitative and qualitative change is the developmental power of the logistic system.

3.5 Strategic simulation model

Simulation is considered as one the best tools for logistic planning. Mostly the simulation model is used for material flow simulation. Principally, the simulation model handles the objects and records the processing time while the objects are going through the system and therefore, in this case, the strategic model is considered to simulate the picking process. The picking performance can be understand as the processing time of the orders and the pickers are known as processing machines. The model can be easily setup with the simulation software Dosimis-3 and this can then be modelled with building blocks. The parameter of the building block can be given in regards to the customer information.

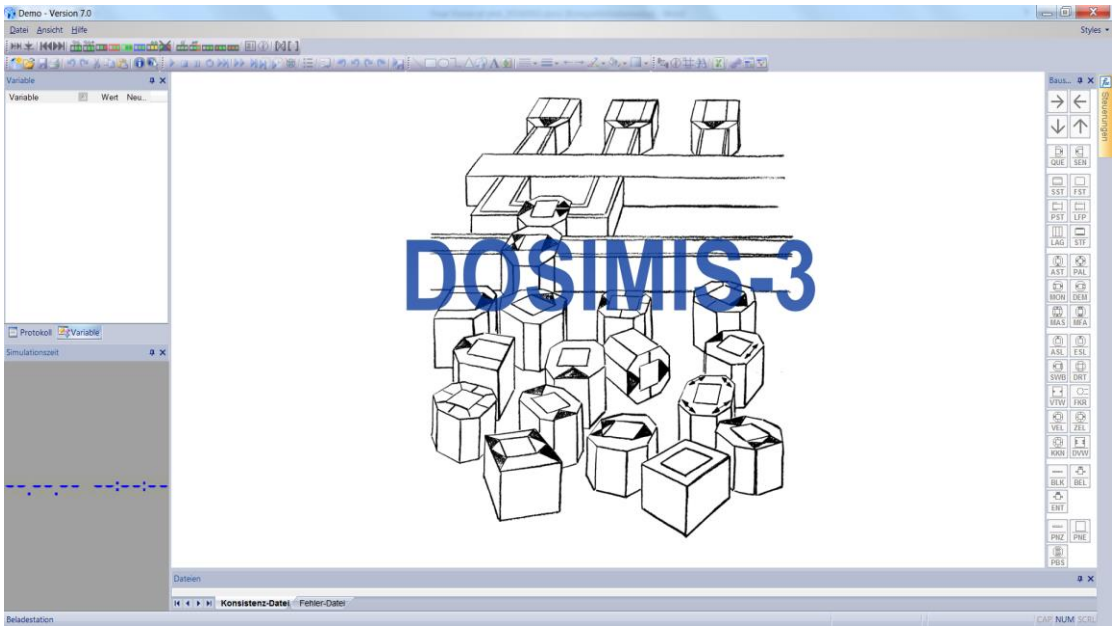


Figure 3-4 Simulation software Dosimis-3 [SDZ 18]

Besides the simulation model, the customer order as input data can be loaded into the model.

Some experiments are possible by adjusting the simulation parameter based on the strategic simulation model. To give a few examples, the number of pickers, the picking strategy, the batch size, etc. The strategic simulation model also delivers statistics, for instance, the utilization of pickers, the throughput time of order, and all of these are useful for the decision maker to choose the suitable picking strategy.

Chapter 4 Design concept of logistic systems for online business

A simple concept is to buy and to sell products through the internet trading platform when talking about online trading companies. There are no more technical barriers for someone who wants to buy or sell private products online. All of this is thanks to online trading platforms as they deliver the trading service for the internet users.

On the other hand, even for professionals, it is not possible for everyone to be successful in online trading. This is because we do not see what is behind the trading and it is a complete business structure, different from other business structures, but not completely new. In particular, it is a challenge of logistic system.

The virtual business cannot be built on nothing as the profits are made online, and the materials are always transferred offline under control by tracking and tracing systems. Therefore, in a sense, the logistic system for online business is similar to the traditional trading shops in some aspects, but the internet interface accelerates the trading processes and forces the material and information flow to move faster and more individually. This weakens the function of local shops and strengthens the function of a central warehouse.

This chapter will discuss several aspects of logistic systems. While many topics are similar, the online businesses brings new concepts to the fore. A general concept for the design of an online shop for the retail of pieces will be developed in the following chapters.

4.1 The decision making of product selection

4.1.1 E-business and product structure analysis

Logistics service is attached to products and, without products, logistics cannot exist. Therefore, a comprehensive understanding of the product is indispensable before the logistics system is designed. An appropriate mode of transport, storage equipment, and inventory strategy are to be decided in consideration of its special feature. In the meantime, logistics system configuration and capital investment should be compatible with the scale and development status of the company. This chapter starts from the premise of product and company analysis based on the above considerations, and later declares the focus and goal of the logistics system design.

Ballou [BAL 92] considers that the design of a logistics system should be based on four business areas. The first deals with customer service levels. Logistics customer service includes the availability of the product, the time that is required by a customer to receive the product, the condition the product is in when it is received, and the accuracy of filling the customer's order. The second area deals with the location of facilities and the demand allocated to them. The third deals with inventory policy and the fourth with transport decisions. It is apparent that all four of these critical areas are economically interrelated and should therefore be planned collectively.

Basically, each single product has a life circle that goes from design idea to mass production, and from manufacturer to end customer. Nowadays life cycles tend to be

shorter, and products are exposed to continuous changes (e.g. updates and versions). Each kind of product also has its customer group and these can range from kids to pensioners, from fashion people to classicist. The product classification can be further refined to deeper levels and, depending on different criterion and disciplines, the product structure can be totally different, so as to be desired by its customer groups and trading goals.

Table 4-1 Example of product structure leads to different customer group and desired trading goals

Classification criteria	Product structure	Customer group	Trading goal
Technology	High tech	Business, higher income	High profit, low sales
	Low tech	e.g. Students, low income	Low profit, steady increase
Fashion	Seasonal	Middle or young age	Seasonal growth
	Classic	Business or old age	All year sales

Nowadays, almost all kinds of products can be found in the internet for trading, and e-business providers are generally classified by the trading products or business scale, such as B2B, B2C companies and even C2C.

The decision making of products for trading is basically driven by the market, where there is a demand, there is a market. A general market survey is helpful for the companies to understand the customer.

Table 4-2 Survey of package flow in e-commerce depends on product categories [3]

Product category	in %
Clothing	18%
Entertain and electronic	11%
Books	10%
Housewares	6%
Hobby and recreation	6%
Computer and accessories	6%
Furniture and decoration	4%
Video and audio recording	4%
Medicine	3%
DIY and flower	3%
Shoes	3%
House and home textiles	3%
Food and wine	2%
Jewelry and watch	1%

Table 4-3 Survey of package flow in e-commerce depends on business scale [3]

Business scale	in %
B2B	39%
B2C	48%
C2B	7%
C2C	6%

And many other factors should also be taken into account to make a better decision of products for trading. Besides all the rational analysis, that are no different from traditional shops, some emotional factors still dominate the decision making, which can totally lead to the success or lose of the business.

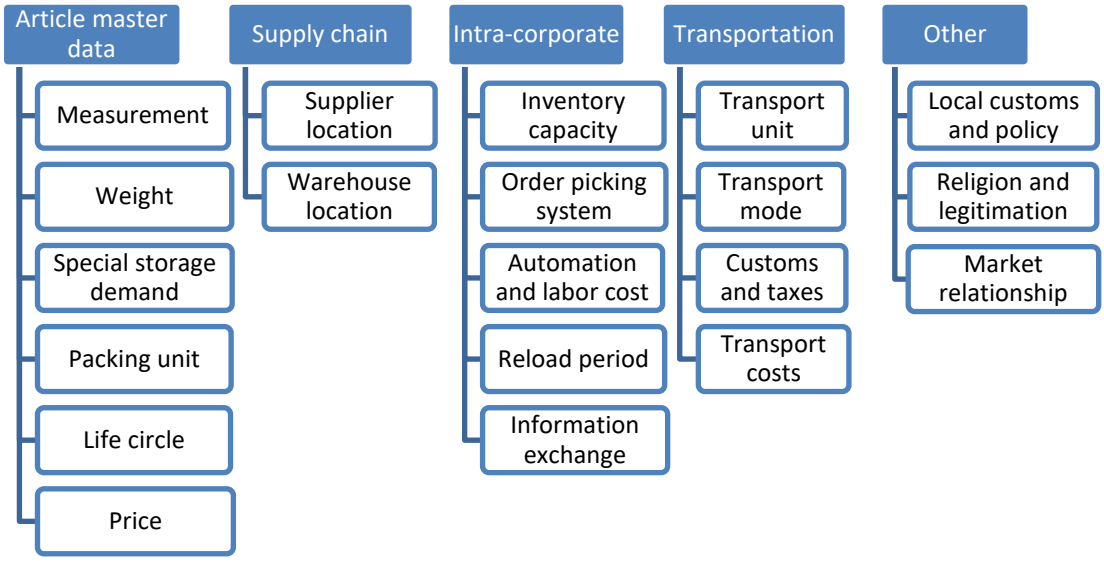


Figure 4-1 Critical factors of products for trading

Figure 4-1 illustrates the critical factors of products for trading in 5 main categories. First, the basic information of products which represents the product attribute, packing and handling unit, price, etc. determines the storage condition, for instance, cool and frozen article must be restored under the suitable temperature, small and expensive article must be secured. Based on selling records and supplier deliveries, the warehouse needs to be carefully planned, for instance, inventory capacity, internal logistic transport technology and labour. Another important external logistics aspect, along the supply chain, a determination of warehouse location, suppliers choose critically affects the transport strategy and further the transport cost. At last, the local factor is also important for trading, such as local trading platform, customs and taxes, etc.

In general, the product structure is coupled with a long-term product analysis which directly or indirectly reflexes the demand of the market based on which, an adjustment can be made to adapt better to the market. On the other hand, different phases of corporation development have a different product structure, either a wider product structure or a focus on specific products.

4.1.2 Product spectrum and the product line depth

The product selection for online business has no limit. In other words, the product can be bought offline, and can be sold online. However, a successful product selection is a balance of product spectrum and product line depth as well as a balance of general products and special products. The products can be selected depending on many criterions in relation to the desired target market.

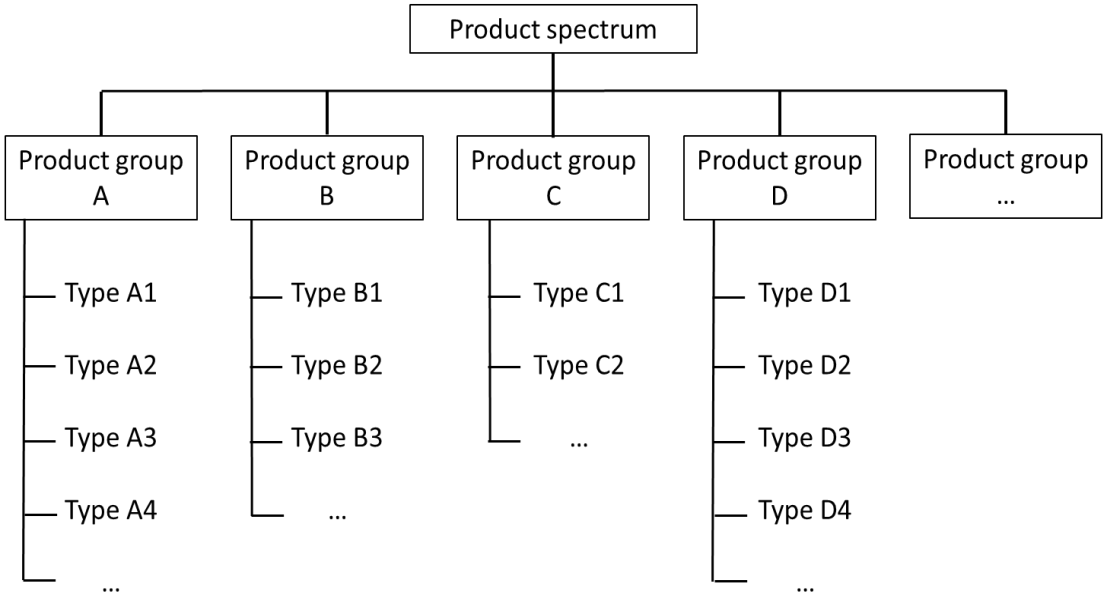


Figure 4-2 Example of product spectrum and product line depth

From Figure 4-2, in the horizontal direction, a comprehensive product spectrum consists of many product groups and these are relatively independent to other product groups and related to the business focus. In each individual product group, a variety of products of different types can attract potential customers and therefore a clear product structure along the product spectrum can strengthen the business' competitiveness. For instance, an electronic hardware company provide many product groups, such as mobile devices, PC and office devices, household devices, entertainment devices with different price levels, brands and performances in each product group to satisfy more customers' demand.

For local physical shops, the product selection is sometimes restricted to the spare rooms, and for online business, without the said special restriction in online shops, the invisible regulation works and determines the success of online businesses. The development of the product line for online businesses is the development in width and depth. In the vertical direction, it is always good to have a comparison from its kind, but, on the other hand, too many options could lead to confusion and high inventory.

The large number of particular or low-demand products that generates a low sales rate is categorized as a "tail" in the business model. The long tail theory was introduced in 2004 by Chris Anderson (editor of Wired magazine) and resulted from an essay written by Clay Shirky (a specialist in new information and communication technology) [CAD 15]. The long tail happens in traditional shops as well as in e-commerce branch. The long tail does not generate more sales than before even with the advantage of the internet. Will Page, the director of Sporty, analyzed online music sales. He noted that

of the 13 million titles available: 10 million do not generate any sales, 8% of sales come from 40 titles and 3% of the total sales generated 80% of the turnover [CAD 15].

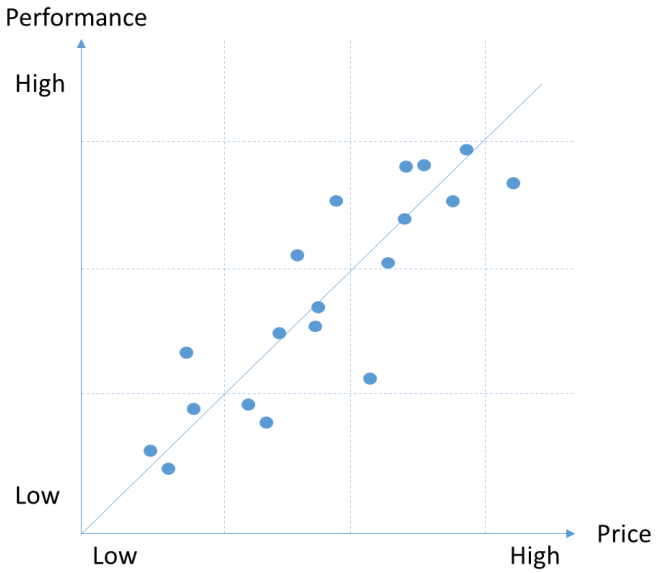


Figure 4-3 Balanced product selection in price performance ratio

In Figure 4-3, a schematic example of balanced product structure illustrates the product distribution in the performance-price diagram. Each point, which represents a product with price and performance coordinate, is evenly distributed along the middle line. Its attraction to the potential customers reaches from low performance expectation to high performance expectation and from low price budget to high price budget under this product structure.

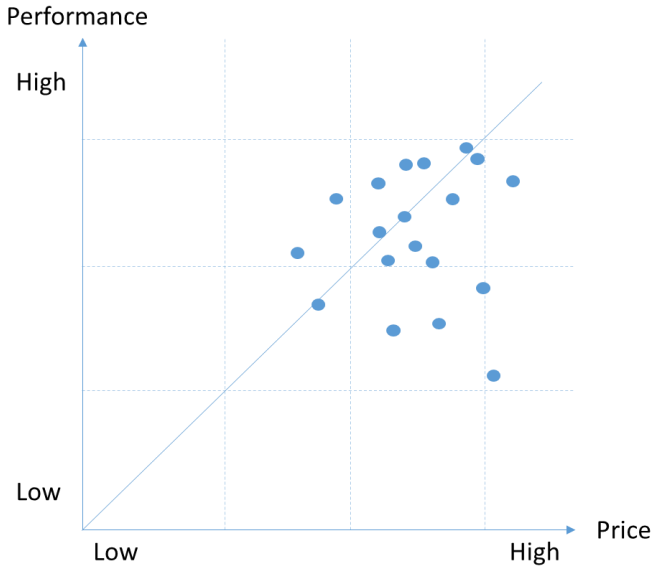


Figure 4-4 High level customer oriented product selection

Another product structure is shown in Figure 4-4. This business criteria focuses on high price and high performance products and is obviously located at the upper side of the diagram. The desired customer group focused on high performance expectation and high price budget.

The position of each product in these figures represent the price performance ratio and these are two basic factors for potential customers searching for desired products. The wider the distribution in both directions spreads, the more attractive the product line is. Therefore, how to fulfill the product structure in online business to satisfy more customers is important to determine the success of the business.

A concrete business model is introduced to illustrate the importance of product structure and how to optimize or strengthen the business model by adjusting the product structure in the following sections.

4.2 The development of service level

The service level is an invisible scale to measure the business through the satisfaction of the customers which cannot be contacted face to face as in online business. Therefore, how to react with the customer orders is a direct way to reflect the service level.

Each enterprise has its own criteria to measure the service level and tries to figure out the indicators. So far on the market, there is barely a black area in online business. In relation to the order fulfillment to customer online support and from express order delivery to return service, in the background the logistic system plays an important role in supporting the improvement of service level in the field of warehousing, procurement and delivery. Among many indicators of service level, the following figure shows the three important indicators to measure the service level.

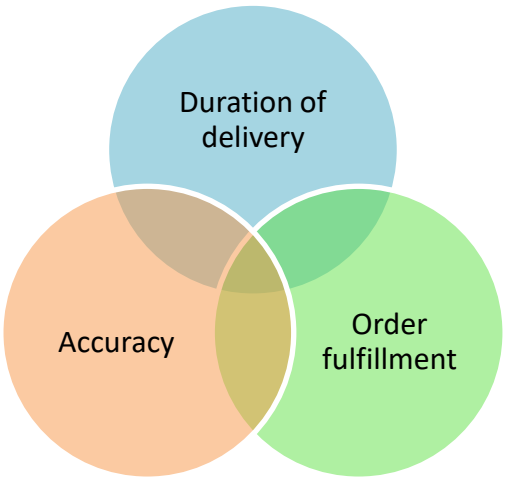


Figure 4-5 Important indicators to service level

Some theories pointed out that the service level can be defined as orders delivered on time. An example introduced by Simchi-Levi and Kaminsky about a Korean manufacturer of electrical products is facing a service level of about 70 percent. That is, only 70 percent of all orders are delivered on time [SKS 08]. On the other hand, inventory keeps piling up, and contains mostly products that are not in demand. Most analysts would have said that these two objectives, improved service and inventory levels, were impossible to achieve at the same time. Indeed, traditional inventory theory tells us that to increase service level the company must increase inventory and, as a result, increase cost. Surprisingly, recent developments in information and communications technologies, as well as a better understanding of supply chain

strategies, have led to innovative approaches that allow the company to improve both objectives simultaneously.

4.2.1 Duration of delivery

The first indication of a high service level for the customers is if the product can be delivered as soon as possible. 10 years ago, we would have been very happy if our present had been delivered from the internet shop in 3 day. Today the express delivery service can make it in 3 or 4 hours. The improvement happens obviously, efficiently and gradually. Nowadays, the next day delivery is no longer a priority. Many online shops offer a same day delivery or even a 4 hours express service. The competition for market shares pushes the logistics to transfer the material from A to B in a critical lead time situation. In order to achieve the high service level, the distance from the local customer to delivery center has to be extremely reduced.

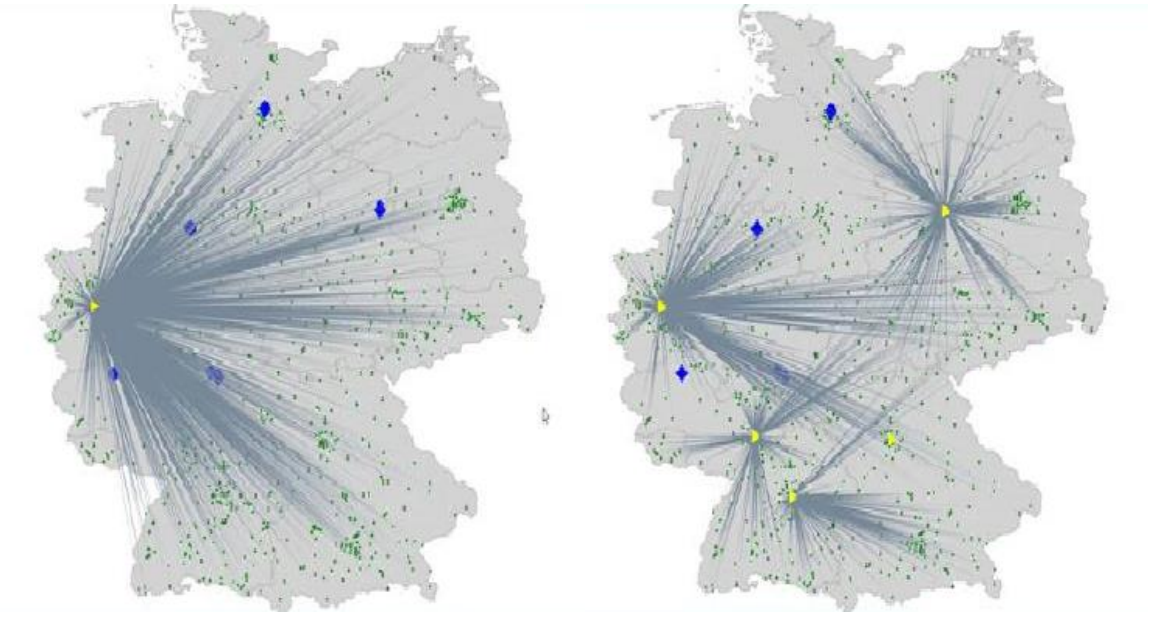


Figure 4-6 Warehouse location in consideration of delivery time

The following example explains the consequences. In the left part of the Figure 4-6, the lower service level for delivery in two days needs only one delivery center, but the higher service level in the right figure needs four decentralized warehouses close to local customers.

Decentralized warehouses can indeed shorten the transport distance and further have also great influence on the service level. In another aspect, where Simchi-Levi and Kaminsky mention the impact of customer aggregation as well as product aggregation [SKS 08]. The great number of customer demand points can be aggregated down to several customer zones which are based on where the location of warehouse can be optimized.

The discussion on certain groups of products leads to another direction of the supply chain structure. As an example, for electronic hardware companies the sales record has a different trend between new devices and consumables such as disks and printer

cartridges. Under this condition, a sort of special warehouse for consumables and spare parts can be divided from the other warehouse where the supplier delivery frequency can be different.

In principle, the order throughput time can be described as follows:

Order throughput time = order receiving time + order processing time + order delivery time

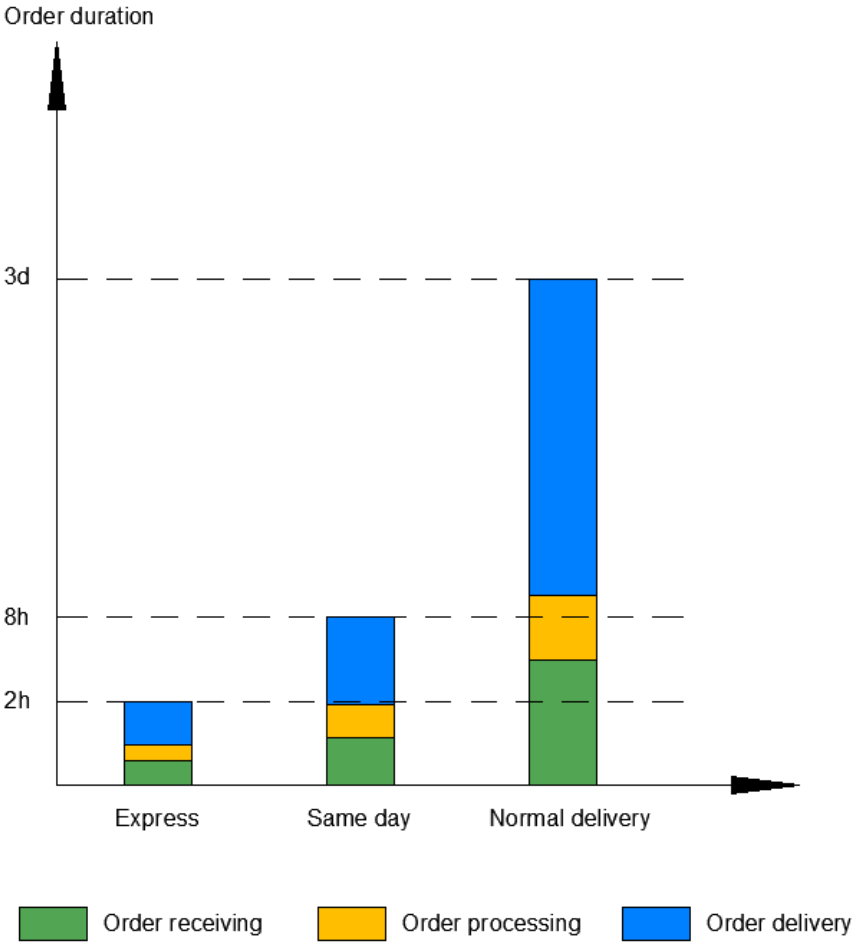


Figure 4-7 Order throughput time for different delivery strategies

Order receiving means the time starts once the order goes from the customer to the online shop up to the start of the order processing. Generally, the customer orders received are collected in an order pool and will be processed until the pool capacity reaches the limit or pool building time has gone up.

Order processing time means the time starts from the generation of the order picking list to the end of the order packing.

Order delivery time means the time starts from the finished order in temporary storage area to the order delivery to the customer or parcel station.

The e-business giant Amazon launched the books category in Germany in Oct. 1998 and after that more and more shopping categories were available to European customers. Besides a large diversity of product selection, Amazon also engages in better services. The key to achieving international e-commerce success lies in understanding one simple fact: customers everywhere want better selection, more convenience, and better service [PIA 04]. In these years, Amazon develops its delivery service from normal delivery to next day delivery for prime customers and further express delivery service in some cities like Berlin and Munich where the customers can get the products in less than two hours after sending the order.

The express delivery should minimize the order throughput time in two ways. Apparently, the shorter the delivery distance, the shorter the delivery time and therefore, the concentration on the delivery resort and its cover district is an efficient method.

The classic delivery zone for local warehouses follows roughly the postal code. In the Figure 4-8, the dark orange area is for and where delivery in one hour is possible and the light orange area for two hours. The address should normally be checked before delivery to check if and in which category express delivery is available.

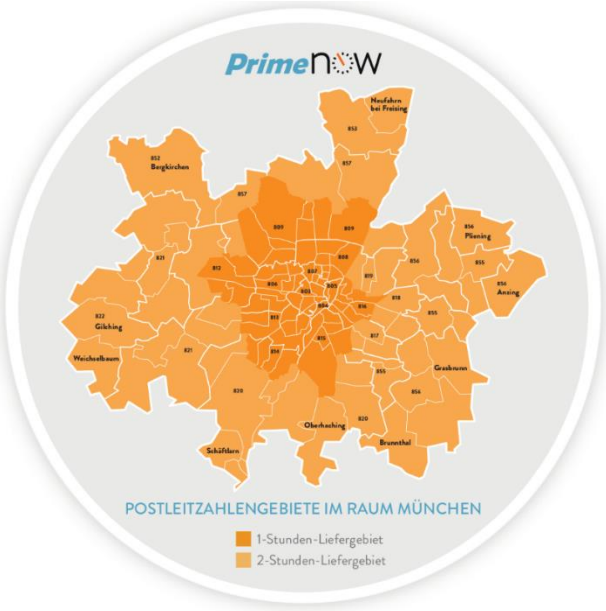


Figure 4-8 Amazon prime now provide express delivery in 2 hours window after postal code in Munich [9]

Another time factor in express delivery is the order throughput time in the warehouse which includes order preparing time and order processing time. To illustrate the throughput time, a strategic simulation model will be introduced with one day customer orders.

A simulation model of order throughput time can build-up depending on different order processing strategies. The simulation software Dosimis-3 can be used here to set up a strategic order picking model. The components of this model contains some basic modules:

Order loading: the entrance of customer order depends on different strategies and the customer order can be read each hour or each day.

Accumulated order pool and order batch building: the customer's orders are collected in this order pool. An order batch with a specific batch size is built in this order pool. As an example, 3 orders which possibly have one or several common picking positions are built as 1 order batch in order to minimize the repetition of the same picking positions and further the order picking time.

Order processing: the number of order picker and the processing performance are set up in this area. The order batches are loaded dynamically and depend on the processing parameter. The orders are processed one after another.

Order finished: the customer orders are accomplished and leave the simulation model and the throughput of customer orders are recorded from the entrance to the end of simulation model.

The simulation model as explained can be build up as follows:

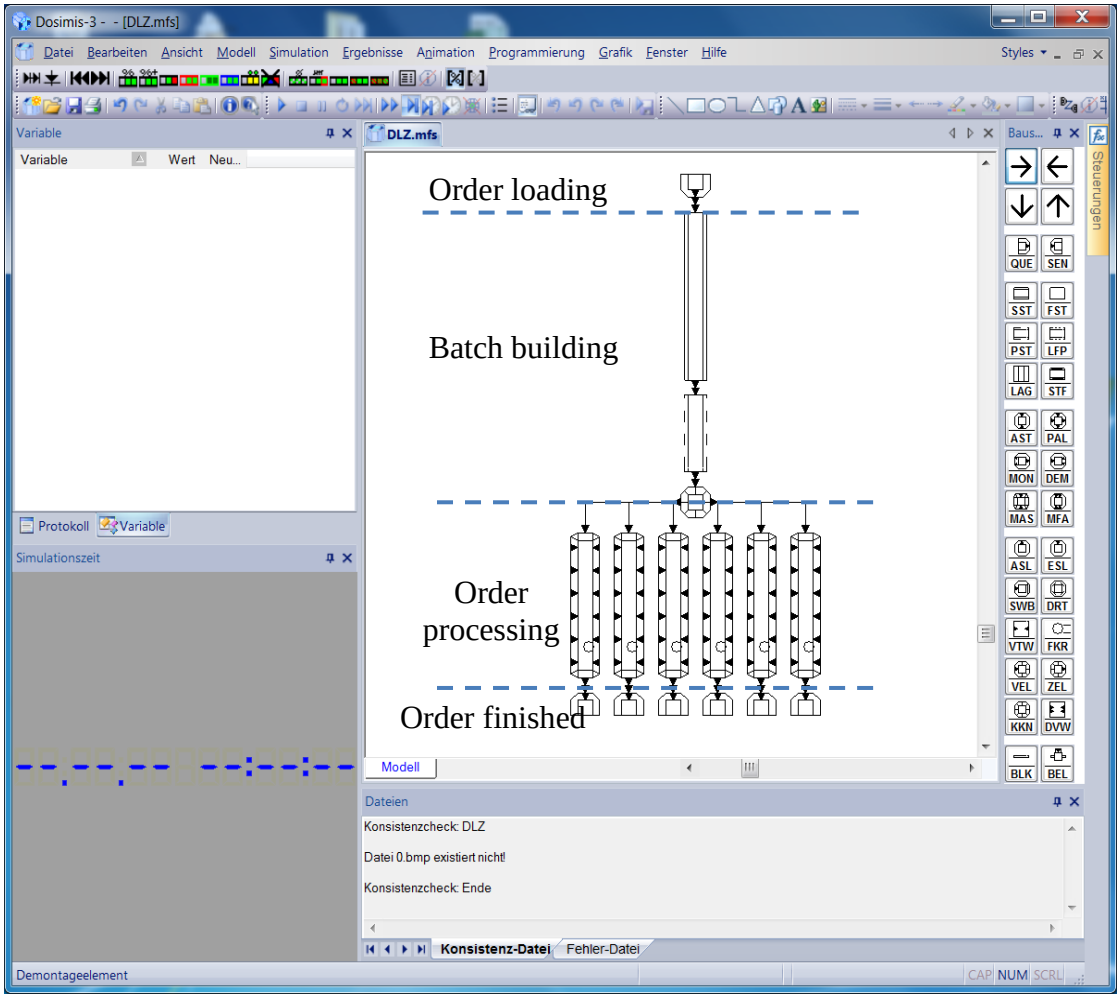


Figure 4-9 Simulation model of order throughput time

Input data: the format of the customer order are sorted by time with the information of order number, article number and amount. For example, a list of customer order as input data is listed below:

Table 4-4 Example table of input data

Order number	Article number	Amount	Date	Time
108222	374631868	1	20.03.2014	08:12:52
108500	769762868	1	20.03.2014	08:26:02
108507	967845868	1	20.03.2014	08:27:13
108580	175580869	5	20.03.2014	08:30:14
108579	129875043	2	20.03.2014	08:30:32
108614	866504868	2	20.03.2014	08:32:48
108545	471806868	1	20.03.2014	08:33:05
108629	125656043	4	20.03.2014	08:33:48
108544	715649868	2	20.03.2014	08:33:59
108556	481769868	1	20.03.2014	08:35:24
108467	109805043	1	20.03.2014	08:37:53
108469	645158868	1	20.03.2014	08:38:23
108571	98178868	1	20.03.2014	08:38:44
108463	859266868	1	20.03.2014	08:42:14
108542	644764868	1	20.03.2014	08:42:34
108586	774461868	5	20.03.2014	08:45:10
108480	664600868	1	20.03.2014	08:46:07
108480	664651868	2	20.03.2014	08:44:57
108480	667119868	3	20.03.2014	08:44:15
108601	737805868	1	20.03.2014	08:46:50
108604	125657043	10	20.03.2014	08:47:53
108616	93684868	2	20.03.2014	08:48:27
108561	97666043	1	20.03.2014	08:46:43
108561	189718868	2	20.03.2014	08:47:36
108561	827527868	4	20.03.2014	08:49:45
108539	402558868	1	20.03.2014	08:49:47
108613	123556043	1	20.03.2014	08:53:06

Order processing: in this example we define six order pickers to handle the customer order, and each picker can take 60 positions per hour.

Experiment: some experiments with different model parameters are simulated in this strategic model. The parameters are shown below:

The key parameters are pool period, order picking strategy, batch size and number of pickers. The customer orders are collected in an order pool. The longer the pool period, the more orders that can be collected. The picking strategies can be made based on the collected orders. In this simulation model, two different picking strategies are integrated and these are single order picking and multi order picking. In single order picking strategy, the customer orders are sequentially handled and therefore, the batch size is always 1. In this case, the number of pickers is introduced as another parameter. In multi order picking strategy, the customer's orders are parallely handled. In this case,

the batch size is a variable and the bigger the batch size, the more orders are picked at the same time. In other words, the orders in one batch are combined as a super order. The repeated order lines in these orders are summed up in one order line and this directly avoids repeated visits for the same picking position.

Table 4-5 Experiment parameter overview

Experiment	Pool period	Order picking strategy	Batch size [order]	No. of picker
1	24h	Single order picking	1	1
2		Single order picking	1	3
3		Single order picking	1	5
4		Multi order picking	3	5
5		Multi order picking	6	5
6		Multi order picking	12	5
7	1h	Single order picking	1	1
8		Single order picking	1	3
9		Single order picking	1	5
10		Multi order picking	3	5
11		Multi order picking	6	5
12		Multi order picking	12	5

Picking positions can be saved through different batch sizes. The following table shows an example of how the picking positions are reduced by batch building.

Table 4-6 Comparison of position without batch building and with batch size 3

Order number	Article number	Amount	Batch number	Article number	Amount
1	1000	3	1	1000	8
1	1001	2	1	1001	2
1	1002	4	1	1002	9
2	1000	5	1	1004	3
2	1004	3	1	1005	1
3	1002	5	1	1006	2
3	1005	1	1		
3	1006	2	1		
Sum	8	25	Sum	6	25

Table 4-7 Comparison of position without batch building and with batch size 6

Order number	Article number	Amount	Batch number	Article number	Amount
1	1000	3	1	1000	13
1	1001	2	1	1001	2
1	1002	4	1	1002	9
2	1000	5	1	1004	3
2	1004	3	1	1005	8
3	1002	5	1	1006	2

3	1005	1	1	1007	2
3	1006	2	1	1010	3
4	1010	2	1		
5	1000	2	1		
6	1000	3	1		
6	1005	7	1		
6	1007	2	1		
6	1010	1	1		
Sum	14	42	Sum	8	42

Table 4-8 Comparison of position without batch building and with batch size 12

Order number	Article number	Amount	Batch number	Article number	Amount
1	1000	3	1	1000	13
1	1001	2	1	1001	2
1	1002	4	1	1002	12
2	1000	5	1	1004	6
2	1004	3	1	1005	8
3	1002	5	1	1006	2
3	1005	1	1	1007	11
3	1006	2	1	1008	2
4	1010	2	1	1009	2
5	1000	2	1	1010	9
6	1000	3	1	1011	6
6	1005	7	1	1012	1
6	1007	2	1	1020	2
6	1010	1	1	1022	7
7	1008	1	1		
7	1020	2	1		
8	1002	3	1		
8	1022	4	1		
9	1004	3	1		
9	1007	9	1		
10	1010	2	1		
10	1022	3	1		
11	1008	1	1		
12	1009	2	1		
12	1010	4	1		
12	1011	6	1		
12	1012	1	1		
Sum	27	83	Sum	14	83

In this example, there are 27 order lines in 12 orders and this means 27 picking positions without batch building. On the contrary, with batch building, the same article can be combined in one batch to reduce picking positions and a bigger batch size means more of the picking position can be saved. Therefore, we know that the positions are reduced by batch building, depending on which picking positions are recounted for batch size

3, size 6 and size 12. In Table 4-9, the first row represents the total order lines in each situation. The other figures will be introduced in the following paragraph.

Some formulas and relations to calculate the picking performance of different batch size, are explained as follows:

Let:
Pos = Total order lines
T_{Sum} = The total order picking time in %
T_{Basic} = The basic time of order picking in total order picking time in %
T_{Travel} = The travel time of order picking in total order picking time in %
T_{Pick}= The pick time of articles in the order list in total order picking time in %
T_{Dead} = The dead time in total order picking time in %
P_{Rel} = Relative performance in comparison with itself
P_{Abs} = Absolute performance in comparison with reference
T = Time consumption for all picking positions
n = Batch size

The total order picking time can be described as the sum of different times:

$$T_{Sum} = T_{Basic} + T_{Travel} + T_{Pick} + T_{Dead} \tag{4.1}$$

As reference, T_{sum} can be assumed as 100%, so that the travel time for batch size n can be calculated as follows,

$$T_{Travel\ batch\ n} = \frac{T_{Travel\ ref} \times Pos_{Batch\ n}}{Pos_{Ref}} \tag{4.2}$$

So as for the dead time,

$$T_{Dead\ batch\ n} = \frac{T_{Dead\ ref} \times Pos_{Batch\ n}}{Pos_{Ref}} \tag{4.3}$$

and the relative performance for batch size n can be calculated with the following formula,

$$P_{Rel\ batch\ n} = \frac{P_{Ref}}{T_{Sum\ batch\ n}} \tag{4.4}$$

The time consumption of each batch size n can be calculated as follows,

$$T_{Batch\ n} = \frac{Pos_{Batch\ n}}{P_{Ref\ batch\ n}} \tag{4.5}$$

Therefore, the absolute performance for batch size n can be calculated as follows,

$$P_{Abs\ batch\ n} = \frac{Pos_{Ref}}{T_{Batch\ n}} \tag{4.6}$$

The calculated value using the formulas above can be filled in the Table 4-9. So that the absolute performance with the different batch size can be compared.

Depends on the experimental data, the original customer orders have in total 3115 order lines. With different batch size 3, 6, 12, the total order lines can be reduced to 2750, 2624, 2546 through static calculation.

The amount of customer orders is the same even though the batch size is different. Therefore, we assume the basic order picking time for each single customer order stays constant for all batch sizes. So as for the picking time, an assumption is made that the gripping time for each single article stays constant and the article can be gripped once per pick. Under this assumption, if the total amount of articles were not changed, the total picking time stays constant despite batch building.

Table 4-9 Picking performance of different batch size

	Reference	Batch size 3	Batch size 6	Batch size 12
Pos	3115	2750	2624	2546
T_{Basic}	35,0%	35,0%	35,0%	35,0%
T_{Travel}	12,0%	10,6%	10,1%	9,8%
T_{Pick}	36,0%	36,0%	36,0%	36,0%
T_{Dead}	17,0%	15,0%	14,3%	13,9%
T_{sum}	100,0%	96,6%	95,4%	94,7%
P_{Rel}	360	373	377	380
T	8,7	7,4	7,0	6,7
P_{Abs}	360	422	448	465

Result:
The goal of these experiments can be explained in two aspects and these are time and cost. For express customer orders, the time factor seems to be more important than the cost. Yet, on the other hand, normal customer orders have the labour cost for order picking be the focus.

In the following paragraph, the detailed explanation and experiment result of order throughput time and utilization of order picker per shift are discussed.

Throughput time:

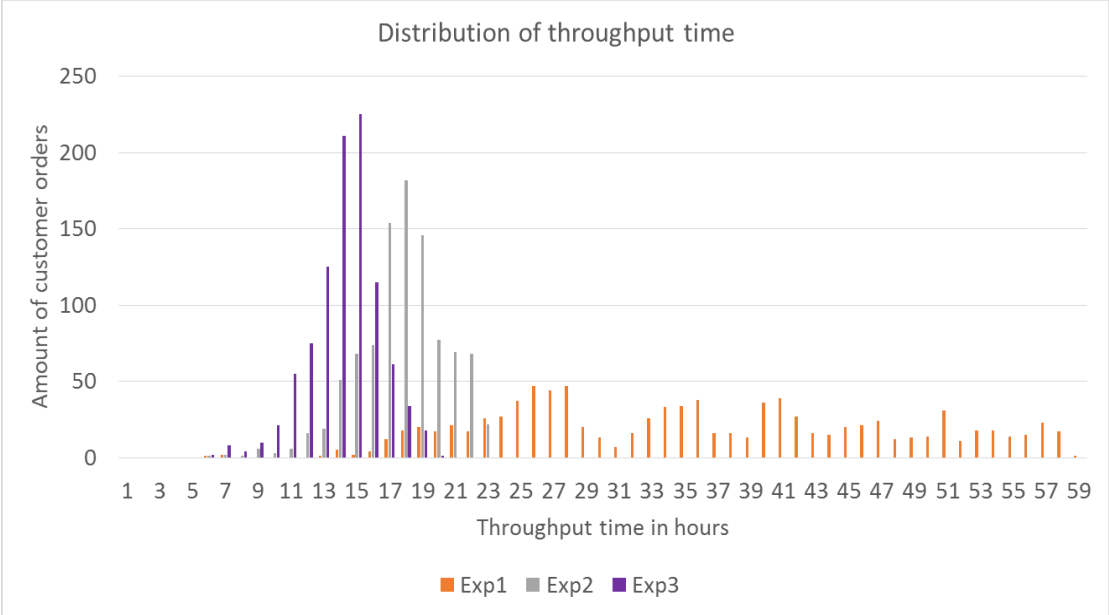


Figure 4-10 Distribution of order throughput time in 24h pool building time

Table 4-10 Parameter for experiment 1, 2, 3

Experiment	Pool period	Order picking strategy	Batch size [order]	No. of picker
1	24h	Single order picking	1	1
2		Single order picking	1	3
3		Single order picking	1	5

In the first 3 experiments, the customer orders are collected in 24 hours to build a large order pool. The customer orders are consequently sequentially picked with single order picking strategy. The number of pickers is the only changing. In the Figure 4-10, the order throughput time diagram clearly illustrated under the same situation, that the more pickers assigned to the system the shorter the order throughput time.

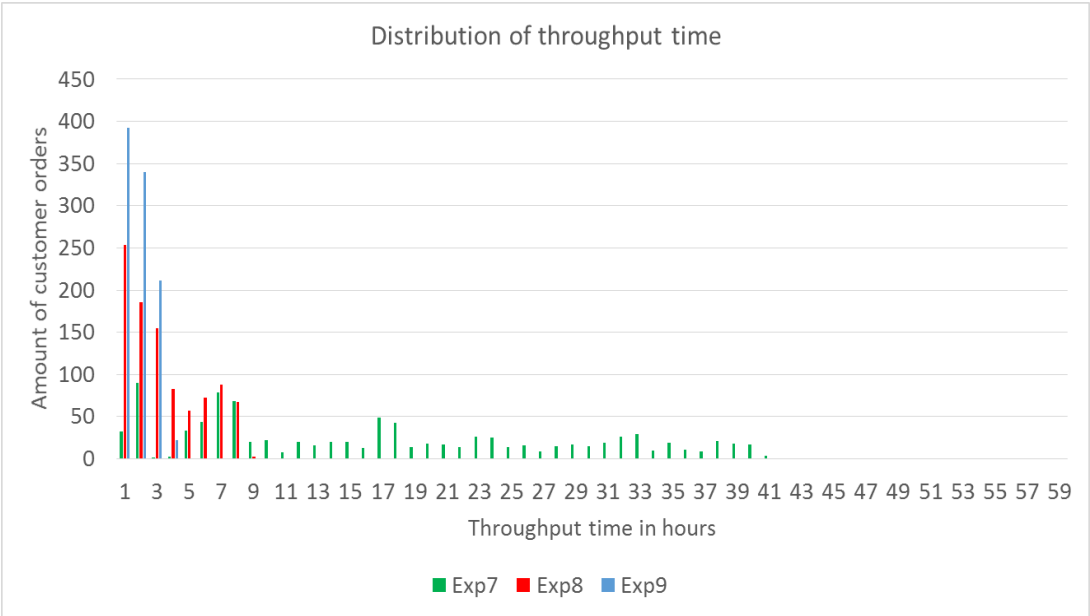


Figure 4-11 Distribution of order throughput time in 1h pool building time

Table 4-11 Parameter for experiment 7, 8, 9

Experiment	Pool period	Order picking strategy	Batch size [order]	No. of picker
7	1h	Single order picking	1	1
8		Single order picking	1	3
9		Single order picking	1	5

In contrast to the last experiments, experiment 7, 8, and 9 have a pool building time of only one hour. From the Figure 4-11, a similar trend can be observed namely the more pickers being involved in order picking means that the average order throughput time will be smaller.

In comparison with Figure 4-10, the order throughput time for 1 hour order pool is much shorter than the 24 hours order pool. It means that, besides the picker factor, the pool time is also critical in regard to order throughput time. The shorter the pool time, the shorter the order throughput time.

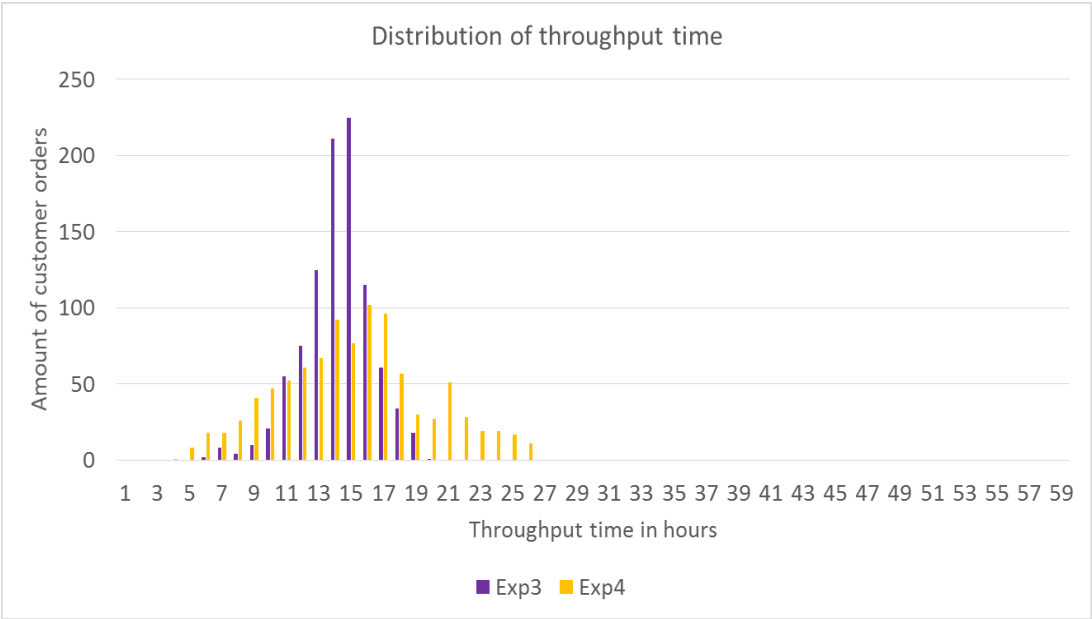


Figure 4-12 Distribution of order throughput time with and without batch building

Table 4-12 Parameter of experiment 3, 4

Experiment	Pool period	Order picking strategy	Batch size [order]	No. of picker
3	24h	Single order picking	1	5
4		Multi order picking	3	5

In these two experiments, the comparison focuses on different picking strategies and these are single order picking and multi order picking in regard to batch size 3. From Figure 4-12, it is obvious that the order throughput time with batch building is longer than without batch building. The explanation of this effect can be traced back to the start and end of order picking. In single order picking, the start and end of order picking determines its own order throughput time and in contrast, in multi order picking, the start and end of order picking with batch size 3 records the time consumption that the 3 orders have and that they have the same start and end time. The order throughput time is longer than the one with single order picking if we separately take one of the three orders into account. Based on this reason, the conclusion reveals that batch building does not have a positive effect on the order throughput time and on the contrary, the throughput time is extended due to the combined order picking process.

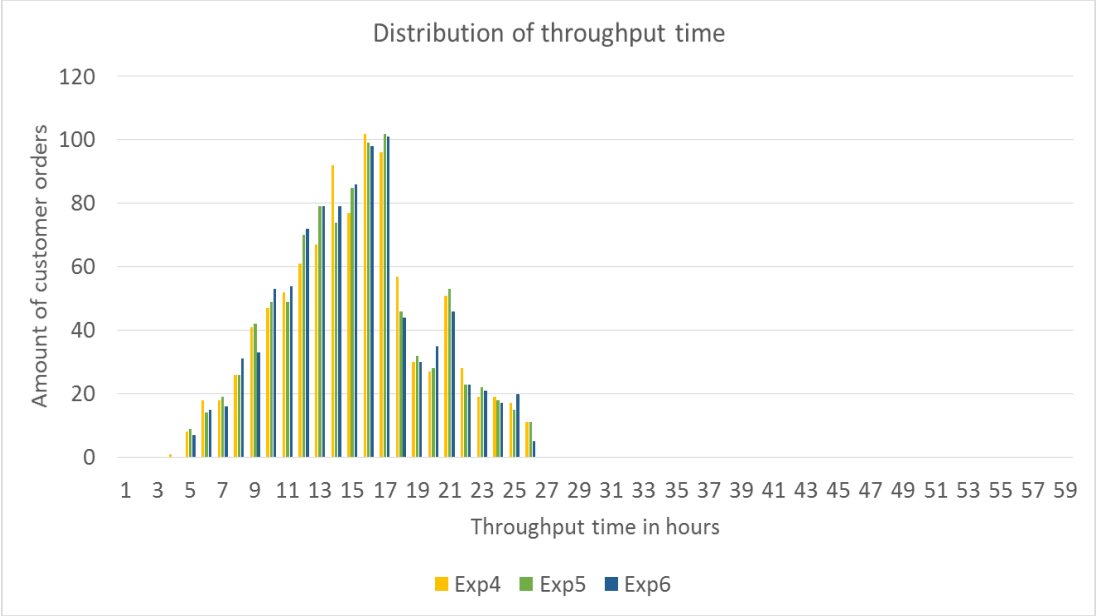


Figure 4-13 Distribution of order throughput time with different batch size

Table 4-13 Parameter of experiment 4, 5, 6

Experiment	Pool period	Order picking strategy	Batch size [order]	No. of picker
4	24h	Multi order picking	3	5
5		Multi order picking	6	5
6		Multi order picking	12	5

Figure 4-13 shows the comparison of order picking with different batch sizes. For small product groups, there is more chance to have the same articles in different orders but in one batch and the repeated order lines are combined into one. It turns out to be that there is a slight difference in order throughput time between different batch sizes as proven by our input data with a big product group. Therefore, the effect of batch building strongly depends on the customer orders and product group, how many order lines can be saved by batch building.

Utilization of order pickers:

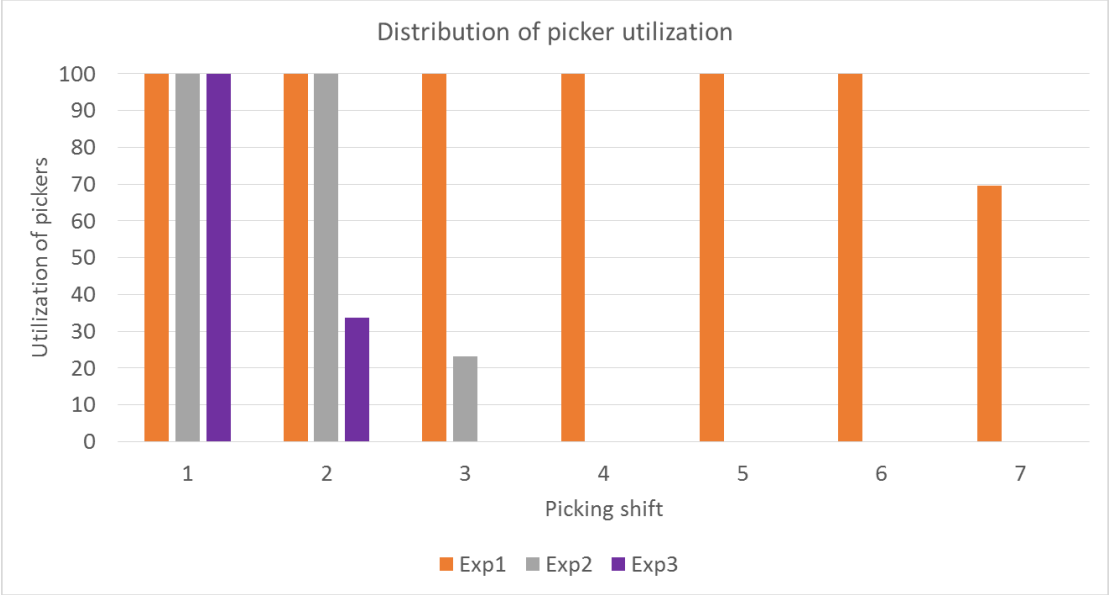


Figure 4-14 Distribution of picker utilization in 24h order pool

The cost factor discussed here is illustrated in Figure 4-14, when one-picker-system needs 7 shifts to finish the customer orders that are collected 24 hours ahead. With the increase of pickers in the system the time consumption is reduced. The more pickers, the less time consumption there is for the same amount of customer orders.

As expected, one picker system takes longer to finish all orders whereas it is 5 times faster for the 5 picker system. Proportionally, the labour cost per order is the same and only time is saved by increasing pickers.

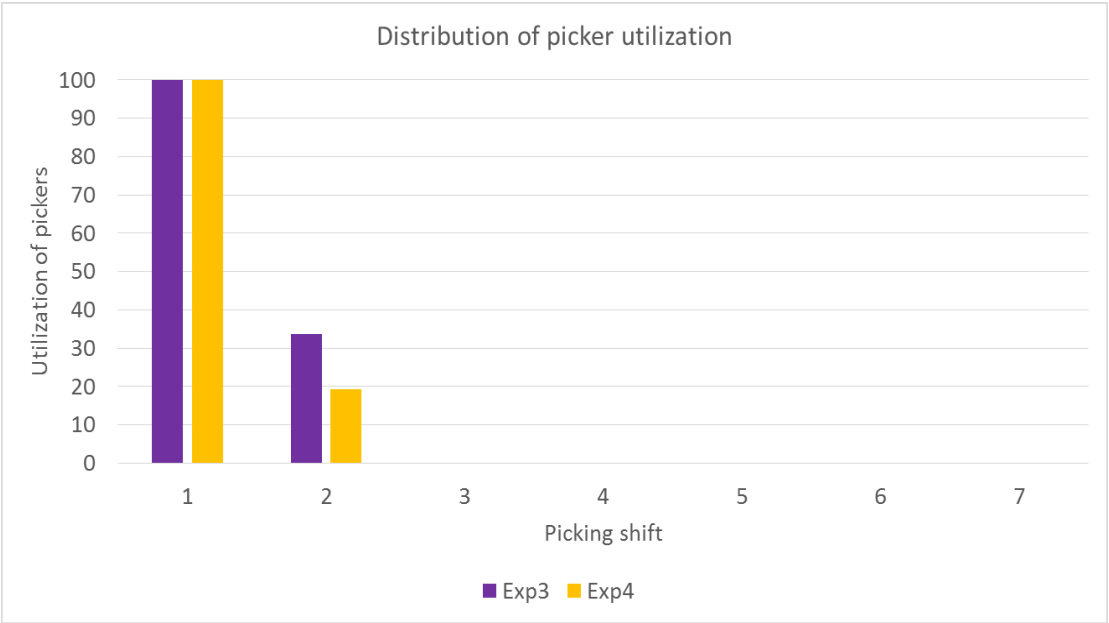


Figure 4-15 Distribution of picker utilization with and without batch building

An interesting comparison of picker utilization between with and without batch building is shown in Figure 4-15. Experiment 4 illustrates the time consumption of multi order picking with batch size 3 where in comparison to single order picking in

experiment 3, the pickers are more efficient with batch building. If the order throughput time in Figure 4-12 is also taken into consideration, it can be argued that, the labour cost can be reduced by batch building due to the reduced time consumption for the same amount of customer orders, but during that time, the order throughput time is extended.

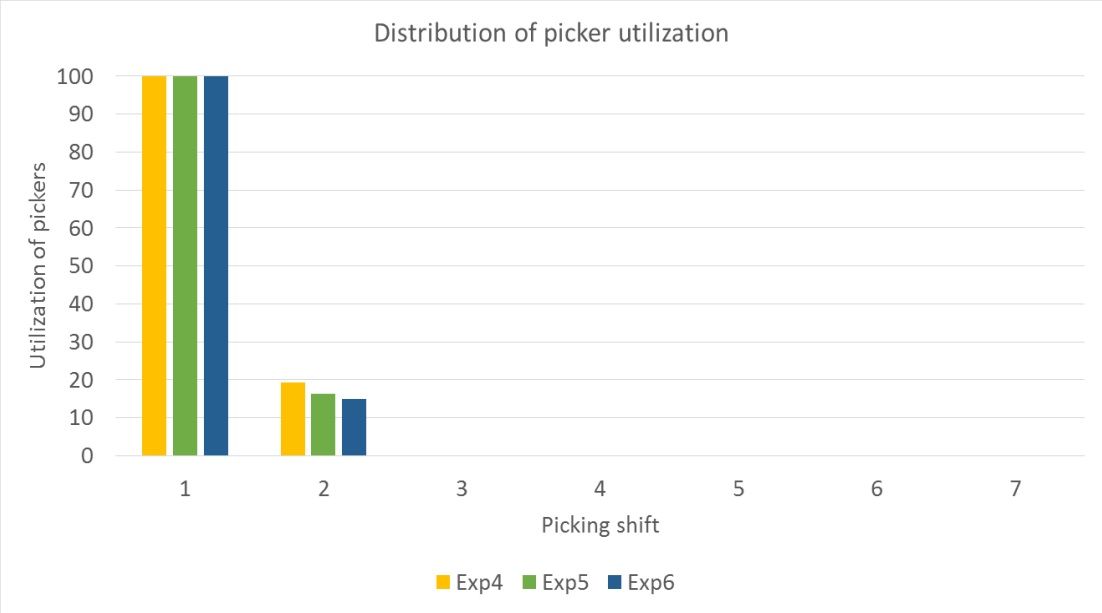


Figure 4-16 Distribution of picker utilization with different batch size

From this example, we can see that the pool building time, batch size and number of pickers can have a huge influence on order throughput time. The decision making of how to manage the picking system should focus on the business strategies. For express order delivery, the throughput time is very critical and in this case, short pool building time, small batch size and more pickers are recommended. As is the cost of each order seems relatively high. Furthermore the combination of large order pool, a big batch size and fewer pickers making a long order throughput inevitable.

4.2.2 Accuracy of customer order

The second main indicator of service level is the accuracy of the customer's order. The package delivered should be exactly the products that the customer ordered. To achieve a high level accuracy of the customer's order it requires many auxiliary logistic devices and picking systems that have been invented to guarantee the manual and automated order picking.

The logistic picking system does not only minimize picking mistakes, but also enhances the picking performance. The most commonly used picking systems for manual picking process are:

- Pick by light – light guided picking system. Paperless picking only with the hint of light so the order picker does not have to know in what order the product is listed and they just take the product where the light indicates.
- Pick by voice – voice guided picking system. The order picker is oriented by the hint of a voice in the headset.
- Pick by vision – vision guided picking system. The direction is shown in the display so that the order picker easily knows where the desired product is and how many

should be taken for the order.

The order picking systems mentioned above are all concentrated on the picking performance and are meant to reduce the picking mistake caused by lack of concentration during the picking process which is usually unavoidable.

In addition, some other methods are also useful for the order control. For instance, the order can be measured by weight or double checked by the end of order picking. For normal consumption like clothes or accessories, the desired accuracy of order picking could reach 99% with the help of auxiliary picking devices, but in some special fields, for instance, medical or chemistry, a higher service level is expected to be nearly 100% or 100% accuracy. Therefore, the automatic order picking system seems to be the best option. This does not mean that the manual order picking system cannot reach high accuracy. However, with the help of IT, such as scanner, the order can be sufficiently checked to make sure the customers get the right product.

4.2.3 Order fulfillment

Some sub factors, or business strategies, should be taken into account in the order fulfillment. From a strategic point of view how we handle the lead time customers expect to get the order.

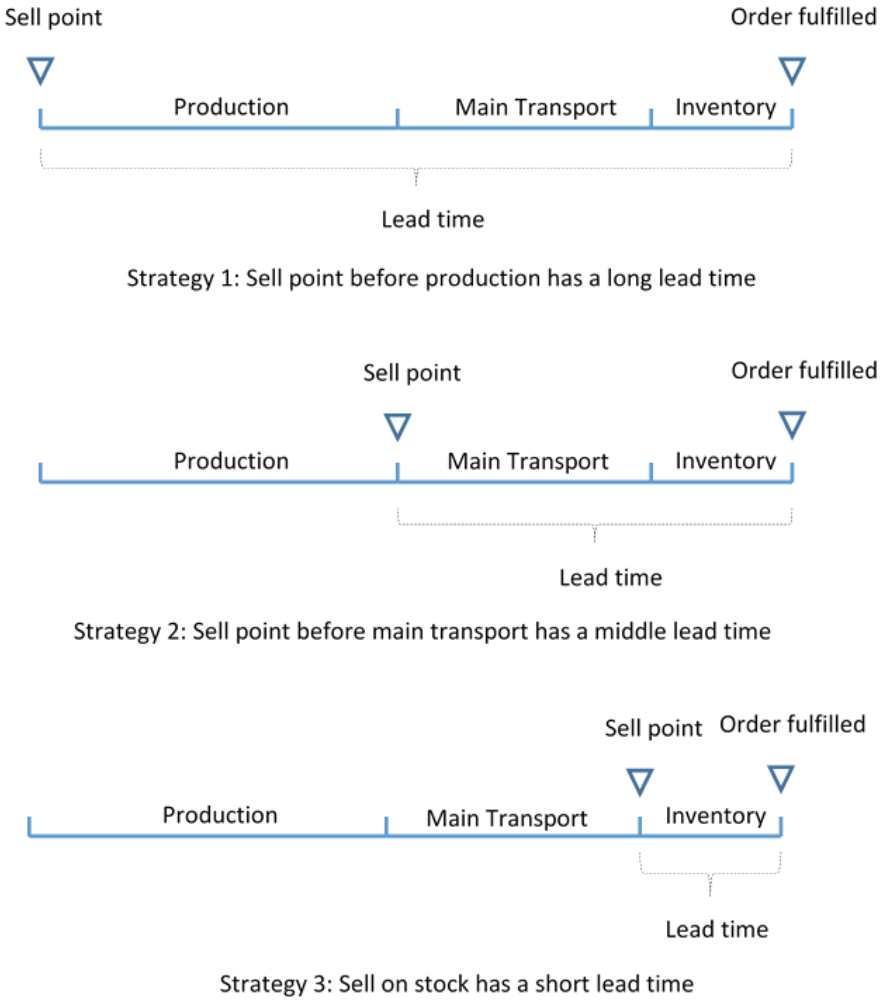


Figure 4-17 Three business strategies for customer lead time

The figure indicates how to satisfy the customer order by adjusting the sell point. For the first business strategy, the perfect example is the automobile industry. In this example the production is customized as the customer order and some specialized components or demands are being combined in the production to fulfill the needs of the customer which is also the big advantage for this business strategy. The only disadvantage is that the customer has to accept a long lead time.

The second business strategy is that the customer order will be taken after the production of a specific output. It totally depends on the market prediction and how intensive the buying wave is. For instance, the electronic products are produced in advance before publishing the product event. However, the order can only be fulfilled after a few weeks due to the long transport time.

The third business strategy which is most commonly used in the online business model is sell-on-stock. With this strategy the customer can get the product in a defined lead time. Buying is only possible when the product is in the warehouse and this means that the inventory level needs to be able to guarantee the fulfillment of customer orders. Therefore, from the logistic point of view some other factors should be also taken into account in this stage, such as safety stock and replenishment frequency. An important question is at what cost and which level the customer order should be satisfied.

The order fulfillment is for some reason a critical factor for the service level. Table 4-14 summarizes the impact of the internet on fulfillment strategies. E-fulfillment logistics requires short lead time, the ability to serve globally dispersed customers and the ability to reverse the flow easily from B2C to C2B [SKS 08].

Table 4-14 Traditional fulfillment versus e-fulfillment [SKS 08]

	Traditional fulfillment	E-fulfillment
Supply chain strategy	Push	Push-pull
Shipment	Bulk	Parcel
Reverse logistics	Small part of the business	Important and highly complex
Delivery destination	Small number of stores	Large number of geographically dispersed customers
Lead time	Relatively long	Relatively short

4.2.4 Optimal service level and operation cost

To summarize, the service level can be defined into three categories and these are the duration of delivery, the accuracy of customer orders and order fulfillment. For each category, there are some critical factors and for example, transport distance to the duration of delivery, error rate to the accuracy of customer order and safety stock to order fulfillment.

Among these factors, there are two trends that are introduced and these are lineal distribution and exponential distribution. The picking performance is proportionally related to the number of pickers. It is more practical to assign more pickers to simply shorten the order throughput time by increasing the picking performance. Therefore, at this stage the lineal relationship between the service level and the operation cost is

predictable. However, to further enhance the service level by improving the error quote needs auxiliary devices or picking robot and this can cause an extreme high investment.

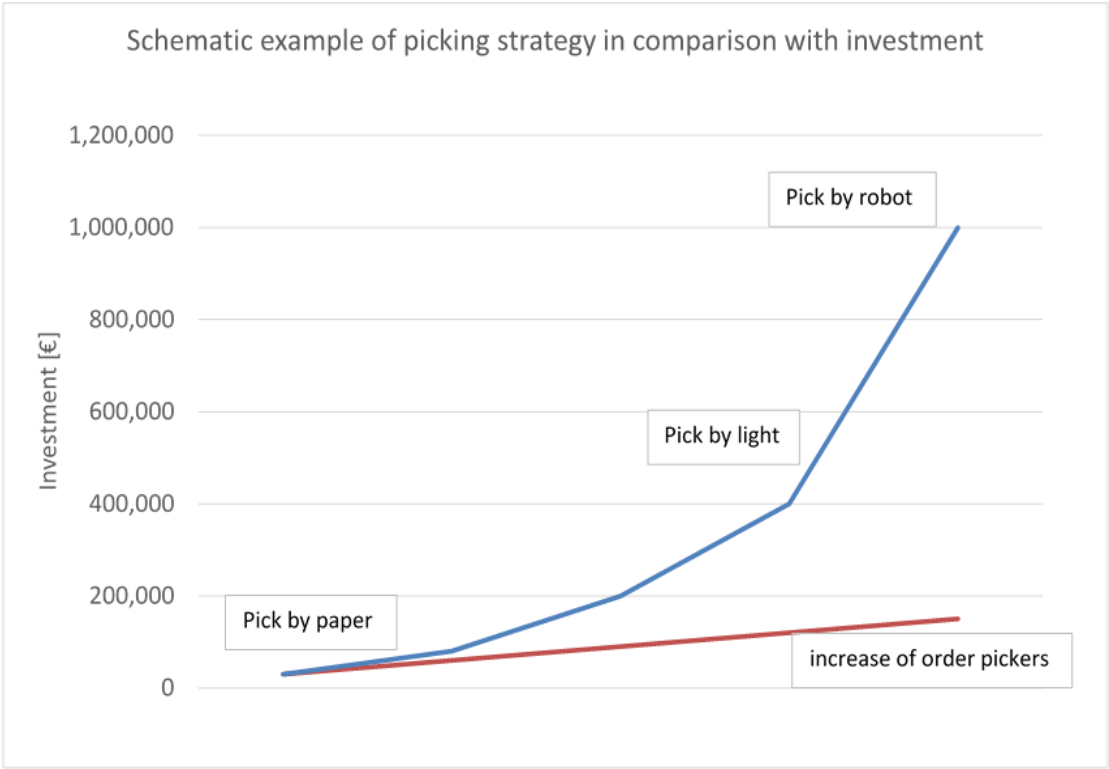


Figure 4-18 Schematic example of picking strategy in comparison with investment

In Figure 4-18, a schematic example explains the relationship between order pickers and picking performance. It shows that, under the same condition, if a double picking performance is expected the simple way is to double the order picker. Therefore, in this case, a lineal distribution is shown in red in this figure, but the solution of increasing the order picker may reach a limit and if a higher performance is expected, the curve tends to gentle gradually with the increase of order pickers.

Another schematic example explains three different picking strategies. It is explained in the log-kompass[10]. For a picking strategy pick by paper is commonly used for a low picking performance of up to 300 picks per hour. The human factor critically influences the picking accuracy but the hardware and software cost are relative low. The picker can be guided by the light with the pick by light equipment and avoids human error, but the investment on hardware and IT system is much higher than the pick by paper strategy. With the performance up to 2,500 picks per hour, pick by robot is probably the most efficient picking device at the moment. The full automated picking arm is totally controlled through IT without the human picking factor and the investment is extremely high. The three discrete points may be not a continuous curve, but it explains that the investment needs to be much higher to raise the picking performance.

4.3 Product procurement

The products are originated from different regions of the globe. Therefore, to avoid a long lead time for the customer the main haul between the product supplier and

warehouse seems to be the critical factor. The transport strategy for the main haul is also different in consideration to the speed, amount and especially cost in the different business phases.

4.3.1 Transport chain design in the start phase of online business

Almost every long distance business delivery is related to intermodal transport and depends on business strategies so the transport mode decision has a special emphasis on some critical factors. Table 4-15 indicates the basic decision factors for each transport mode.

Table 4-15 Decision factors for each transport mode

Transport mode	Speed	Amount	Cost	Connection point
Air	++	--	++	Airport to airport
See	--	++	--	Harbor to harbor
Rail	+	+	-	Station to Station
Road	-	-	+	Door to door

Combined transport by sea and road, transport chain is as follows.

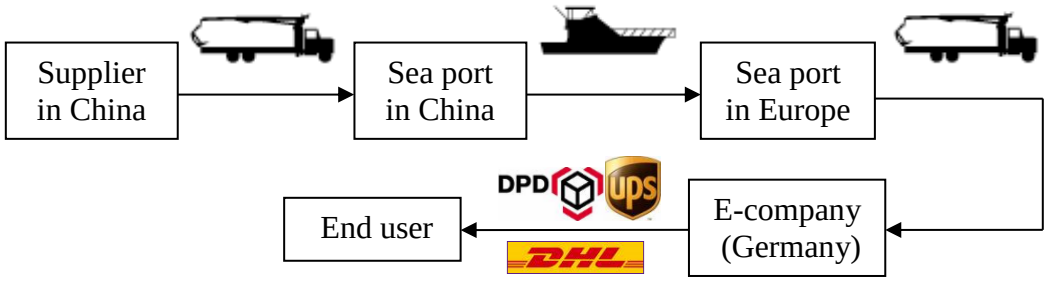


Figure 4-19 Transport chain model of e-company in B2C phase

It is very important to choose an appropriate mode of transportation in order to minimize total logistic operation costs and satisfying customers´ requirements. The products are manufactured in East Asia due to a predominant location advantage for transporting containers directly to Europe by sea. At the same time, it is the best way to transport low-value, high-volume goods over long distances according to the characteristics of sea transport.

Load unit selection

Mixed FCL will be used as the main strategy for container transport in order to reduce the transport cost and further reduce the total cost. The FCL means the load reaches its allowable maximum (or full) weight or measurement and the whole container is intended for one consignee. The mixed FCL means the container is fully loaded with mixed products from many manufacturers. Therefore, the consideration is that the transport will be triggered if the products, delivered from manufacturer to the consolidation point, reach the weight or volume of FCL. Usually FCL is more cost effective and safe then using other sea freight services. However the average order size in the B2C world is small, but it involves a wide range of product types. This means that the amount of each product bought from its manufacturer is also small. Therefore,

the container ought to be loaded from a variety of different manufacturers with different products. Although the shipping cost can be reduced in this way and a longer lead time is an inevitable consequence. The full container has to be loaded and shipped until all products are manufactured due to the fact that the manufacture cycle of various products differs from each other. The mixed FCL is a better choice compared to the rising cost of storage for large quantity of products.

4.3.2 Transportation chain design in the developing phase

In this phase customers can be divided into two types and these are end users and shop handlers.

End user
The people of this group usually see the products on the website and choose one or more products they want and add them to the shopping cart. Once the order is confirmed and the products are paid by the customer, the package delivery companies will be chosen. There are some package delivery companies which can be used, such as UPS, DPD and DHL. The products will be sent as packages through one of these companies.

Shop handler
There are more transport options for retailers, as well as for the private customer but transport through the package delivery companies would be the most commonly used way to forward the products direct by the customers. This kind of delivery companies are generally contracted to provide their transport service so that the e-companies can put more emphasis on core business competitiveness. For instance, DHL provides business solution for e-commerce companies. The packages will be picked up in a time window from the warehouse and transported further to their customers.

It is more common however that the products are picked up by third party delivery companies which are contracted by the customers. Therefore, a delivery window for each pickup company should be planned in advance and so the corresponding customer orders should be picked and temporarily stored in the loading area before cut off time. This pickup strategy also has a great influence on the priority of customer order picking.

In the business phase, a company's transportation fleet for express customer service and flexible delivery schedule is another transportation channel. Besides the operation costs, many other factors should be taken into account, such as business model, company image and customer service level.

Strategic decision of delivery companies
Nowadays, many logistic service providers offer value-added transportation services, such as online tracking, pickup service, and on demand delivery. These value-added services are forwarded from service providers to customers through e-companies and these more or less improve the competitiveness of the e-companies. Some basic strategies are briefly listed below:

- Delivery provider A – small package that is provided by express delivery service
- Delivery provider B – large amount package
- Delivery provider C – price advantage
- Delivery provider D – local or regional network advantage in North America

4.3.3 Transportation chain design in the developed phase

A complex transport combination in pre-haul, main-haul and after-haul involves air, road, rail and sea. It is beyond doubt that the material flow of e-companies barely differs from traditional shops. What is particularly important is for products with time sensitive life cycle. The critical main haul determines when the products can be posted on the e-platform. The shorter the main haul means the more profit for the e-companies.

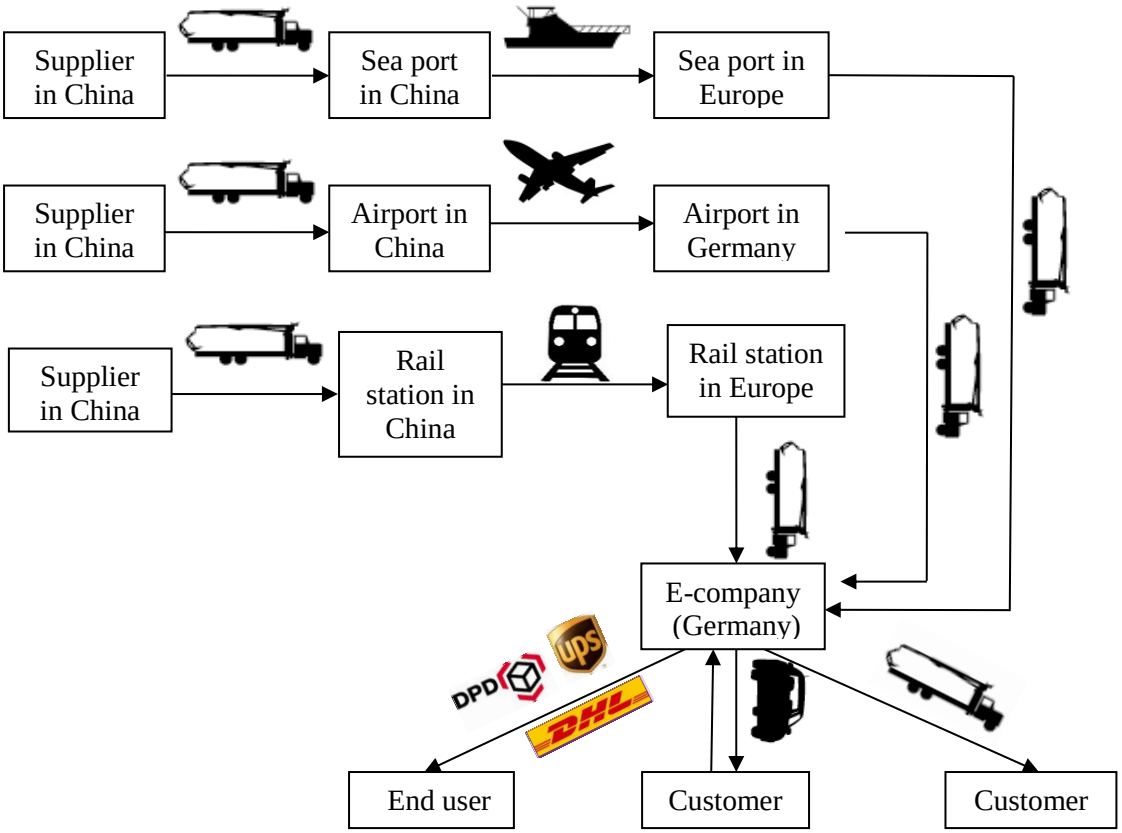


Figure 4-20 Intermodal transport chain

The strategy on the mode of transport depends always on the attribute of the product. Low value, high volume, and not time sensitive products are probably delivered by sea. For example, the consumption products CD and DVD cases can be transported from China by containerships. On the other hand, high value, low volume and time sensitive products will bring more profit, if the products can be transported from the production country to the market by air. For example, the capacity and type of USB sticks update frequently on the market. In this case, air transport is the most effective transport mode above all others. A dynamic profit chart describes the difference of sea and air transport in the following figure.

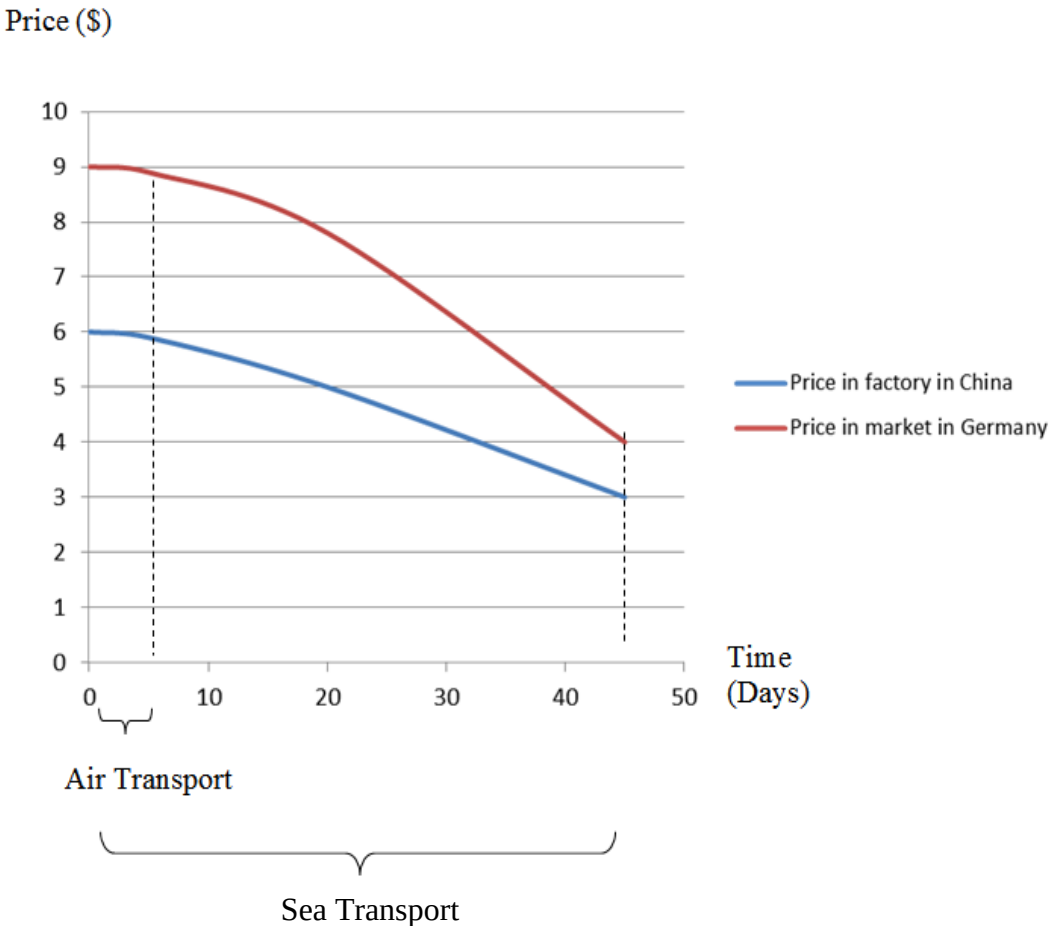


Figure 4-21 Comparison of using sea and air transport modes

Air transport provides a very fast service over large geographical distances. Thus, it is usually used for time-sensitive express goods or emergency deliveries. On the other side, this mode has the highest cost per ton kilometer which is why it is considered to be the greatest disadvantage of it. Therefore, air transport is generally used for goods which are of high value and low weight. In other words, goods with a high value-to-weight relationship can sustain high transport cost as this transport cost is very small compared to inventory holding costs. For example, same high-tech products just like USB sticks, which we have mentioned earlier, are usually transported by aircraft. The comparison of using two modes of transport is illustrated in Figure 4-21. After about 45 days transit time some new style of USB sticks may have appeared on the market if we adopt the sea transport. The price of our USB sticks in market will drop down from 9$ to 4$ even lower than the price (6$) we have paid for in the factory. There is no doubt that our profit will be reduced significantly even to the point of a deficit. The situation is quite different if we choose air transport. The five days' transport time brings our products to the market just in time.

4.4 External logistics concept for online business

The quantitative change in capital, capacity, customer and experience fulfills the necessary preparation for qualitative change which heads in different directions as the online business steadily grows. Horizontally, the spectrum of trading products is widely expanded from specific products at the very beginning to further large product

structures so as to attract other customer groups. Vertically, a massive outsourcing plan can reduce the wholesale price and further brings more profit from the trading. A mature online market attracts not only private customers but also other business partners and this leads to another business level B2B.

Many online business providers encountered, or suffered critical problems, such as insufficient inventory for the sale season, information blockade and change of customer groups. The questions are probably the same, but the solutions in each phase, where operating conditions differ from each other, are completely different. Above all, the supply chain governance is discussed in the following sections.

4.4.1 The first phase: Start with B2C e-commerce

1. Supply chain model

At first, in order to put products into the market, it is necessary to know the need of the market. For instance, Ebay would be a suitable channel for the companies to sell the products and at the same time to publicize their online shop. The corresponding supply chain can be described as below:

Figure 4-22 Supply chain model of e-company in B2C phase

In this supply chain, the e-company is connected direct to the end users.

2. Supply chain characteristics

In this phase, starting with an immature supply chain, origin suppliers are searched to fulfill the unpredictable demand of customers. Some factors have to be considered to establish a stable and reliable supply chain.

- Suppliers: In the global market many products are manufactured in developing countries. Asia as one example, leads to long transport distances from manufacturer to end customer and further raises the complexity of the supply chain governance.
- Product: Has a short life cycle and are frequently replaced by new products. This challenges the supply chain to react also in short time by adjusting the transport mode and inventory level.
- Market: As a new business provider into the market, especially in the recent years, the competition from other online traders is extremely huge and unlike the traditional shops, the competitor can locate anywhere with any business scope.
- Sales: At the beginning large numbers of online customers are mostly unknown, unstable and unpredictable. Therefore, to sustain a healthy business development it is important to attract a specific customer group and ensuring a sales target. Some special price strategies and customer services can be considered in this phase.
- Customer order: Trivial customer orders with small volume consists mostly of one or several pieces for one customer. The order structure will affect the order picking process and the warehouse facilities.

- Service level: Customers have high expectations about quality of services and demand fast delivery of shipments.
- Information flow: Greater demand for and availability of information covering transactions over the entire supply chain.

3. Logistic design strategy

1) Customer-oriented information system

Generally, the information in e-commerce includes:

- Business documents, like purchase orders, invoices, contracts etc.
- Product information, e.g. product web site, inventory, location tracking
- Customer information, e.g. personal information, payment and feedback

Delicate website design

An online business must make a good first impression because most potential customers will not come back for a second time if their first look is not visually appealing enough. It is true that the product is what is ultimately important, but just as a brick and mortar storefront conveys a certain message, the same can be said for an online store. Some ways to update the functions, including the improving of navigation, simplifying checkout process (such as one-step checkout and easily replaced passwords), and sending out e-mails with special offers.

Customer satisfaction

Provide comprehensive customer service. One example is a real-time service allowing on-line shipment tracking and after sale service.

Email

An email address in the website seems to be a practical form of communication and is very convenient for the customers to get a direct contact. It is important to respond to them as soon as possible.

Telephone

There are also a number of customers who want to be able to speak to a real person. A phone number on the web site is necessary. There are also some companies allowing customers to enter their name and telephone number on the website and then call back to them within seconds. In this case a call-center, which consists of people who can help customers professionally, is necessary and it should be there 24 hours a day.

Real-time service

People can submit a question, complaint or request through instant message and get response immediately. That means to give your customers answers to their questions in real-time or give them some good advices when they hesitated to make decision will increases the customers' satisfaction level.

In this case, a system in place to respond to customer questions and complaints promptly is necessary. There are many methods available to provide a real-time service dependent on the size of the business. Above all, in comparison to emails, live chat is more direct and convenient. Just by clicking on the "Start Chat" button on the website, a communication between your service team and your website visitors will be initiated. Undeniably, real time is one of the greatest advantages of live chat.

There are also several advantages of live chat conversation over telephone call. Live chat saves people's money because of it people can communicate freely all over the world. It also allows more than one person to chat at the same time and enables people to send pictures, links or even audio to each other. If you just rely on telephone, all of these tasks are quite difficult to complete.

After sale service
Setting up personal relationships and regular information exchange such as regular newsletter and new products information.

2) Layout design
The layout design to fulfill the logistic demands always struggles with special restrictions as not every warehouses are built on the green field. The material flow in the general design phase can completely resolve the blueprint and further affect the detail planning.

Figure 4-23 illustrates two common warehouse layout design methods, whereas one has a linear layout another one has a U shaped layout [JON 08].

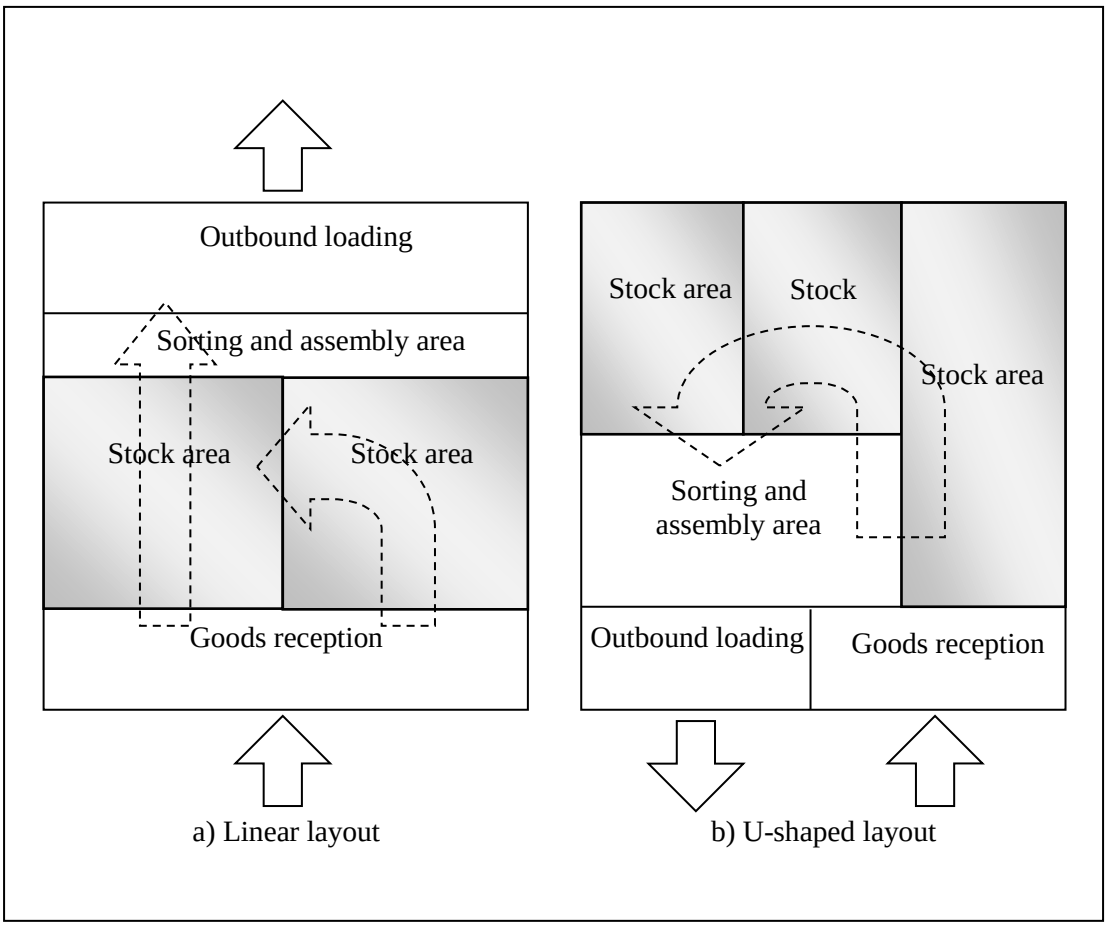


Figure 4-23 Warehouse layout design method [JON 08]

In linear layout, as shown in Figure 4-23 a), goods reception and outbound loading are separately located at the front and back side of the store. Goods are transported nearly the same distance and all of them flow through the entire store. In this case, the location of goods with different picking frequencies will be treated the same and therefore a lot

of unnecessary handling work and costs are involved. This type is suitable for an automatic handling system and the handling of goods with large volumes.

U-shaped layout, as in Figure 4-23 b), is arranged by locating goods reception and outbound loading at the same end of the warehouse. Using this layout, the location of goods has a great impact on the handling of work efficiency. It is possible to make more efficient handling by choosing the best location to place the goods.

Basically, no matter the linear layout or U-shaped layout, the key strategy is to minimize the length of material flow in order to speed up the pass-through time.

4.4.2 The second phase: The transition from B2C to B2B e-commerce

1. Supply chain model

Though B2C e-commerce is characterized by low investment, simple business operation and a flexible executive pattern, compared with B2B e-commerce, it has also relative low economy benefit, unstable sales record, and difficulty in controlling the relationship with customers. Therefore B2C e-commerce can be recognized as the foundation for capital accumulation and comprehensive understanding of the market and meanwhile it promotes the trend of development to B2B e-commerce. In this phase, B2C and B2B e-commerce coexist in the business model and make a change in the downstream of the supply chain, as is shown below:

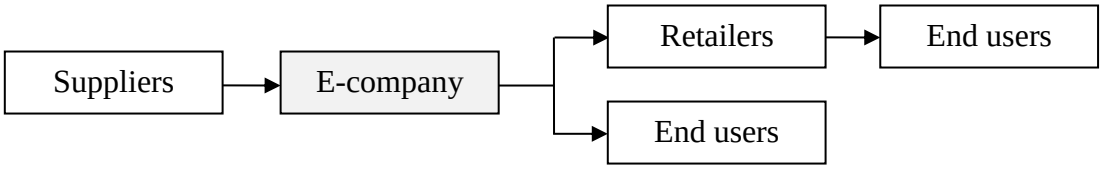


Figure 4-24 Supply chain model of e-company in transition phase

2. Supply chain characteristics

- Individual customers are marginalized and retailers become the new customers.
- Increase of larger orders from retailers which is usually several cartons or pallets.
- Retailers have high expectations about the price and quality of the product.

3. Logistic design strategy

1) Use customer ABC-analysis to deliver effective services

ABC-analysis can be used in many fields, for instance, the value of products, the frequency of order picking, etc. Therefore, to distinguish different customer groups, an ABC-analysis based on customer scales is recommended in this transition phase with both business and private customers.

Just like as we mentioned before, there are normally 20 percent of products which generate 80 percent of the total profit contribution. Similarly, it is often the same case that a small number of customers give a large part of the total profit contribution. In this situation, a general service for all customers will lead to unreasonably high costs. This means, that the wholesale customers getting a higher priority or service level than the private customers.

Using ABC analysis, the customer can be grouped into three categories A, B and C, based on their share of the total sales. But this does not mean that A class customers should get total focus because of their high proportion of profit contribution and the company should ignore the other 80 percent customers. Sometimes, the customers change from category to category. Additionally, most customers in class C are end users. Usually they buy some products which are highly profitable despite the fact that they only make small orders. They are still our concern and it is always necessary to provide different and appropriate service to them.

2) Warehousing structure

Customer orders contain not only one or two products, but mostly a dozen or several cartons, or even a full pallet, due to the emergence of B2B. In this case, the inventory level and warehouse space have to be increased and because of this, the travel distance and search time are in the meantime extended for the coworkers during order picking. Therefore, it seems to be a simple strategy to separate the traditional warehouse into a reserve storage area and a forward pick area where the most popular SKUs are stored to reduce the complete order picking time. Figure 4-25 illustrates the SKU flow through the forward-reserve areas in warehouse.

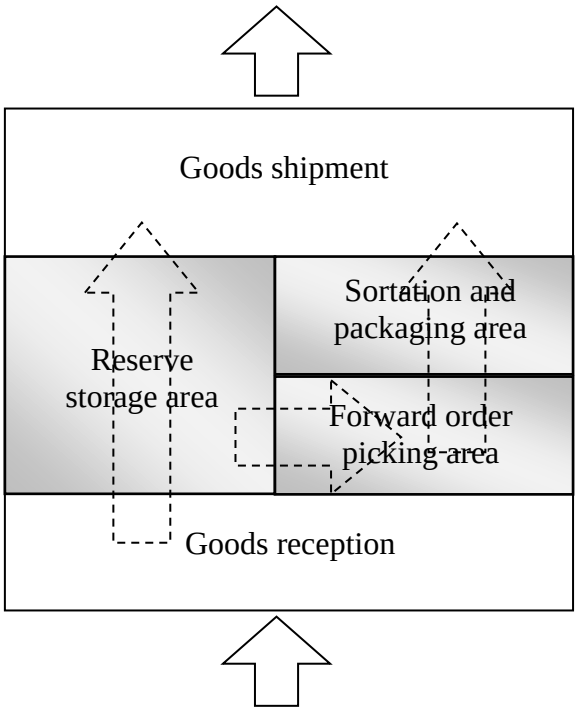


Figure 4-25 Forward-reserve storage

In this case, incoming products are received and stored in pallets in the reserve storage area. Single case quantities of each product will be placed in the forward area. When orders are received, single items for B2C customers or carton products for B2B customers will be picked in the forward picking area and then sent to the order sortation and accumulation area. At the same time, pallet products will be picked in the reverse storage area for B2B customers or to replenish the forward pick area.

Obviously, there are tradeoffs and cost considerations involved in the forward – reserve problem. From a perspective of cost, while it is true that a fast picking area reduces

labor time dedicated to order picking, it is also a fact that it requires more frequent replenishments from the reserve area and increases the replenishment labor. Also, there will be a need for higher investments in space and more material handling equipment. The order picking costs increase and the replenishment costs decrease and vice-versa, as the size of the forward picking area increases. Deciding which items are to be placed in the forward picking area and finding the optimal space allocation for each of them in such a way that it minimizes the order picking, replenishment and equipment costs is known as the Forward/Reserve Problem (FRP) and was first introduced by Hackman and Rosenblatt (1990) [SAL 01].

4.4.3 The third phase: Development of B2B e-commerce

1. Supply chain model

In this phase, the supply chain model is simplified and e-companies deal ideally only with retailers. It depends on the business strategy and not every e-company develops themselves into this phase and abandons the end customers. The supply chain model can be simply indicated as follows:

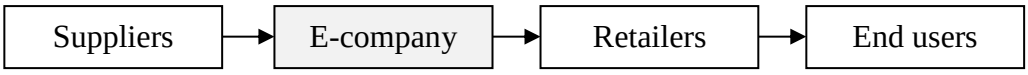


Figure 4-26 Supply chain model of e-company in B2B phase

The stable and huge profit when dealing with retailers is a decisive advantage of dealing with said retailers. On the other hand, the large amounts of material handling enforces the e-companies to expand their warehouse capacity and order processing methods.

The trading platform of e-companies seems to, instead, turn into an information platform. In the background, a more integrated IT system with retailers' inventory level is more of a concern to the company.

2. Supply chain characteristic

- Stable regular customers with a long-term business relationship.
- Most orders are for a large amount of products.
- Large warehouse capacity.
- Partial space is occupied by unsold products.

3. Logistics design strategy

1) Integrated VMI system with customers

For customers, who frequently and regularly replenish the inventory, it is currently recommended to work with an integrated VMI solution, which allows the e-companies to constantly observe the inventory level and depending on necessity, a prompt and rational order will be generated and automatically sent to the warehouse. Besides the real time reaction, these customers always possess a high priority.

The following table briefly indicates when we should send a "Warning SOS" signal to the customer and then generate a replenish order. For instance, the safety level of an inventory is 100 Pieces and when the inventory level drops down to the aforementioned

level an “SOS” signal will be sent. For each customer and each product, the replenish amount is theoretically different and depends on its consumption period.

Table 4-16 Example of “SOS” signal in VMI System

Customer id	Company name	Products id	Inventory level	“SOS” signal
00024	Company A	A1538	128	
00038	Company B	B7362	35	SOS
00045	Company C	C0061	89	SOS
		C1538	21	SOS

2) Warehousing structure

Purchasing or leasing a reserve warehouse for the unsold or reclaimed products in order to guarantee the turnover of the main warehouse. As mentioned before, electronic products like computer accessories are time sensitive products. These kind of products are usually upgraded or replaced by new products which are more efficient or perform better. Overstock of obsolete products is difficult to avoid. These unsold products or defective products, are damaged during transport or material handling process and occupy a substantial part of the space in the warehouse. In this case, a new warehouse which is large enough for the current inventory level seems to be the only solution.

The unsold and reclaimed products are more concerned in business strategy in this phase as the reflux of products enormously increases. These kinds of products brings relatively low benefits, but occupies the company's productive resources for a longer time. For this reason, a separate reserve warehouse or external service provider who deals with the returned products is apparently a suitable solution.

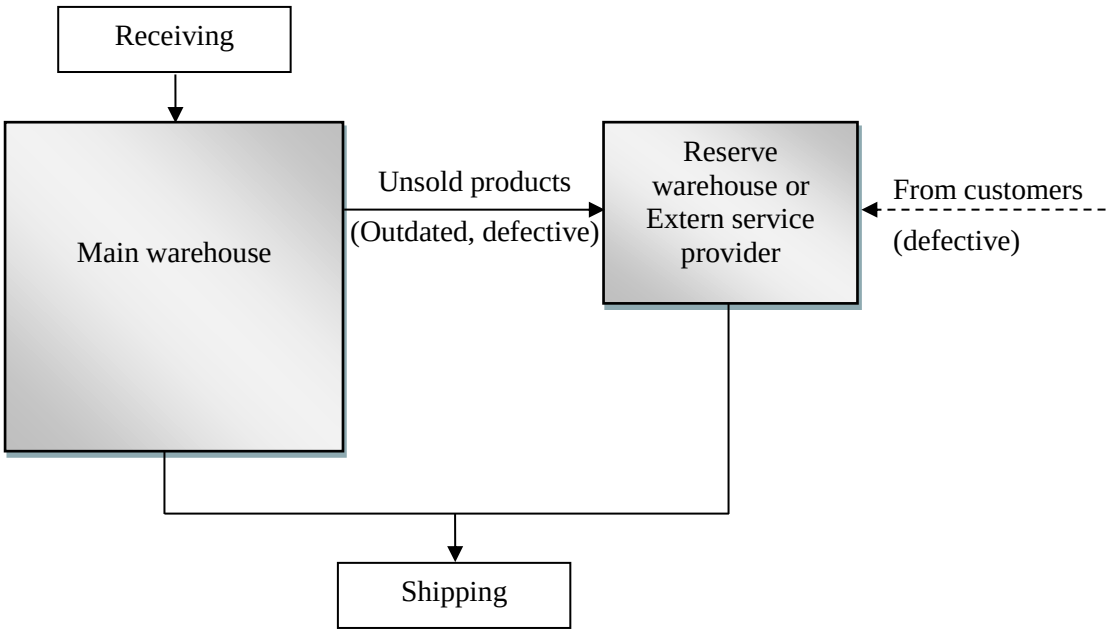


Figure 4-27 Use of reserve warehouse

4.5 Internal logistics concept for online business

4.5.1 Arrangement of products location

The strategic position of the warehouse plays an import role in the online business, and the performance of the warehouse determines how we can fulfill the customer's order. An effective warehouse management includes many different factors. Above all, the effectiveness of order picking lies on the strategy and depends on where the products are located in the warehouse. Location of products in the stock area can be divided into several different categories:

- **Fixed or random location**

Fixed location means that the products are stored in a fixed place. Random location means products do not have fixed storage places, but they can be stored anywhere in a free location. Fixed store location requires a larger storage volume in comparison with random location.

- **Deep in the store location or near to the door location**

Products which are handled or picked with high frequency will be placed near to the inbound and outbound loading area. On the other hand, infrequent products can be located deep within the store.

- **Use ABC analysis**

The grouping of the products into categories is based on the nature as well as the size of the products. Fast moving products (category A) preferably are stored at a picking height (the height at which the products can be picked with the least effort) and at the front end of the warehouse. In this way, the distance between depot and pick location will be reduced to a minimum. Slow moving products (category B and C) are stored in the back.

- **Correlated location**

Each order usually includes a variety of products and it is obvious to find that some products are normally ordered together by customers or come from the same supplier. For example, when a customer has ordered a number of keyboards, he also probably wants some mouse and even mouse pads. In this case, one way to minimize handling work is to store products that usually appear in the same order close to each other in the store. This is called correlated location. Taking this into account we can put the mouse and mouse pads next to the keyboard. Similarly, you can find the CDs next to DVDs.

- **Floor level location or higher level location**

Usually weight and volume affects locations too. Lighter goods are normally located at higher levels and heavy goods are located closer to the floor. At the same time a high level store requires more advanced handling equipment and takes more time to store and retrieve. On the other hand, floor level, or just above, is more convenient and faster to handle.

Actually, in many cases a combination of several store location types is used. For example, fixed and lover level locations can be combined to pick customer orders, and random and high level locations are used for buffer stores from which products are taken to replenish picking sites. We should also choose the suitable storage location of

products based on their characteristics. Just like USB sticks, which are of low weight and volume, being picked frequently and common should be included in the same picking orders with CDs. According to these considerations USB sticks should be located near to the outbound loading and goods reception area and direct above the CDs.

4.5.2 Material handling system

Selective pallet packing requires numerous aisles and results in lower storage density in comparison to other types of the pallet racking system. However, it is the most commonly used and effective storage system to keep products in the warehouse.

After the arrival of goods, the products are unloaded and then placed in an appropriate storage area in the warehouse. Afterwards, order picking happens and the goods will be packaged or directly loaded to move out of the warehouse. All of these activities, in the same way like loading and unloading, moving in or out of the warehouse and picking and packaging of goods, belong to the materials handling. The materials handling is an integrated part of the storage system.

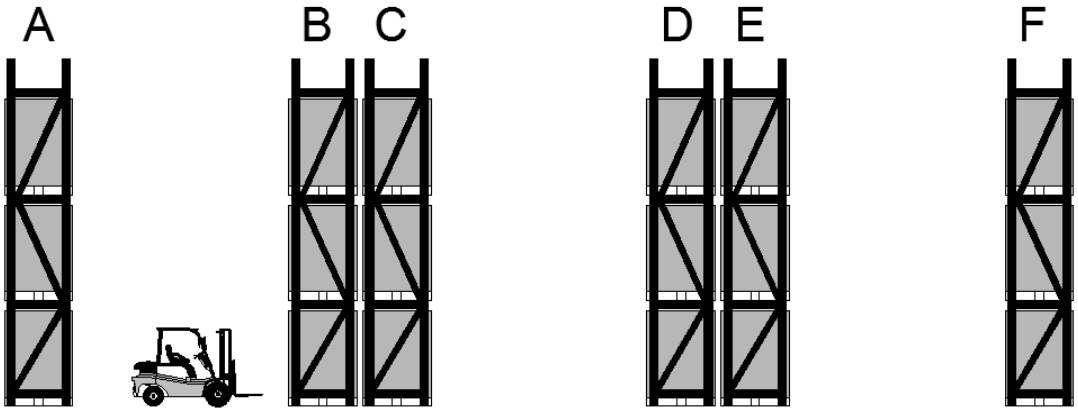


Figure 4-28 Basic structure of stock area

There are a large number of materials handling equipment types for handling different types of storage. It is very important to select the appropriate material handling equipment that should be fast, flexible and at an appropriate price. At the same time, there are several factors that affect the selection of the materials handling equipment. The warehouse facility, the product characteristics (weight, size, value and so on) and the time requirements all influence the type of materials handling equipment a company uses.

4.5.3 Order picking routing

Order picking process, defined as the process of retrieving items from storage locations in response to a specific customer request, is the most laborious and the most costly activity in a typical warehouse and takes up to 55% of warehouse total operating costs. [TWBFT 03] It is labor intensive task and requires special attention. Order picking systems can be classified according to different criteria such as man to goods or goods to man, or full automatic to full manpower. Nowadays, new picking procedures, such as Pick-to-light, Voice-directed picking and others, have emerged in the man to goods

procedures. Top technology is sometimes not necessary in the order picking procedure for small and middle companies. Therefore, a simple and easy handling system seems more practical and at a lower investment for a company with a limited budget.

A standard research circumstance, is a simple picking procedure of man to goods with the companion of a forklift as a carrier. An optimized picking route should be a direct and efficient method in order to increase the picking effectiveness by shortening the picking time.

Calculation method of the order picking system

1) Description of the warehouse:

1. Each picking position is assigned to a corresponding pallet place.
2. Two upper levels of the shelf are assigned as a reserve storage and the bottom level as a picking area. In other words, the picking activities happen only in a horizontal dimension (X) and the vertical dimension (Y) is not related.
3. Shelves are commonly used with a width of 1.8 meters or 2.7 meters for 2 or 3 side by side placed pallets and the shelf depth is of 1.1 meters and the center distance between aisles (W_a) is 5 meter.

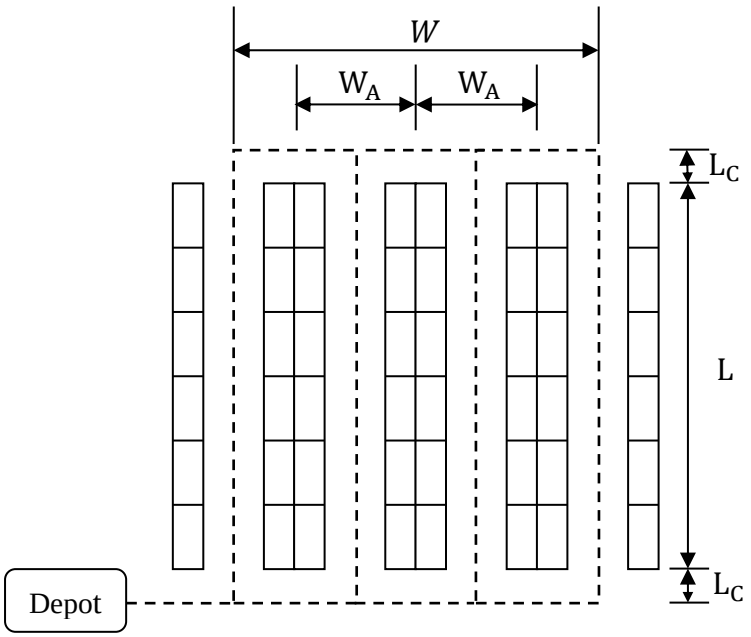


Figure 4-29 Dimension of the warehouse layout [SAD 07]

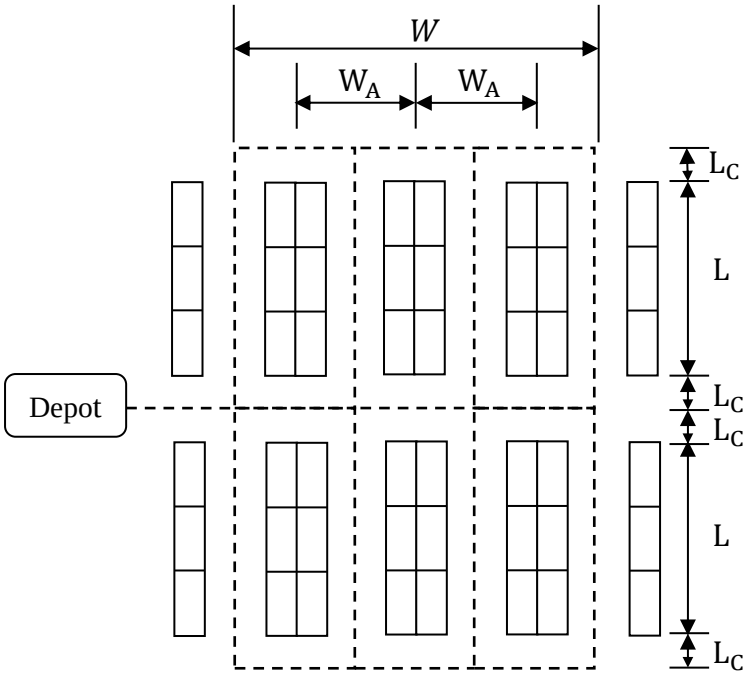


Figure 4-30 Dimension of the warehouse layout with central path [SAD 07]

There is no big difference between two layouts. The distance between the first and last aisle can be saved, if the picker retrieves the objects from both sides of the shelves successively from the central path before going forward to finish picking in relation to a layout with a central path. The upper side of the layout in Figure 4-30 is very similar to the layout in Figure 4-29 and the only difference is the fact that the aisle length is half the size of the one without the central path. The layout in Figure 4-29 is recognized as the basic layout of the warehouse in the following calculation.

Let:
s_n = The length of the order picking route for n position
s_r = The length of the order picking route for r position in one aisle
s_{AD} = The sum of the distances within the aisles
s_B = The sum of the basic path
s_{ACP}= The sum of the Aisle change path
N_A = Number of aisles
L = Aisle length
W_A = Center distance between aisles
W = Distance between the first and last aisle
L_c = The distance between the end of the aisle and aisle changing path
M = Number of products
M_A = Number of products in an aisle
n = Number of products per picking
r = Number of positions that are picked in an aisle
λ = Exponential distribution parameter

In general, if the distribution of the article in one aisle is known and the random variable for the longest distance from the beginning of the aisle is defined as $X_{(n)}$, the cumulative

distribution function $F_{x_{(n)}}(x)$ can be described after the statistic of [GB 04] and [MGB 73],

$$F_{x_{(n)}}(x) = [F(x)]^n \quad (4.7) \text{ [SAD 07]}$$

Thus, the derivation $f_{x_{(n)}}(x)$ can be further described as,

$$f_{x_{(n)}}(x) = n \cdot [F(x)]^{n-1} \cdot f(x) \quad (4.8) \text{ [SAD 07]}$$

If n article are picked in one aisle, the expected value of the middle distance from the beginning of the aisle is defined as $E(X_{(n)})$ and because the picker goes back to the beginning of the aisle after the last pick, the total picking route in this aisle is two times the expected value,

$$S_n = 2 \cdot E(X_{(n)}) \quad (4.9) \text{ [SAD 07]}$$

And because of the general definition of expected value, the maximal expected value of n picks can be described as,

$$E(X_{(n)}) = \int_0^\infty x \cdot f_{X_{(n)}}(x)\, dx$$
$$= \int_0^\infty x \cdot n \cdot f(x) \cdot [F(x)]^{n-1}\, dx$$

Thus, the picking route S_n is as expected,

$$S_n = 2 \cdot \int_0^\infty x \cdot n \cdot f(x) \cdot [F(x)]^{n-1}\, dx \quad (4.10) \text{ [SAD 07]}$$

Uniform distribution describes the random item storage in the warehouse, no matter how frequently the item is picked, the distance from the item position to the entrance of the aisle and its picking rate appears to belong to a uniform distribution, see Figure 4-31 (1). The formula of uniform distribution can be described as $f(x)$ and further the cumulative distribution function $F(x)$ and the expected value $E(x)$

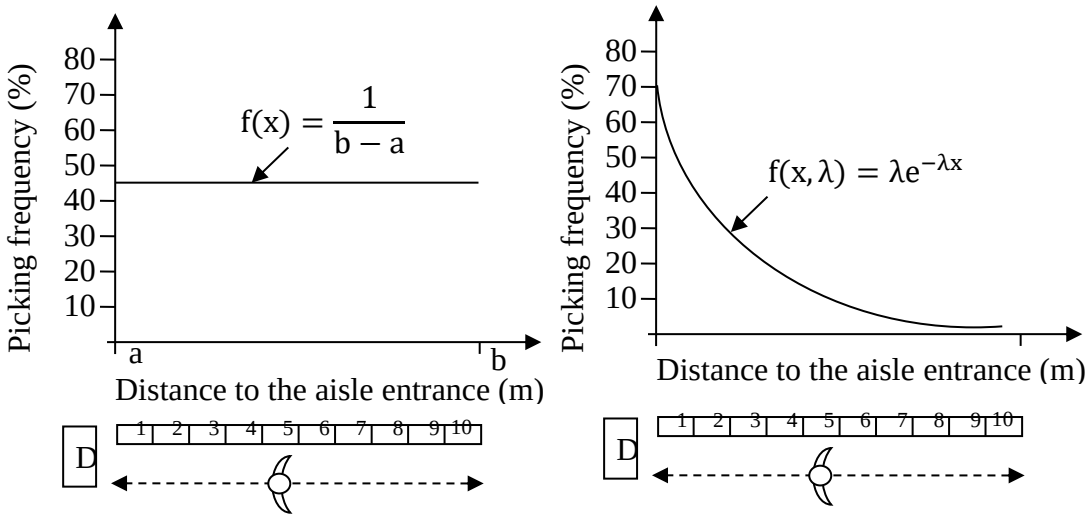
$$f(x) = \begin{cases} \frac{1}{b-a}, & for\ a \le x \le b \\ 0, & elsewhere \end{cases} \quad (4.11) \text{ [SAD 07]}$$

$$F(x) = \begin{cases} \frac{x-a}{b-a}, & for\ a \le x \le b \\ 0, & elsewhere \end{cases} \quad (4.12) \text{ [SAD 07]}$$

$$E(x) = \frac{a+b}{2} \quad (4.13) \text{ [SAD 07]}$$

Exponential distribution means addressing the item in some specific order, and one example is using ABC analysis, where items are categorized according to the relationship between item amount and picking rate whereas A-article, which possesses

the highest picking rate, will be located closer to the entrance of the aisle and will be followed by B- and C-articles. Thus, the distance between the item position to the entrance of the aisle and the picking rate appears to belong to an exponential distribution, see Figure 4-31 (2). Thus, the exponential factor λ is involved in the formula (4.14), (4.15), (4.16)



(1) Uniform distribution (2) Exponential distribution

Figure 4-31 Uniform and exponential distribution

λ is the parameter of the exponential distribution and is often called the *rate parameter*. It can be calculated based on the cumulative distribution function of the exponential distribution.

$$f(x;\lambda) = \begin{cases} \lambda e^{-\lambda x}, & for\ x \geq 0 \\ 0, & for\ x < 0 \end{cases} \quad (4.14)\ [SAD\ 07]$$

$$F(x;\lambda) = \begin{cases} 1 - e^{-\lambda x}, & for\ x \geq 0 \\ 0, & for\ x < 0 \end{cases} \quad (4.15)\ [SAD\ 07]$$

$$E(x) = \frac{1}{\lambda} \quad (4.16)\ [SAD\ 07]$$

It is obvious from all of the above formulas that the picking route is not only affected by the picking strategy but that some other factors also play an important role. Some of the other factors are the size and shape of the warehouse, the shelf length and the amount, the product amount and the storage strategy. In other words, for different stock amounts and warehouse layouts, routing policies of order picking should be changed in relation the aforementioned variables. To prove this theoretical result, the method of choosing a suitable routing policy is demonstrated in the next chapter according to different cases.

By order picking, the picker should receive the order list from the depot location and take an empty carrying device. The picking route that starts from the depot location to the first aisle is called the basic path, and the distance from one aisle to another aisle is called aisle change path. The distance from one picking position to another picking position is called the aisle path. This procedure is shown below.

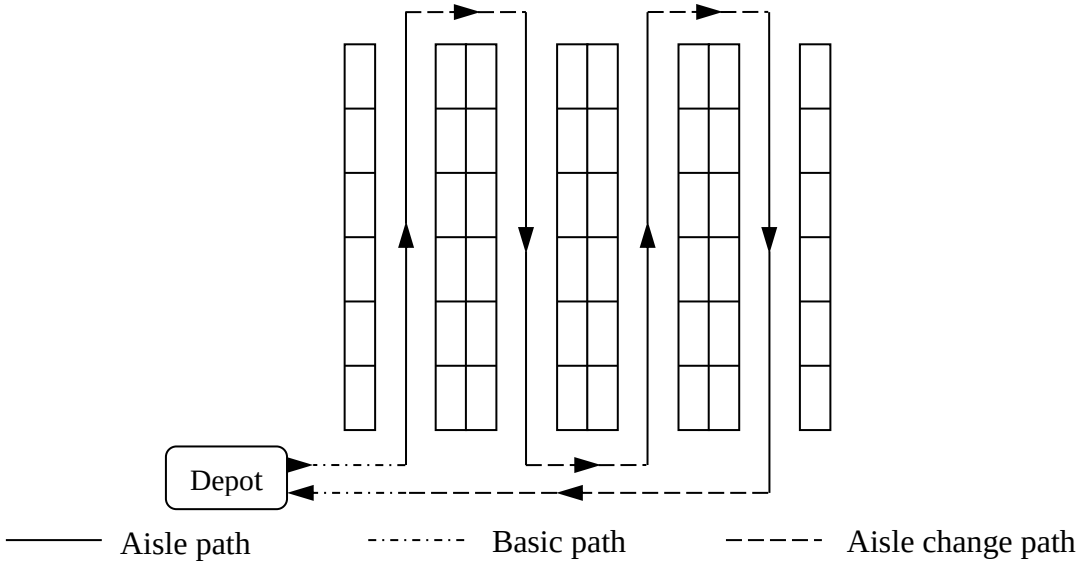


Figure 4-32 Order picking route illustration [SAD 07]

Therefore, the total picking route consists of three parts. These are basic path, aisle change path and aisle path. The calculation can be formularized as below.

$$\boldsymbol{s_n = s_B + s_{AD} + s_{ACP}} \quad (4.17)\ [\text{SAD 07}]$$

2) Calculation the length of basic path s_B:
Usually the pickers start and end the picking route at the same point (depot). This is called the central depot. This depot can be located anywhere in the warehouse either at the left side, the right side or in the middle of the front or the end of the warehouse. It can also be located inside or outside the order picking district. If the depot is located inside the order picking district then the basic path is zero.

Sometimes, pickers drop off goods at another location which is not the original starting depot and this is then called the decentral depot. The setup of the decentral depot leads to more warehouse space occupation and conveyors. The central depot can be simply assumed as inside the picking area and in this case means s_B=0.

3) Calculation the length of Aisle change path s_{ACP}:
The calculation of s_{ACP} can be formularized differently in two cases, when pickers have to go through all aisles to finishing the order picking,

$$s_{ACP} = 2 \cdot W \quad (4.18)\ [\text{SAD 07}]$$

The second case, the pickers go through the aisles which stores the desired goods on the order list. The following formula describes this situation.

$$s_{ACP} = 2 \cdot \frac{n}{n+1} \cdot W \quad (4.19)\ [\text{SAD 07}]$$

4) Calculation order picking route within the aisles s_{AD}:
According to Volker Sadowsky [SAD 07], the order picking route within the aisles under a different strategy can be accurately calculated as follows:

Return strategy:

Return strategy with repetition:

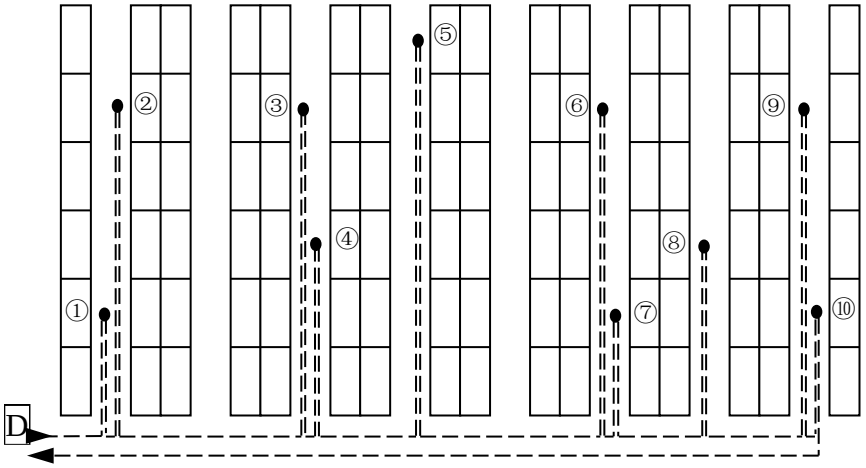


Figure 4-33 Return strategy with repetition [SAD 07]

In this case, in consideration of the number of products per picking n and the possibility of each product in the aisle $f(x)$, the aisle length L, the additional distance L_c and factor 2, causes the picker to have to go back through the same route in the aisle. The distance between the aisles can be calculated using the following formula,

$$S_{AD} = 2 \cdot n \cdot \left(L_c + L \cdot \int_0^{\infty} x \cdot f(x)\, dx \right) = 2 \cdot n \cdot \left(L_c + L \cdot E(x) \right) \quad (4.20)\ [\text{SAD 07}]$$

For uniform distribution and exponential distribution the expected value $E(x)$ is different and thus, the formula can be rewritten as,

Uniform distribution, where $a = 0, b = 1$:

$$s_{AD} = 2 \cdot n \cdot \left(L_c + \frac{1}{2} L \right) \quad (4.21)\ [\text{SAD 07}]$$

Exponential distribution:

$$s_{AD} = 2 \cdot n \cdot \left(L_c + L \cdot \frac{1}{\lambda} \right) \quad (4.22)\ [\text{SAD 07}]$$

Return strategy without repetition:

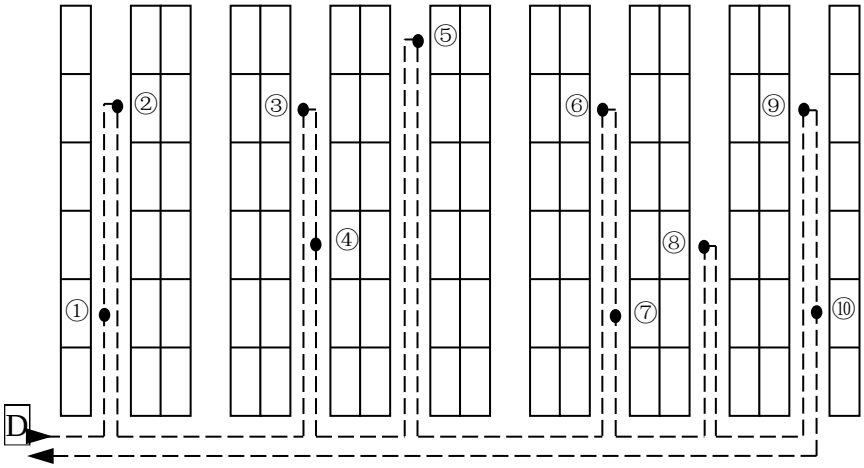


Figure 4-34 Return strategy without repetition [SAD 07]

In this case, the total picking route within the aisle contains the factor S_r, which represents the picking route in one aisle for r position and its probability of occurrence $p_{total}(r)$, and here the restriction of r is from 1 to n, due to the fact that there is a maximal n position in one aisle. The picking route within the aisle can be described as,

$$S_{AD} = 2 \cdot (\sum_{r=1}^{n} p_{total}(r) \cdot S_r) \qquad (4.23)\ [\text{SAD 07}]$$

If $p_i(r)$ is defined as the possibility of occurrence for r position in aisle i and there are N_A aisle in the warehouse, the total probability can be deduced as,

$$p_{total}(r) = \sum_{1}^{N_A} p_i(r) \qquad (4.24)\ [\text{SAD 07}]$$

And the assumption is made that the number of articles and the possibility of picking pro aisle are the same, so the value of $p_1(r)$, $p_2(r)$ … $p_{N_A}(r)$ is also the same, thus,

$$p_{total}(r) = N_A \cdot p(r) \qquad (4.25)[\text{SAD 07}]$$

In consideration of formula (4.23) and (4.24),

$$S_{AD} = 2 \cdot N_A \cdot \sum_{r=1}^{n} p(r) \cdot S_r \qquad (4.26)\ [\text{SAD 07}]$$

As mentioned before in formula (4.9), therefore,

$$S_r = 2\left(L_C + L \cdot \int_0^{\infty} x \cdot r \cdot f(x) \cdot [F(x)]^{r-1}\, dx\right) \qquad (4.27)\ [\text{SAD 07}]$$

In order to calculate the picking route within the aisle, the probability of r position from total n position in one aisle should be decided first,

$$p(r) = \frac{\binom{M_A}{r} \cdot \binom{M-M_A}{n-r}}{\binom{M}{n}} \qquad r = 0,1,2,\dots,n; \quad n \le M_A \qquad (4.28)\ [\text{SAD 07}]$$

Here, $\binom{M_A}{r}$ represents the number of possibilities to pick r position in one aisle with M_A articles, $\binom{M-M_A}{n-r}$ represents the number of possibilities for the rest picking position n-r in the other aisle with $M - M_A$ articles and the total possibility for n position in M articles $\binom{M}{n}$.

In summary, the picking route within the aisle can be deduced as,

$$S_{AD} = 2 \cdot N_A \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A}{r} \cdot \binom{M-M_A}{n-r}}{\binom{M}{n}} \left(L_C + L \cdot \int_0^{\infty} x \cdot r \cdot f(x) \cdot [F(x)]^{r-1}\, dx \right) \right] \quad (4.29)\ [\text{SAD } 07]$$

Therefore, for uniform distribution:

$$s_{AD} = 2 \cdot N_A \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A}{r} \cdot \binom{M-M_A}{n-r}}{\binom{M}{n}} \cdot \left(L_c + L \cdot \frac{r}{r+1} \right) \right] \quad (4.30)\ [\text{SAD } 07]$$

Exponential distribution:

$$s_{AD} = 2 \cdot N_A \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A}{r} \cdot \binom{M-M_A}{n-r}}{\binom{M}{n}} \cdot \left(L_c + L \cdot \frac{1}{\lambda} \cdot \sum_{k=1}^{r} \frac{1}{k} \right) \right] \quad (4.31)\ [\text{SAD } 07]$$

Midpoint strategy

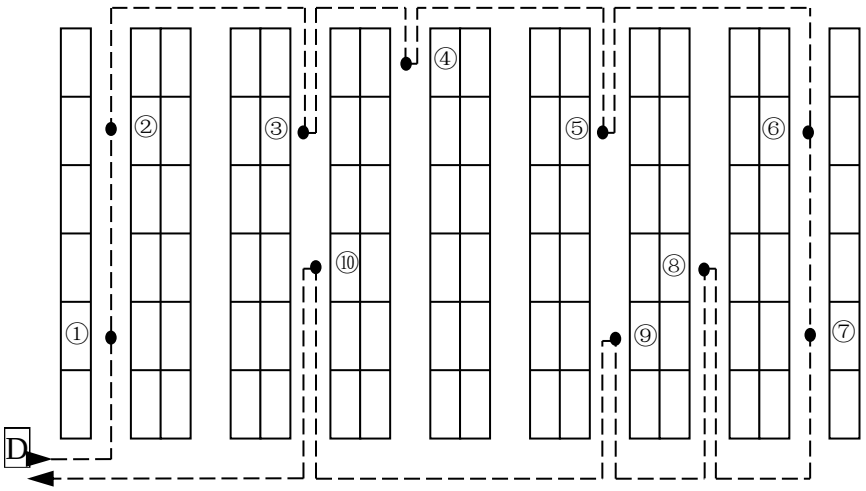


Figure 4-35 Midpoint strategy [SAD 07]

The midpoint strategy can be considered as two times return strategy without repetition in the case that the warehouse can be separated into two parts. In consideration of the first aisle and the last aisle being included in the picking route within the aisle the operation can described as,

$$S_{AD} = 2 \cdot (2 \cdot L_C + L) + 2 \cdot N_A^* \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A^*}{r} \cdot \binom{M-M_A^*}{n-r}}{\binom{M}{n}} \left(L_C + L^* \cdot \int_0^{\infty} x \cdot r \cdot f(x) \cdot [F(x)]^{r-1}\, dx \right) \right] \quad (4.32)\ [\text{SAD } 07]$$

Where, $N_A^* = 2 \cdot (N_A - 2) \qquad N_A > 2$

$M_A^* = \frac{M_A}{2}$

$L^* = \frac{L}{2}$

According to Sadowsky [SAD 07] as a reference, the following formulas are corrected and being used for uniform distribution:

$$s_{AD} = 2 \cdot (2 \cdot L_C + L) + 4 \cdot (N_A - 2) \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A/2}{r} \cdot \binom{M - M_A/2}{n-r}}{\binom{M}{n}} \cdot \left(L_C + \frac{L}{2} \cdot \frac{r}{r+1} \right) \right] \tag{4.33}$$

And exponential distribution:

$$s_{AD} = 2 \cdot (2 \cdot L_C + L) + 4 \cdot (N_A - 2) \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A/2}{r} \cdot \binom{M - M_A/2}{n-r}}{\binom{M}{n}} \cdot \left(L_C + \frac{L}{2} \cdot \frac{1}{\lambda^*} \cdot \sum_{k=1}^{r} \frac{1}{k} \right) \right] \tag{4.34}$$

In this case, λ^* is the exponential factor for each side of the aisle. In the case that the ABC classification is equally separated for both sides, the value of λ^* is the same.

$$\lambda^* = \lambda_1 = \lambda_2 \tag{4.35}$$

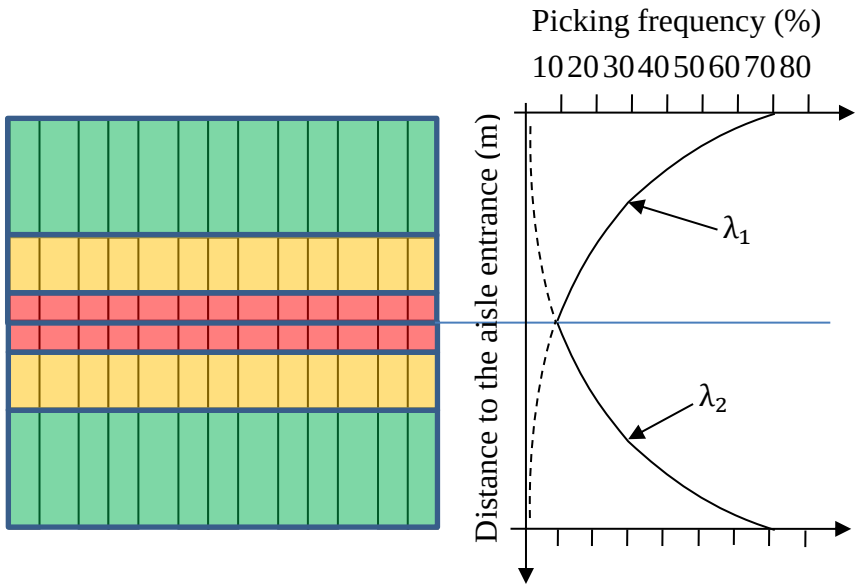


Figure 4-36 Equally separated ABC classification for both sides of the aisle

In this case, the ABC classification is not equally separated for both sides of the aisle. The value of λ_1 and λ_2 should be recalculated first and then after formula (4.34), for exponential distribution with midpoint strategy, the formula can be deduced as follows.

Exponential distribution:

$$s_{AD} = 2 \cdot (2 \cdot L_C + L) + 2 \cdot (N_A - 2) \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A/2}{r} \cdot \binom{M - M_A/2}{n-r}}{\binom{M}{n}} \cdot \left(L_C + \frac{L}{2} \cdot \frac{1}{\lambda_1} \cdot \sum_{k=1}^{r} \frac{1}{k} \right) \right] + 2 \cdot (N_A - 2) \cdot \sum_{r=1}^{n} \left[\frac{\binom{M_A/2}{r} \cdot \binom{M - M_A/2}{n-r}}{\binom{M}{n}} \cdot \left(L_C + \frac{L}{2} \cdot \frac{1}{\lambda_2} \cdot \sum_{k=1}^{r} \frac{1}{k} \right) \right] \quad (4.36)$$

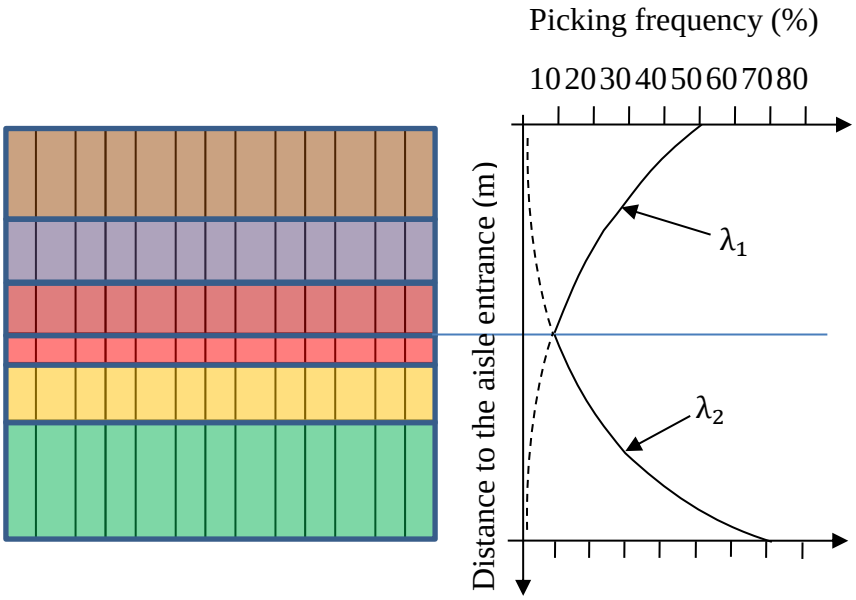


Figure 4-37 Unequally separated ABC classification for both sides of the aisle

Transversal (S-shape) strategy:

Transversal strategy without skipping

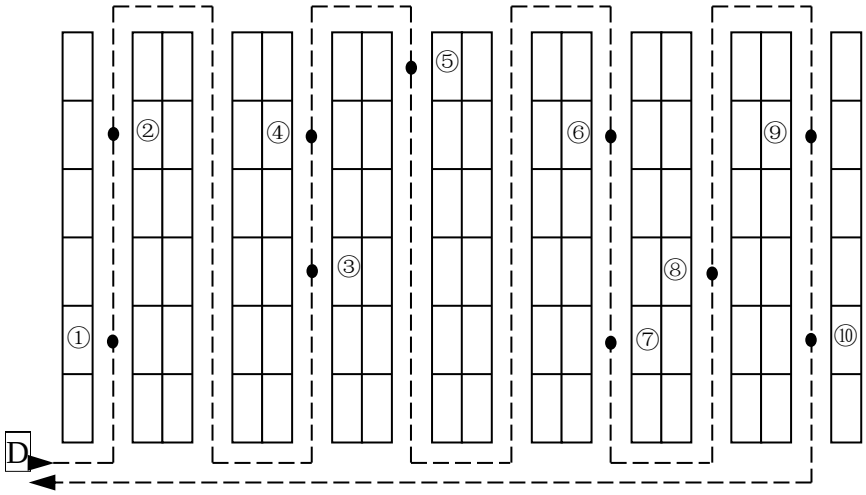


Figure 4-38 Transversal strategy without skipping [SAD 07]

$$s_{AD} = \begin{cases} N_A \cdot (L + 2 \cdot L_c) & N_A \; is \; an \; even \; number \\ (N_A + 1) \cdot (L + 2 \cdot L_c) & N_A \; is \; an \; odd \; number \end{cases} \quad (4.37) \text{ [SAD 07]}$$

If N_A is an even number, the picking route within the aisles equals the number of aisles multiplied by the sum of aisle length and two times the distance between the end of the aisle and the aisle changing path. But if N_A is an odd number, for the last aisle, the picker cannot finish the picking at the other side of the aisle, and that's why there is an extra aisle length and two times the distance between the end of the aisle and the aisle changing path for the picker to go back to the other side of the aisle.

Transversal strategy with skipping

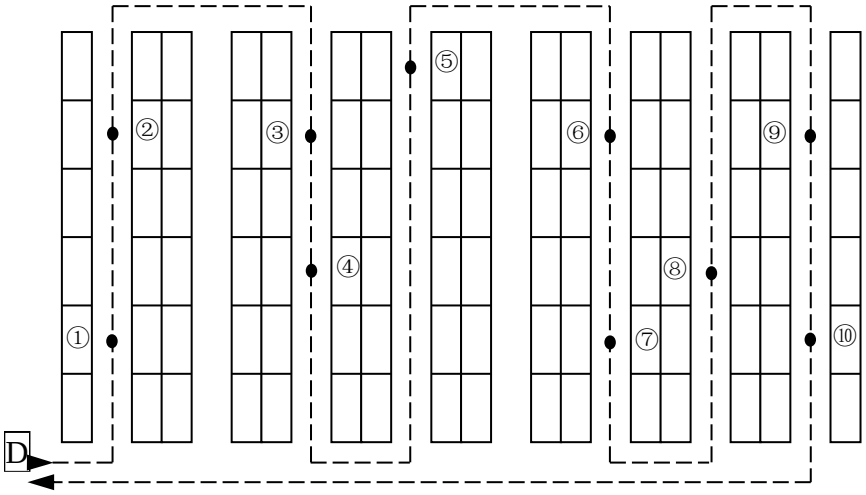


Figure 4-39 Transversal strategy with skipping [SAD 07]

If one article should be picking in one aisle, the picking should go through this aisle, and this means that the distance is $2 \cdot L_C + L$ and the probability can be represented as $\sum_{r=1}^{n} p(r)$, therefore, the picking route within the aisle can be described as,

$$S_{AD} = (2 \cdot L_C + L) \cdot N_A \cdot \sum_{r=1}^{n} p(r) \qquad (4.38)\ [\text{SAD } 07]$$

It is clear that the sum of all probabilities is 1 and therefore,

$$\sum_{r=0}^{n} p(r) = 1$$

$$\sum_{r=1}^{n} p(r) + p(0) = 1$$

$$\sum_{r=1}^{n} p(r) = 1 - p(0) \qquad (4.39)\ [\text{SAD } 07]$$

The formula (4.38) can be deduced as,

$$S_{AD} = (2 \cdot L_C + L) \cdot N_A \cdot \big(1 - p(0)\big) \qquad (4.40)\ [\text{SAD } 07]$$

The probability can be calculated with formula (4.27),

$$p(r) = \frac{\binom{M_A}{0} \cdot \binom{M-M_A}{n-0}}{\binom{M}{n}} = \frac{\binom{M-M_A}{n}}{\binom{M}{n}} \qquad (4.41)\ [\text{SAD } 07]$$

In summary, the picking route within aisles with transversal strategy with skipping can be described as,

$$s_{AD} = N_A \cdot (2 \cdot L_c + L) \cdot \left[1 - \frac{\binom{M-M_A}{n}}{\binom{M}{n}}\right] \qquad (4.42)\ [\text{SAD } 07]$$

4.6 Reverse logistics strategy

4.6.1 Reduce return rate

Reducing return rates to even a single percentage point can result in a substantial improvement of the overall profitability [RIV 02]. But it is not easy to reduce returns by tightening the return policies, because it also leads to the loss of large numbers of customers.

As Dana Dubbs [DUB 01] stated, good product quality and efficient logistics programs in relation to the forward side invariably reduces the number of returns on the reverse side. Therefore, the information is collected about return products and identifies the return reasons and the ration of the occurrence of such returns. Then, through the system design and processes improvement of forward logistic, some returns can be controlled and avoided. As shown in the following table:

Table 4-17 Reasons and solutions for return

Returned product	Reasons for return	Percent		Corresponding solution
		B2B	B2C	
Inferior product	Manufacturer defect	25%	15%	Choose supplier with good product quality and highly reliable credit
	Dead on arrival	20%	15%	Strengthen inbound quality control
Damaged product	Damaged during storage	5%	5%	Storage according to the product attribute; rationally arrange the storage space
	Damaged during material handling process	5%	5%	Prevent incorrect operation of the material handling equipment and product
	Damaged during delivery	5%	10%	Choose appropriate internal cushioning material and external packaging to protect product
Delayed product	Order processing delay	5%	5%	Improve the efficiency of information processing, such as staff training, computer operating system updates, etc.
	Material handling delay	5%	10%	Improve the efficiency of material handling process, such as order picking system optimization
	Delivery delay	10%	10%	Quote the delivery time longer than expected; allow customer to track their orders
Wrong product	Product description deviation	5%	5%	Make product descriptions accurately
	Wrong product ordered	5%	15%	Provide consumer guide und real-time service
	Wrong product delivered	10%	5%	Before delivery, check product according to the order

4.6.2 Reverse logistics system layout

Once the company provided a return policy it became almost impossible to achieve a 0% return rate. The establishment of an effective system of Reverse Logistics is the key method to reduce costs, increase revenue and improve customer satisfaction.

Reverse logistics system

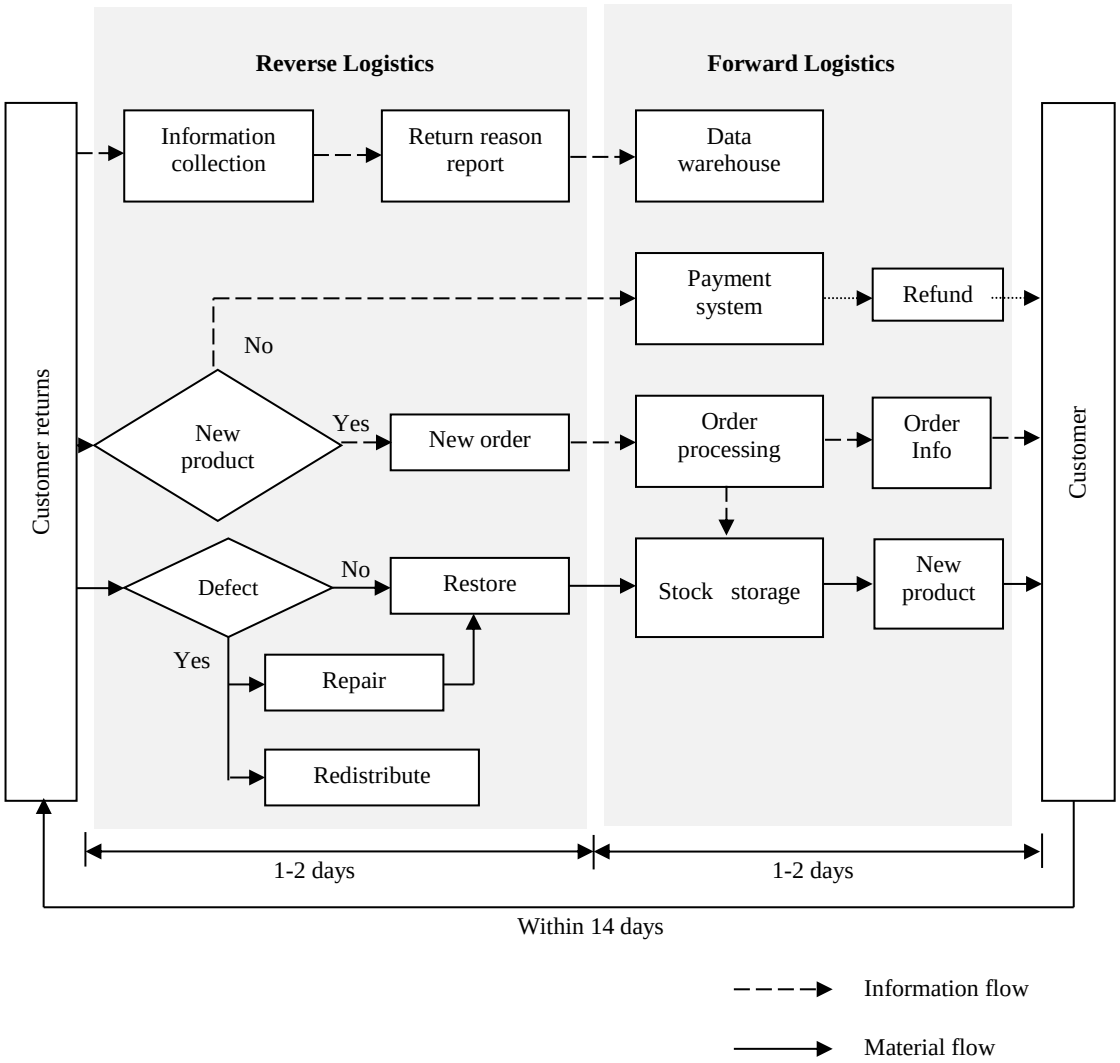


Figure 4-40 Reverse logistics system

In the model depicted above, customers can return any item within 14 days and then the e-company receives the returned products and records detailed information (model, size, color, number etc.) about the product. This usually takes 1-2 days. This collected information will be used to analyze the reasons for the return. At the same time, if the customer still needs this product then a new order will be sent and a new product will be delivered in 1-2 days for the second time. If not, the money will be paid back to the customer. After receiving the defective product from the customer, the e-company will make a test on the returned product to determine if the product is still new and just needs to be restored, or if only the package is damaged and needs to be repacked, or the product doesn't work anymore and must be repaired. So if the returned product can still not be sold as a new product after the repackaging or the repair then, instead, it will be needed to be returned to the manufacturer and the e-company will keep these products and obtain compensation from the manufacturer according to the contract. Since most of the products are manufactured in China or other foreign countries. For manufacturers, the costs of recovering defect products and disposing them are generally higher than the value of these product themselves. After that, there are several ways to

redistribute them and some of them can also be part of a value recovery process. Some of these are outlined below.

Sell via outlet: Returned products which have only a cosmetic defect, and still have the capacity to work, will be sold as an obsolete product at low prices online or in warehouses regularly.

Sell to secondary market: Firms buy these products at low prices and then sell them to other markets in less developed countries or underdeveloped areas.

Donation: A product that is usable but needs some reparations, or is outdated, is given to a charitable organization is an alternative. This option can lead to tax advantages [RT 99].

Destroy: The last option is to dispose of the returned product. If these products are useless then to keep them in warehouse is just a waste of storage space. These kind of products should be thrown away in a timely manner.

In addition, some attention should be paid to the following aspects:

a) Defect and not defect
   Returned products can simply be divided into defect and not defect. If the returned product is defect then the return cost and the redelivery cost of a substitute product will be paid by the seller. However, if the returned product is not defect and the return is caused by the customers' own mistakes then the return cost will be paid by the customer themselves. In addition, sometimes the contracted delivery company is responsible for the return and delivery cost as their work may lead to product damage and delay and this can also result in a product return.

b) Return or retain
   The e-company should also determine whether to ask the customer to return the product or not related to the defect product. For example, a customer has bought five products and one of them does not work. In this situation the return cost will be paid by the seller as mentioned before. So if the product cost is less than the return cost then it is more economical to let the customer keep the product and send another instead.

c) B2C reverse logistics ≠B2B reverse logistics
   From Table 4-17, we can also find that most of the returned products in B2B e-commerce are either defect or delayed and wrong products, whereas the latter representing a small percentage in comparison with defect products, since B2B customers usually keep a safety stock to meet uncertainties such as supply delay unlike end-users who occasionally buy on impulse. However, once B2B customers receive defect products their risk of stockout will be increased significantly. Therefore the reverse logistics must "speed-up" dealing with B2B product returns. Specifically, the substitute product should be delivered a second time after the receipt of the returned information rather than at the receipt of the returned product in B2C reverse logistics.

4.6.3 Simplify the process of customer returns

According to a study [MAR 09] there is a direct correlation between flexible return practices and future customer orders. 85% of online shoppers have stated that they would not buy again from the company if the returns processes were not convenient. On the contrary, 95% of the customers reported they would buy again if the returns process was convenient. Therefore, making the returns process easier can not only compensate the negative impact of defective products but also win the customers back to the company.

There are some approaches which are used by the e-company to make customer returns process easy and convenient:

Keep customer informed
Once the e-company receives the returned product or sends out the substitute product or refunds the customers' money then the e-company informs the customer immediately. A real time status update supports the customer's return service.

Provide return shipping label
A return shipping label from the shipping carrier will be sent together with the product which lets the customer easily know how to send the products back in the case that it is necessary.

Make refund as fast as possible
Customers will generally be more willing to make an online purchase if they find that they will be refunded quickly for any product that they have returned.

4.7 Cash flow in online business

Cash Flow is nicknamed the 'lifeblood' of all businesses and it is the primary indicator of business health. It is generally acknowledged that a company's cash flow is the movement of cash in and out of the company in the form of payments to suppliers and payments from customers [7]. Cash flow can be described as a cycle that involves cash inflows and outflows.

Cash inflows are the money coming into your account:
- Money from the sale of your products
- Loans of bank
- Tax repayments
- Interest of company accounts

Cash outflows are the money going out of your account:
- Purchasing products
- Purchasing fixed assets
- Purchasing office material
- Paying salaries, rent, etc.
- Paying taxes
- Paying loan and interest

Cash flow can not only be understood as incoming and outgoing flows, furthermore it can be categorized in relation to different activities. Therefore, we distinguish the cash flows into operating cash flows, investing cash flows and financing cash flows [MCK 04].

Operating cash flow includes all revenues, fees, contributions, and interest received and all cash paid in regard to resources consumed to provide goods and services.

Investment cash flow involves acquisitions of long-term assets during a fiscal period.

Financing cash flow includes cash flows resulting from borrowing or reporting debt [MCK 04].

Table 4-18 Classifying cash flow into operating, investing, and financing activities [MC 05]

Classifying Cash Flow into Operating, Investing, and Financing Activities	
Cash provided or used by operating activities	Cash collected from customers for sales Cash payments to employees and suppliers Interest paid Income taxes paid
Cash provided or used by investing activities	Cash disbursements and collections from making and collecting loans Investments made and proceeds from sales of investments in debt and equity instruments Cash disbursements from the purchase and cash proceeds from the sale of property, plant, and equipment
Cash provided or used by financing activities	Principal amounts borrowed and repaid on debt Proceeds from the issuance and cash disbursed in the repurchase of equity securities Dividends paid

4.7.1 Healthy cash flow creation

Cash flow management is the management of incoming and outgoing cash flow to make a financial balance. It is not easy just to pay the bills and check the account, but for most of the time, a balance from short-term purchasing performance, middle-term capital operation and long-term business development.

The cash flow is extremely critical in the beginning phase of an online business. Each category of cash flow should be observed to avoid the gap between cash inflows and cash outflows. Therefore, a cash flow analysis is necessary in regards to cash flow management. Cash flow analysis, regardless of financial aspects, involves examining the activities of the business that affects the cash flow and further back tracking into area of supply chain management.

For small business financing, a shortage of cash flow can be the death of the company. Therefore, to roll the business bigger and to get a healthier cash flow, a balance of inventory level and cash flow, furthering the entire supply chain is critical to the small business' money management. On the contrary, back tracking to the causes of cash flow problems that are apparently related to money management, the initiator could actually have an insufficient inventory capacity of specific products. In the era of small profit society, the profit and loss curve in cash flow might simply be affected by the means of transport, the payment of suppliers or even the appointment to meet the customers' desire.

Shown in Figure 4-41, the material flow of a small business originates from the suppliers. As the only transit station, warehouses which connect the physical flow of materials between suppliers and customers deliver more value-added services and fulfill the desires of customers and play the critical role in the center. In the other direction, the cash flow comes from customers and then flows backwards to the supplier. This has the effect that the profit in the company's account shows not merely the price difference. Other costs, such as operation costs, transport costs, taxes, even a long-term debt are the bypass flow of the total profit and in other words, are all connected to the cash flow and related to the money management.

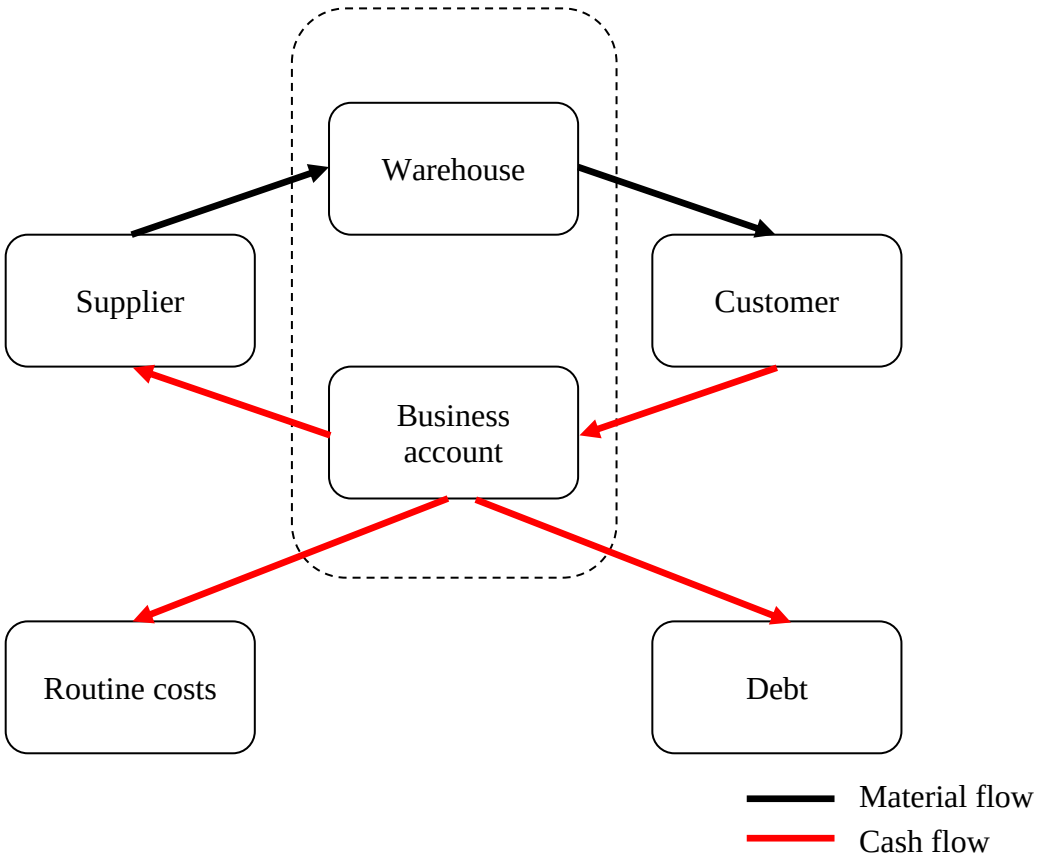


Figure 4-41 Material flow and cash flow in e-company

Basically, a healthy cash flow is always shown in an upwards curve as in Figure 4-42. The monthly money income covers all costs and makes a surplus. This ensures further operation activities and the next wave of inventory reload. The cash flow can be downwards in some months, because of some events, such as outsourcing, settlement

of the debt, or delay of customer payment but all activities, which can possibly generate a negative impact on the cash flow should be restricted in a short time and to a small risk so that the total asset of the company can gradually grow as expected in Figure 4-43.

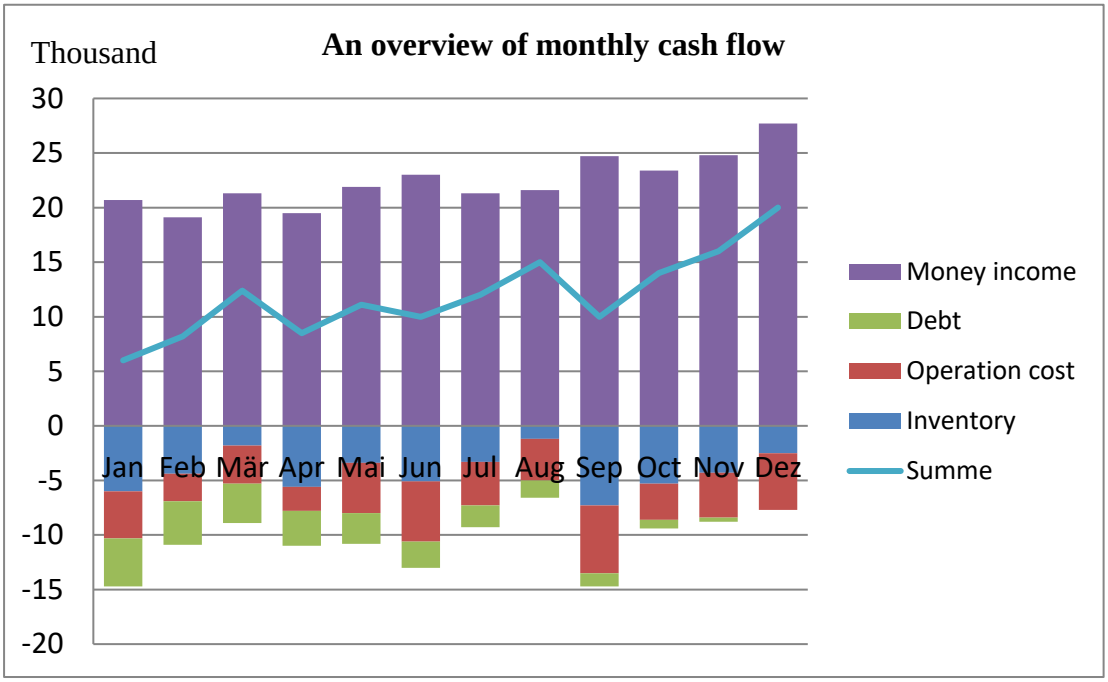


Figure 4-42 Healthy cash flow

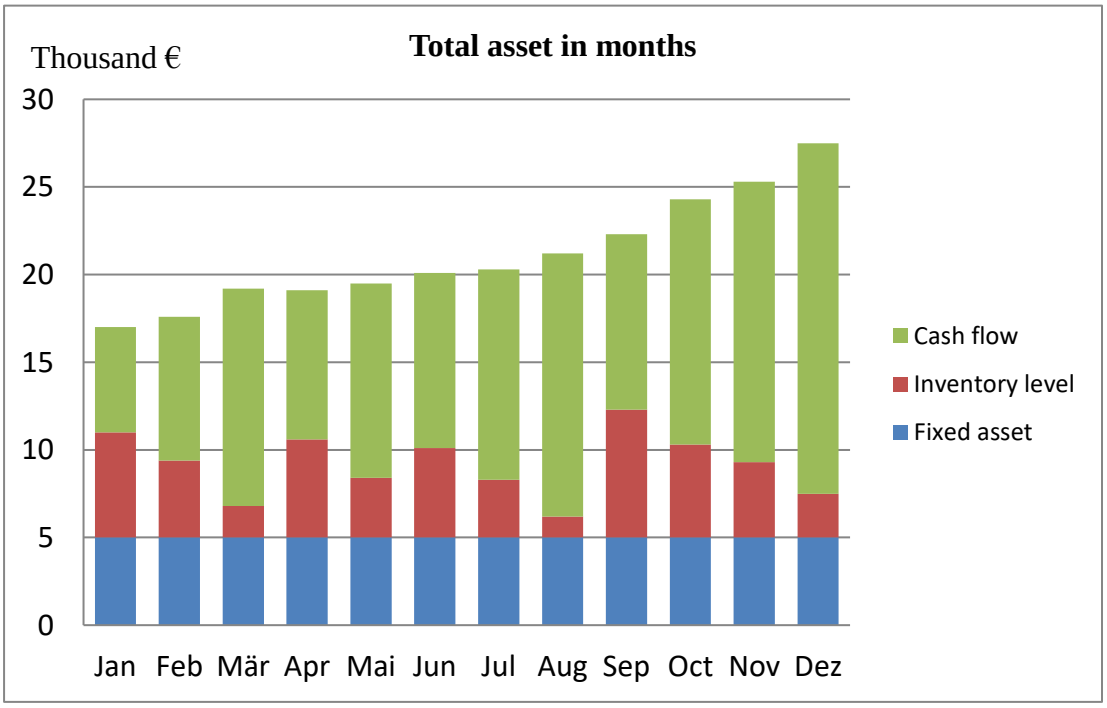


Figure 4-43 Total assets in months

So as to understand the cash flow and further introduce the strategy of money management, the composition of cash flow will be categorized into different branches as indicated in Figure 4-44.

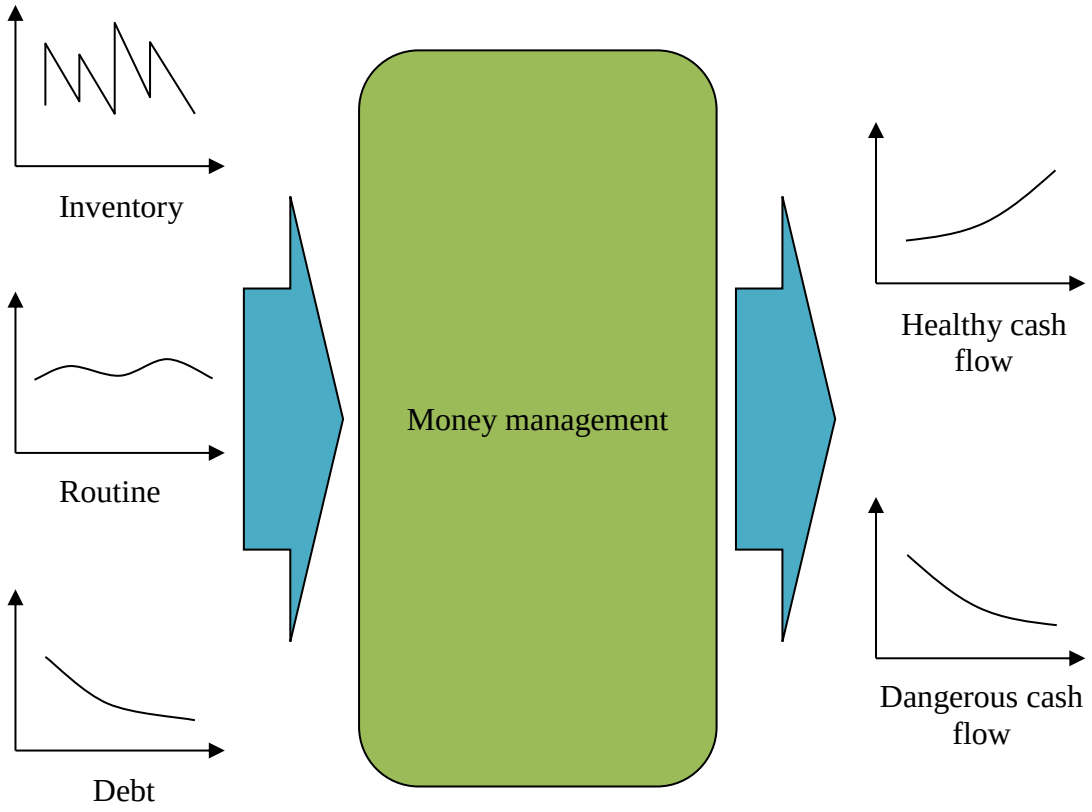


Figure 4-44 Trends of cash flow curves

In consideration of a real sales record, each individual curve has a different fluctuation trend and the curves are converged through money management, affected by the business decision, and further derived as total cash flow and this can lead to an upwards or downward trend caused by different business activities.

Some main factors of the typical zigzag curve, which indicate the inventory status, includes fixed inventory interval, safety stock, maximum stock level and inventory turnover. The change of these main factors can extremely affect the performance of cash flow as shown in Figure 4-45. The maximum stock level and inventory turnover are proportional to the cash flow and on the other hand, the inventory interval and safety stock are inversely proportional to the cash flow.

The routine costs include transport cost, operation cost of the company such as the salary of coworkers, rent for the warehouse and office etc. This matter of expense may take a big portion of the total expend to pay the deposit or purchase office equipment at the beginning of businesses. The routine cost is getting stable and slightly fluctuates from month to month as the business goes on.

Debt may not happen to every business depending on different business strategies in the short or long run. Furthermore the debt burden also differs in years.

For the income cash flow, the customer grasps the control panel and decides when, in which method and at which rate, they should proceed to the payment. This does not mean that the payment is out of control. A good money management takes the customer relationship and their credit into account and restricts the risk within an acceptable range.

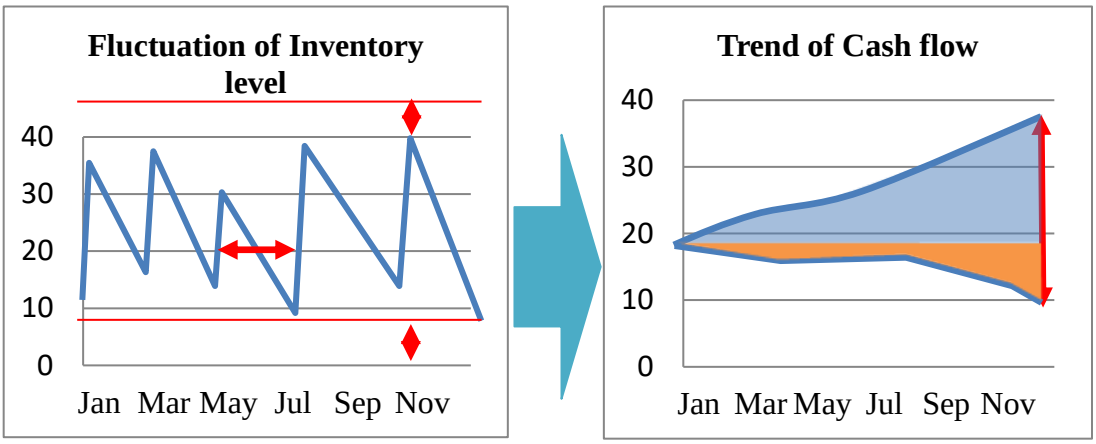


Figure 4-45 Effect of inventory level on cash flow

From the financial point of view, regardless of the spectrum of money management, money is spent with a well-thought-out plan in place where we expect a good profit. Therefore, money is the only carrier to the decision makers and thus, all strategies and activities are concentrated on the virtual figure. To go back to industry business, material flow and complete supply chain management dominates the business' success. The decision of money transfers cannot be made to exclude the consideration of the physical flow of material. Figure 4-46 lists the key factors in the supply chain management which has a feedback effect on the money management.

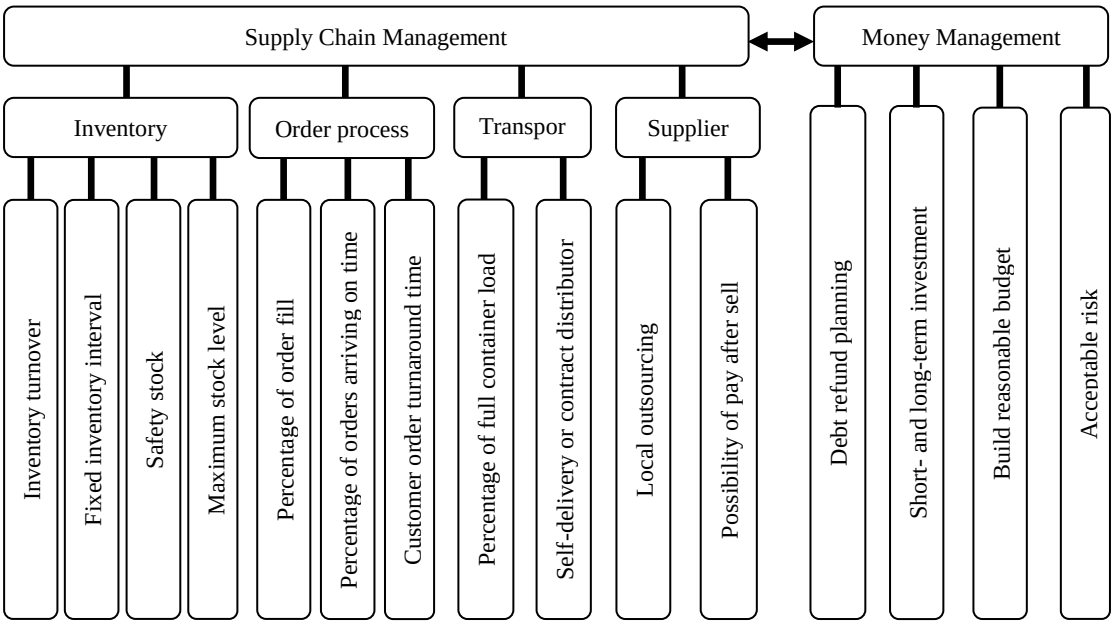


Figure 4-46 Key factors related in supply chain management and money management

4.7.2 Logistics cost management

The cash outflows in logistic systems can be categorized regarding different logistics activities. It involves the entire physical cost carrier along the supply chain from the supplier to the end customer and also relates to indirect cost carriers such as information exchange and communication. In some cases, a potential cost caused by shortage or

lack of supply are also included in the logistic cost. Basically, in the logistics system, logistics cost can be categorized into 8 types and will be shown as follows [JON 08]:

- Transportation and handling costs
- Package costs
- Inventory-carrying costs
- Administrative costs
- Ordering costs
- Capacity-related costs
- Shortage and delay costs
- Environmental costs

Transportation and handling costs related to the moving of goods originating from internal and external freight transportation and the packaging and damages of goods during handling.

Packaging costs include all costs related to packaging materials and the processes of packing and marking goods.

Inventory-carrying costs are generated by keeping goods in stock and can be further estimated as capital costs, storage costs and uncertainty costs.

Administrative costs include all those costs which are associated with long-time planning and operative management of material flows.

Ordering costs are those costs which can be attributed to the processing of purchase and manufacture orders.

Capacity-related costs are constituted by annual depreciation and costs for maintenance and the operation of plants. It involves the costs that are generated by the high expectations of limited productivity with a higher degree of utilization on other logistics resources.

Shortage and delay costs arise when a delivery cannot take place in accordance with a customer's wishes.

Environmental costs happen for many different reasons. The selection and performance of external transportation influences the environment through emissions, congestion, tyre wear, load on infrastructure, noise, etc.

Whilst logistics costs do vary by company and by industry, it is a fact that, across the economy as a whole, the total cost of logistics as a percentage of gross domestic product is estimated to be close to 10 per cent in the US [CHR 12] and in other countries costs of similar magnitudes can be seen.

Logistic impact on cash flow

However, logistics activity does not just generate cost but also revenue through the provision of availability. Thus, it is important to understand the effect that logistics and supply chain decisions have on profit.

4.8 Risk Management

4.8.1 Framework of risk management process

Risk refers to the uncertainty that surrounds future events and outcomes. It is the expression of the likelihood and impact of an event that has the potential to influence the achievement of an organization's objectives [RAU 11].

Risk management processes can be described as follows.

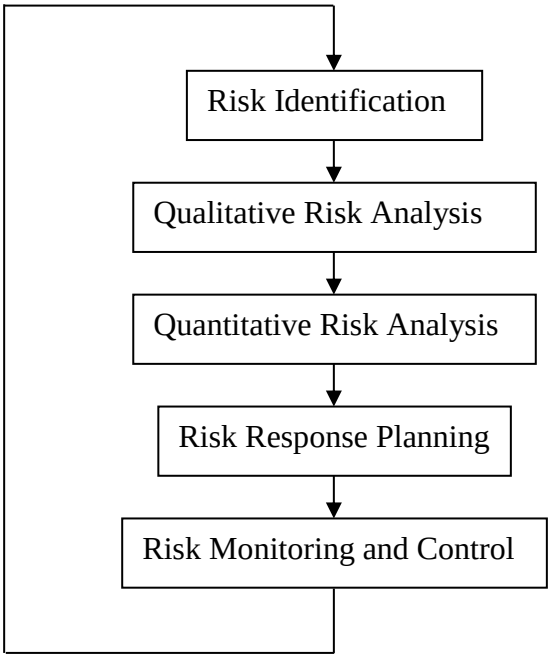


Figure 4-47 Risk management process

4.8.2 Risk Identification

Apparently, time, quality and expenditure dominate the success of the e-commercial activities and can be classified into different areas. The corresponding risks which are detected in the following categories can be summarized as operational risks, employee risks, financial risks and strategic risks.

Operational risks
Operational risks are associated with the business' operational and administrative procedures. These include:

Suppliers/Manufacturers risks
- Unqualified foreign suppliers/manufacturers
- Products do not satisfy quality requirements
- Production delay
- Product supply delay
- Paid products undelivered
- Lack of delivery services
- Documentation and specification error
- Supplier changes

- Supplier collapse

Transportation risks
- Volatile transportation costs
- Transport delay
- Products damaged and loss during transport
- Wrong products amount and type delivery
- Inappropriate transport modes selected
- Lack of transport vehicles and equipment
- Lack of carriers and service providers
- Traffic accidents

Storage risks
- Unsuitable storage condition
- Underestimated storage demands
- Inappropriate operation
- Storage or handling equipment breakdown

Customers and Orders
- Customer order change with specific demand
- Communication misunderstandings
- Customer information error or loss
- Customer order failure
- Order reception delay

Information risks
- Outdated online information processing system
- Information processing and storage equipment damaged
- Data recording or processing error
- Information loss by hacker attack

Employee risks

Even though employees are vital to business success, there are still risks associated with having employees. Some risks are:
- Underestimation of manpower demands
- Volatile labor costs
- Employee health and safety problems
- Employees unable to work at extended time
- Product loss because of employee theft

Financial risks

Financial risks are part of the financial structure of your business, business transactions, and the financial systems you use.

Some possible risks to consider are:
- Interest rates changes
- Foreign exchange rates risk
- Delay in banking processes

- Delay in payments
- Non-payment by customers

Strategic and economic risks
These risks concern the long-term strategic objectives of the organization. They can be affected by variables such as capital availability, sovereign and political risks, legal and regulatory changes, reputation and changes in the physical environment.

- Price influence by market fluctuation
- Trade strategy change between the land manufacturer and the land of consumption
- Market proportion decrease because of more business competitors
- Unsuitable customer group

The identification of the risks differs from each other in relation to the unique position of each online business handler and so does the impact to the company. Therefore, in the following chapter, a specific risk management matrix will be analyzed that depends on the practical situation and operation experiences.

4.8.3 Weighting of risk evaluation

The two main factors of risk management are the impact and likelihood of the risk determine the risk. However, the evaluation of these two factors depends totally on the personal experience and perspective of the company. The complete list of risks contains many fields of information and these cannot be mastered be every person. Therefore, a weighting factor is here defined in consideration of the personal perspective. For example, the machine operator has more knowledge, knows how often the defect products are produced and the impact that is has on the manufacture plan. The account understands more financial risks and knows little about the supply chain.

The following table indicates an example of weighting factor in risk management in different departments of an enterprise.

Table 4-19 Example weighting factor of risk evaluation in different departments

	Department					
Risks	General manager	Human resource	Financial department	Logician	Machine master	**Sum**
Operational risks	5	1	1	10	10	27
Employee risks	5	10	1	5	1	22
Financial risks	10	1	10	1	1	23
Strategic and economic risks	10	1	5	5	1	22

The weighting factor can be explained from 1, which is not important, to 10, which is very important.

The perspective factor for the corresponding group in the specific risk category can be calculated using the following formula,

$$Perspective\ factor = \frac{Weighting\ value\ of\ one\ group}{Sum\ of\ all\ weighting\ value}$$

Table 4-20 Perspective factor for each department group

	Department					
Risks	General manager	Human resource	Financial department	Logician	Machine master	**Sum**
Operational risks	0,19	0,04	0,04	0,37	0,37	1
Employee risks	0,23	0,45	0,05	0,23	0,05	1
Financial risks	0,43	0,04	0,43	0,04	0,04	1
Strategic and economic risks	0,45	0,05	0,23	0,23	0,05	1

The risk level is the reflection of likelihood and risk impact regarding standard risk management. If the personal perspective is taken into account then the risk level can be reformulated as follows:

$$Risk\ level = Likelihood\ \times Impact\ \times Perspective\ factor$$

The personal opinion of risk impact and likelihood plays a critical role for the risk evaluation in different groups in regards to risk management. Therefore, besides the two factors in the standard risk management, the perspective factor is here a part of risk management to expand the definition.

4.9 IT concept of logistic system for online business

4.9.1 Information flow in online business

The information exchange for online business is far more important and complicated compared to a traditional local business. On one side, a huge volume of information data is generated during the online trading, based on which the customer information is analyzed and categorized, and now the online handler can feed the customer with the desired information based on the customer search history. The information is transferred from customer to online shop and collected to make a better decision of warehouse management when the online trading is accomplished.

Generally, the information collected from online trading can be categorized into these types:

- Customer group – basic information about customers. For example, age, gender etc. It helps the online handler to know the customers better in order to attract the potential customer group.

- Article master data – contains basic information about products. For example, what kind of products are ordered the most by the customers, is it a seasonal product or not, is it A-article or C-article? Depending on this information, the life cycle of one product can be illustrated and the adjustment on warehousing, selling brings the benefit for online shops.

- Customer orders – basic information about the orders regarding how many products are ordered from one customer and how often they reorder. How many orders should be processed per day? This information is useful for the strategy of order picking as a decision like single order picking or multi order picking or even man-to-goods or goods-to-man can totally change the warehouse structure.

- Inbound and outbound transport – basic information about the deliveries, from suppliers and also from the last mile carriers. This information is needed to connect inbound and outbound material flow.

4.9.2 IT supported logistic structure in business operation area

The physical structure of the online business can be planned based on the information collected from online trading and procurement from the suppliers. The IT connects each part of the functional areas and helps the users to make a better decision.

Generally, all information can be collected and processed through IT, and, to achieve some goals, some destination information can also be generated or documented. In this case, some special software is in charge of information management and gives feedback on the physical materials to arrange the production, warehousing, delivery and transport.

In some aspect, IT is the interface between user and physical material. With the help of IT some business strategies are made and further affects the logistic structure.

- Supply chain management – from the start of the supplier and to the end of customer, every movement of material is accompanied by the information flow.

In comparison to the supplier, especially the one far from the selling point, it is relative difficult to manage the supply chain due to the long transport distance and various transport options. For instance, the products should be collected together before shipment. To meet the shipping appointment it is important that all suppliers must deliver their products on time in order to avoid a delay. The products from other suppliers may also have to wait until the last one has arrived. This could further lead to a severe inventory shortage of specific products.

In consideration of such situations, the information is shared among all shipping companies and logistic planners in case the shipping is canceled or the load is not in time delivered. The platform helps the shipping companies to find the potential customer for the remaining capacity on board and on the contrary, the logistic planners are more flexible to plan the transport and make fast reactions regarding delayed products.

In the last mile delivery, the distance to the end customer is always critical in minimizing the lead time and this is especially true for online businesses due to the fact that the order could be received from every corner of the globe. Therefore, to enhance the service level, many companies insist on decentralized warehouses or local business partners to reduce the transport distance. However the weighting of each region or customer is different from time to time and this means that the location is dynamic and the capacity is always changing. The information needs to be synchronized and analyzed so that the service level is kept.

- Inventory management – with the support of IT, it is possible that the warehouse could be much more efficient.

Among many indicators, which can be the critical measurement of the inventory, the turnover rate, inventory level and safety stock play an important role in evaluating the inventory.

The inventory is directly observed by IT in real time and the warehouse sends the feedback of the product information. If the inventory level drops below the safety stock, a replenishment signal is generated to the procurement department or automatically to the corresponding suppliers, so that the necessary stock can be reloaded for consumption in time.

In cooperation with other departments, for example procurement and marketing, the signal from inventory level can be sent to adjust the buying strategy or trigger some product promotions so that the spare rooms can be made for new products.

- Order management

The location of each products is optimized by the picking frequency and the order picking benefits from the optimized route regarding the local point of view. IT also makes it possible, that a multi order picking tour combines with the high picking frequency products, so that the picking position can be saved and thus the picking route can also be saved.

For different picking strategies the need of labour resources and the throughput time are also different. As one example, a small order pool which is built in one hour can be picked in minutes. The throughput time of these orders is relatively short, but the order picker is needed every hour every day. On the contrary, if the orders are collected for one day, the big order pool keeps the order picker busy for between one and two shifts and saves the rest of labour resources. In this case, the throughput time is longer than one day, but the labour costs can be reduced. Express customer orders also challenge the IT to push customer orders through the order picking system.

Nowadays, IT involves almost all logistic activities from goods reception to delivery, inventory capacity observation to order picking route organization. Some of the functions also involve the production plan or supplier vendor. IT in online business is not simply the storage of information, but the auxiliary tools for the logistic planning and strategy making.

On the market, many warehouse management systems are engaged in such activities. Some key indicators are not invisible and turn out to be decisive factors in logistic planning with the help of IT.

Furthermore, mobile devices are commonly used in online shopping. This seems to be the new trend and will continue to be in the near future with the development of information infrastructure taking a bigger market share.

Chapter 5 Concrete realizations of logistic system in online business

Business background

An online business for electronic devices, founded in the Western Germany in 2001, starts with relative low investment and small warehouse inventory. The company is located in a populated region where more workforces in the local labour market are available, with a relatively short distance to Rotterdam.

5.1 Product structure analysis

Typically, electronic devices like portable discs have a short life cycle and require a fast replacement. Most of the electronic products bring the most of their profit in the first one or two years and then the sales record goes down steeply to make room for a new gadget. Figure 5-1 illustrates the developing trends of such products in a year's sales records.

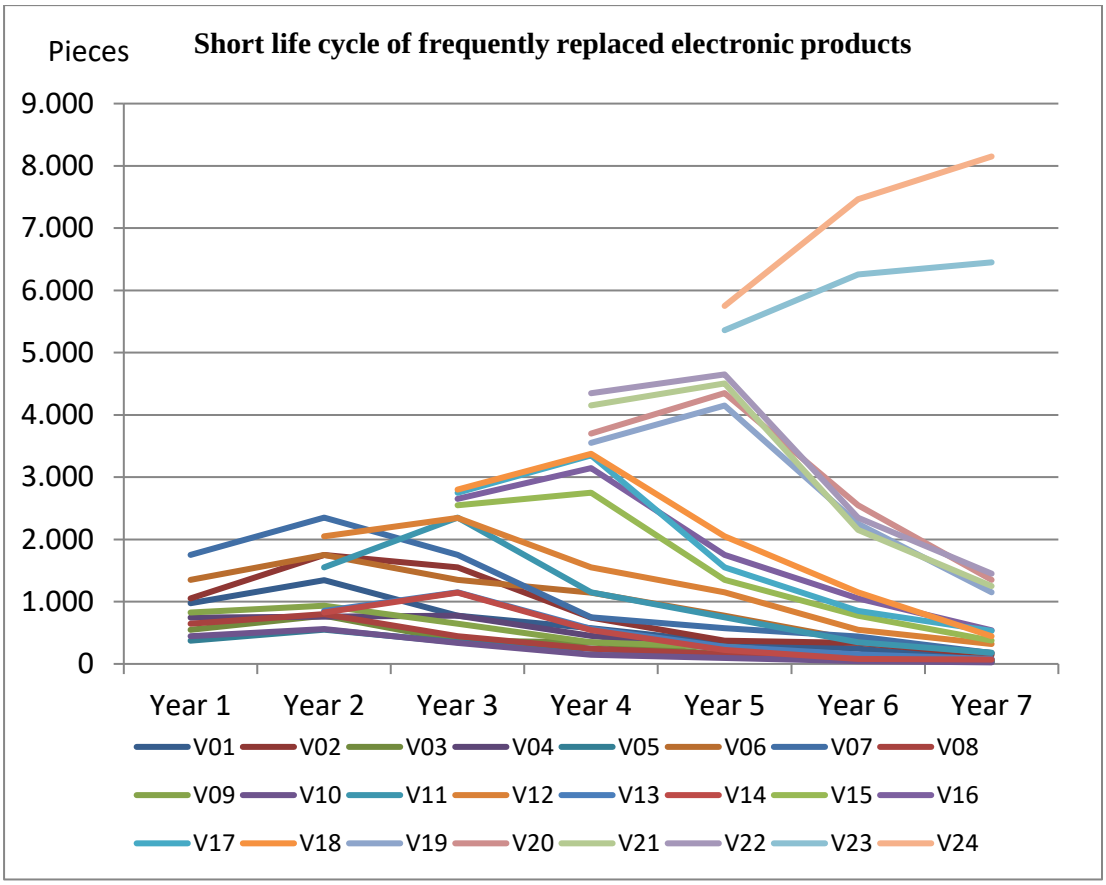


Figure 5-1 Short life cycle of frequently replaced electronic products

This kind of electronic product shows a curve with a one wave crest. It happens to most of the electric products in the long term. The sale amount steadily increases at the beginning of its life circle in the market as it is a brand new product. After a few years, the increase will slow down as the product becomes more familiar and saturates the market. The profit of this product may also reach its peak during this time. The collapse of one product accompanies the growth of another product, especially when the next generation takes over the market and the life cycle of the former product will end up quickly in the following few years.

Figure 5-2 indicates another category of products such as batteries and copy paper. These kind of products have a relatively stable physical life circle. Consumable and standard products appear in the sale market for many years, but in the long run, with the update of the new standards, this kind of product will also go on or has to be replaced in the market.

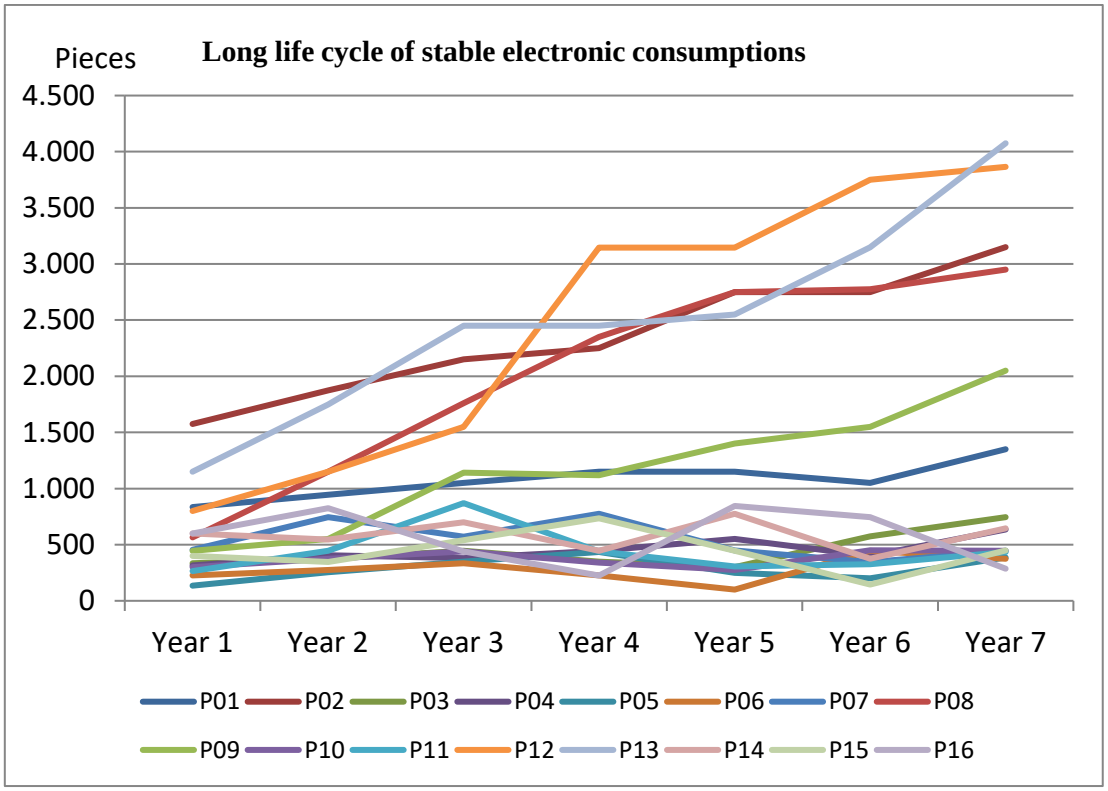


Figure 5-2 Long life cycle of stable electronic consumptions

5.2 Business strategy through phases

At the beginning, the online business focuses on the online shop with the aid of trading platform. The startup strategy is simple and practical and this leads to a simplified supply chain model in the way that the products are manufactured in China with company-'s own brand, transported further to Germany by sea, and then stored in the local warehouse. In the first phase, most of the customers are end consumers who order normally small orders with low profit.

The company changed a lot from B2C to B2B in the following ten years. The business strategies are always adjusted from time to time to meet the requirement of the customers. It seems totally different in comparison with the strategies in the first phase despite the gradual and smooth changing.

Table 5-1 The strategy changing from B2C to B2B

Strategy	B2C	B2B
Manufacture	● Own plant can totally cover the order of customers	● Own plant produces only one part of the order. ● Partner manufacturers are needed to meet the demand. ● Decision making between self-manufacturing and outsourcing
Transport	● Low transport volume ● Mix container with others ● Dependence on logistic service providers	● More frequent container traffic ● Full container load ● Own company fleet
Storage	● Rent warehouse ● Small inventory ● Simple warehouse function	● Fix investment in warehouse ● Large inventory with multifunctional area ● High inventory turnover rate
Customer service	● Point to point service for end consumer ● Dependence on trading platform	● Point to surface service for business customer ● More value-added service available ● More promptly information exchange
Financial	● Low reload volume ● Tight buying police to avoid shortage of cash flow	● More flexible for new products ● High reload volume ● Pay after sell for business customers

In different periods of e-business, logistics plays different roles as the situation of the company changes. The adjustment can happen in each segment along the supply chain.

In the start phase of the business, not only in the electronic branch but also in other businesses dealing with material flow or information flow and even the service branch, the concept of logistics should penetrate into each sector as a part of the decision making. The business model should be as simple as possible to build up the basic structure, so the building blocks are assigned with basic functions.

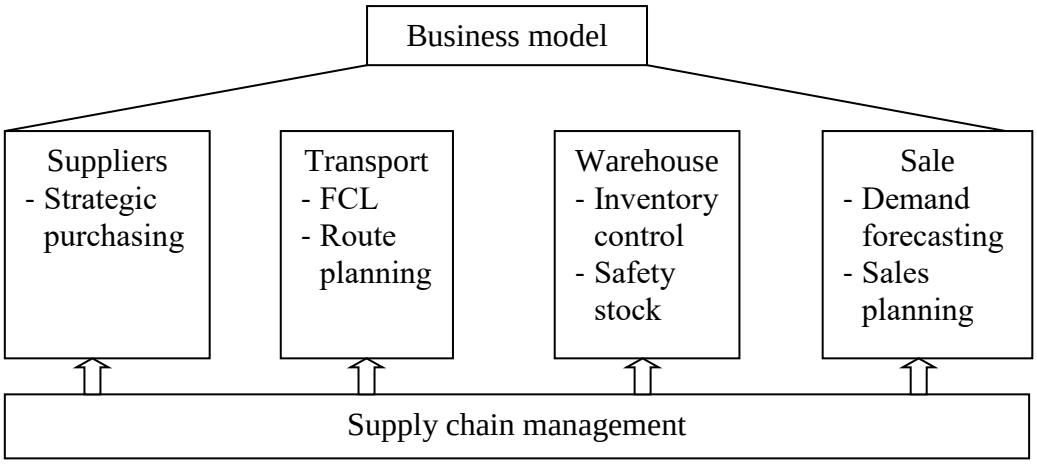


Figure 5-3 The basic compose of business model in the start phase

The function of each building block expanded as the development of the company, and also the new building blocks were introduced to the business model. This shows that any change or decision may affect the business model especially at the beginning of business operation years.

E-commerce has its own characteristics which differs from other businesses due to the fact that it is a customer-oriented business. The connection between customers and company is established through electronic devices and internet or PCs can be seen as two examples. The demand of the customer dominates the business strategy and, therefore, product diversification and quality control, fast and reliable delivery, customer service satisfaction and stable technical support seem particularly important to the e-commerce, and some correlative segments are pulled in to fulfil this requirement.

Some segments that cannot be detected by customers, warehouses are an example, should be handled by the company. However, the update or expansion of the warehouse rely on the inventory data collected in the past operation years and this is especially true when the business goes stable with regular customers. Some decisions can be made based on this information to improve the warehouse efficiency and strengthen the competition by optimizing the supply chain.

The basic business model has its advantage and disadvantage. The simplified business process reacts fast to the market demand and would enable the e-company to take a bigger share from the market. Some improvements are extremely necessary to strengthen the business model in the long run to keep this accomplishment going and attract existing and new customers even though this may, in the meantime, lead to some negative side effects during the business transformation period.

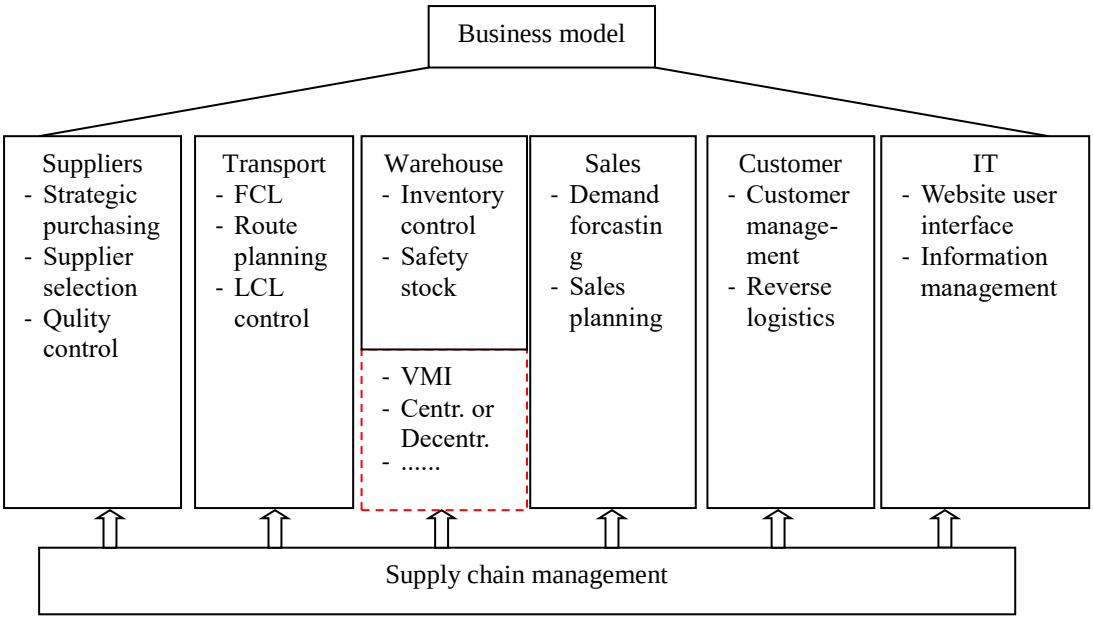


Figure 5-4 The developed business model with more modules and functions

5.3 Business performance in crisis

In the past decade, the sales trend went up steadily before the financial crisis in year 5, but the sales record drops at a lower rate thanks to the slowly increased product type. The following two figures demonstrate a slight difference in the developing trend after year 5 where the annual sales in unit had gone down and the number of product type goes up.

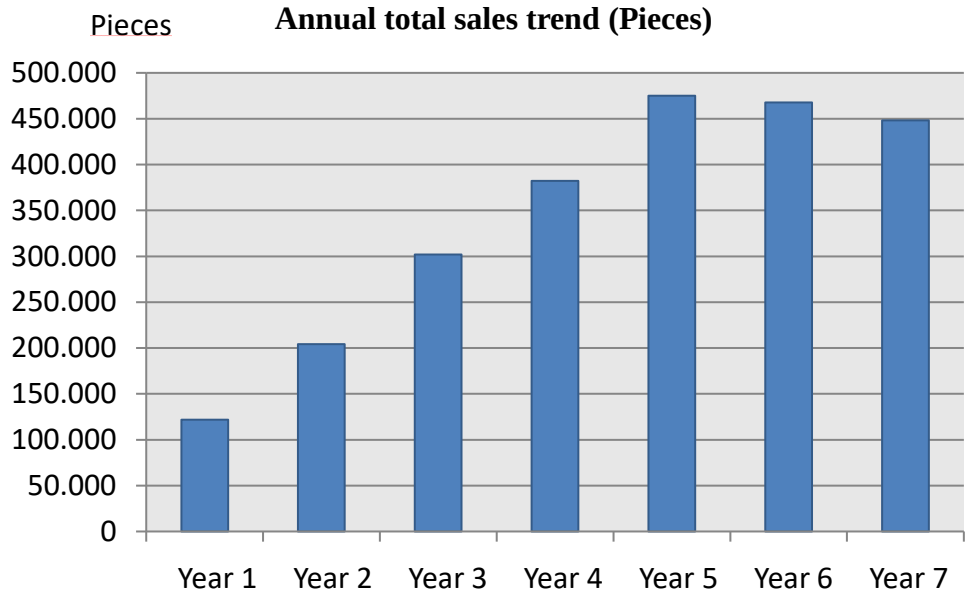


Figure 5-5 Annual total sales in unit before and after financial crisis in year 5

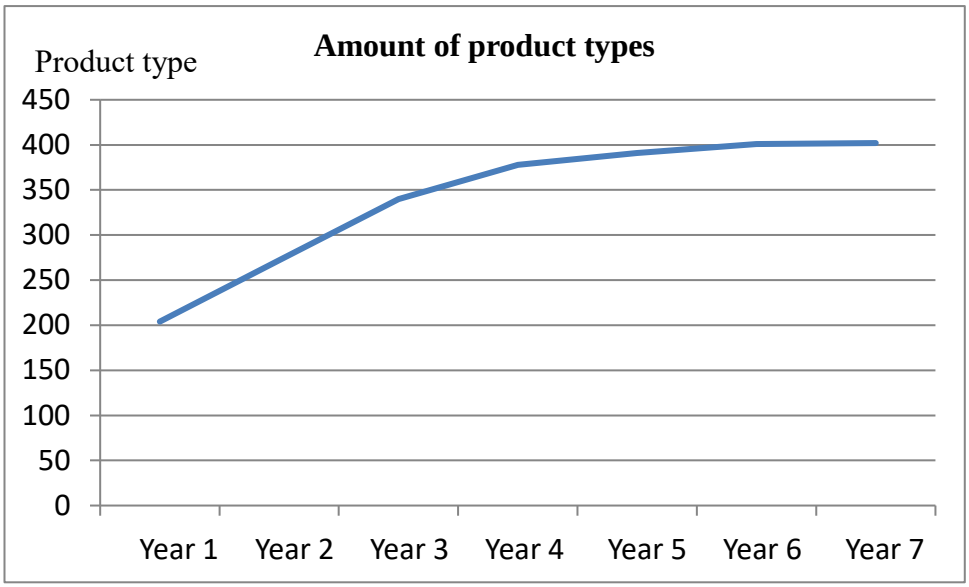


Figure 5-6 Number of product types before and after financial crisis in year 5

A rough factor can be summarized, using the yearly sales record, to indicate the relationship between annual sales amount and the amount of product type. In the first four years, the annual sales amount increases as the amount of product type increases. As we complement our product type gradually, the increasing tendency is getting mild since year 5 and likewise the sales amount that even worsens to negative growth.

Table 5-2 Increase/decrease rate in comparison with yesteryear

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Total sales amount	100%	+67.62%	+47.81%	+26.58%	+24.27%	-1.56%	-4.16%
Total product type	100%	+33.33%	+25%	+11.18%	+3.44%	+2.56%	+0.25%
Reference factor		2.0	1.9	2.4	7.1	-0.6	-16.7

As demonstrated, the relationship between the sales amount and the amount of product type and the characteristic of different type of products is obvious. The procurement and marketing strategy can be outlined:

- Hunting for creative new products to keep the vitality of company and the credit of our customers.
- Observe and slough off the products with degressive sales amount over time.
- Reasonable prediction of specific products according to the product attributes.
- Adjustment of the product structure and emphasis on the beneficial and sustainable type of product and minimizing the inventory of unstable products.

5.4 Calculation of order picking route with real data

The logistic center is built in Gelsenkirchen. Many experiments are introduced to determine the critical factors in the planning phase and furthermore, in each experiment, several scenarios are defined. One or two factors are recognized as variables to make sure in what way the picking strategies can be influenced by these factors in order to find out the best picking strategy for different warehouse layouts. So that the comparison can be both performed in a horizontal and a vertical direction.

Table 5-3 An overview of experiments of order picking with different factors

Experiment	Scenario	Description
1	1-3	General factors are introduced, such as λ, N_A, M_A
2	4-8	Exponential factor λ as parameter
3	9-13	Fixed number of products, N_A, M_A as parameters
4	14-18	Fixed number of products in an aisle, M, N_A as parameters
5	19-23	Fixed layout and number of products per picking, n, number of tours as parameters
6	23-26	Number of products in one picking as parameter

Scenario 1: The warehouse is built in 8 aisles and 50 articles per aisle in this basic scenario. The average number of products per picking is around 20 articles according to the customer orders. The extra factor lambda can be calculated through ABC analysis for exponential distribution.

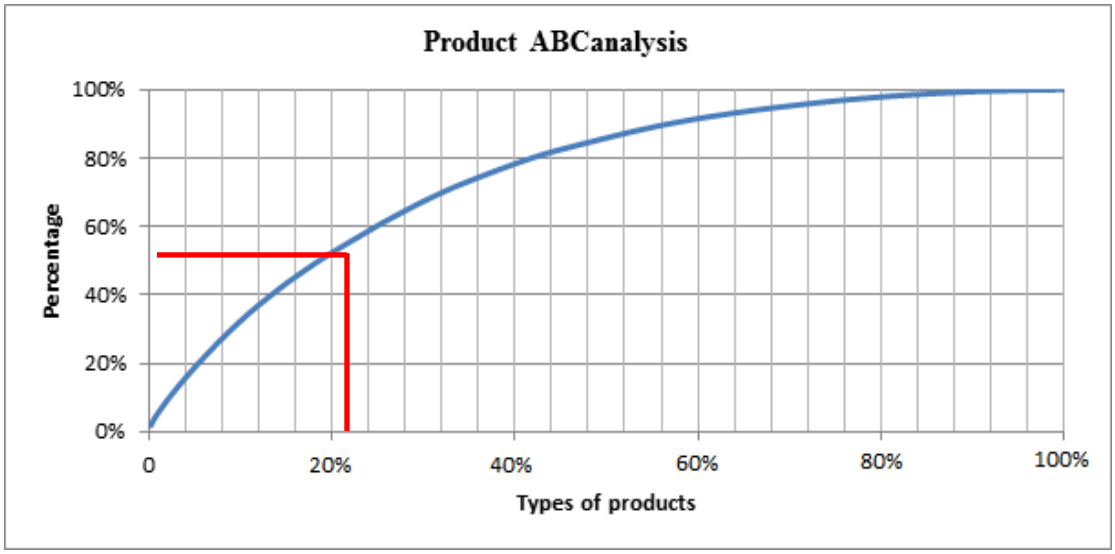


Figure 5-7 Product ABC analysis in Is-Situation

A product ABC analysis is demonstrated in Figure 5-7 where 20% of products take possession of ca. 50% picking amount. According to the formula 4.12, when x equals 0.2 and F(x,λ) equals 0.5, the corresponding λ is 3.466 as calculated.

Scenario 2: This scenario is the same as scenario 1, only the factor lambda has changed due to the different distribution of articles in ABC analysis. In this scenario, 20% of A-articles take possession of 80% picking amount. Under this circumstance, λ equals 8.047.

Scenario 3: The warehouse is reorganized to 10 aisles and 40 articles per aisle. Therefore, each aisle is short. The factor lambda is the same as scenario 1 for exponential distribution.

The detailed factors are listed as follows:

Table 5-4 Parameters of 3 order picking scenarios

Scenario	n	N_A	M_A	M	W_A	L_c	L	λ	$1/\lambda$
1	20	8	50	400	5	1	22.5	3.466	0.289
2	20	8	50	400	5	1	22.5	8.047	0.124
3	20	10	40	400	5	1	18	3.466	0.289

In each scenario, 8 different picking routes are calculated after different picking strategies which are,

- Return strategy without repetition in exponential distribution
- Midpoint strategy in exponential distribution
- Return strategy with repetition in exponential distribution
- Return strategy without repetition in uniform distribution
- Midpoint strategy in uniform distribution
- Return strategy with repetition in uniform distribution
- Transversal strategy without skipping
- Transversal strategy with skipping

The picking routes under different conditions are compared after calculation. The results are shown as follows:

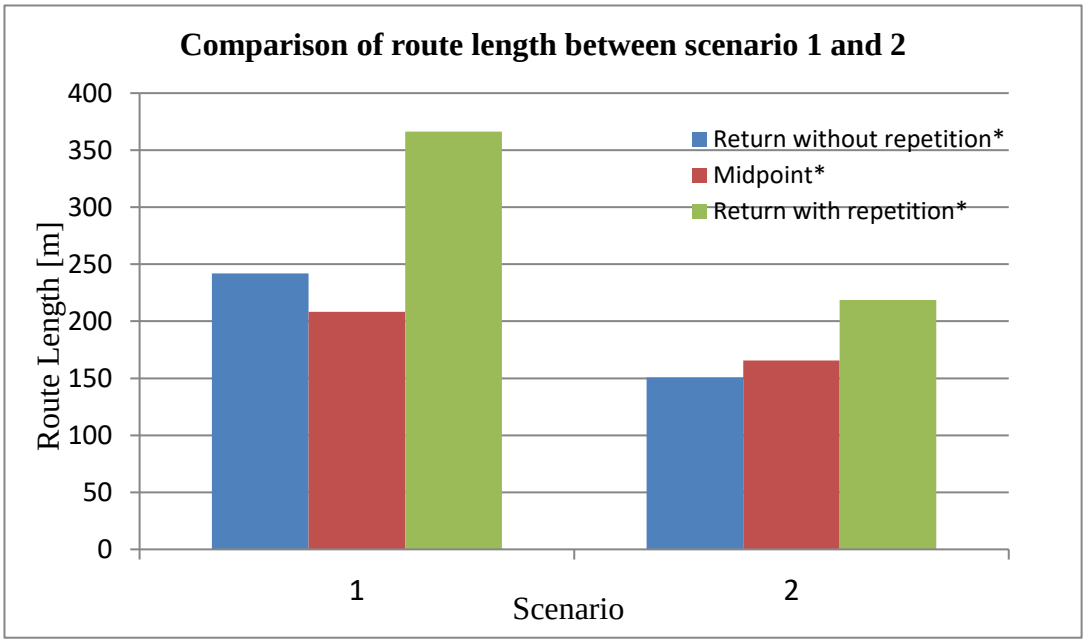
Table 5-5 Route length in 3 scenarios by using different storage and order picking strategies

Scenario	Return without repetition *	Midpoint *	Return with repetition *	Return without repetition **	Midpoint**	Return with repetition**	Transversal with skipping	Transversal without skipping
1	241.91	208.27	366.35	314.00	251.71	556.67	250.02	266.00
2	150.66	165.58	218.51	314.00	251.71	556.67	250.02	266.00
3	242.74	213.82	333.46	312.11	254..79	485.71	262.69	290.00

*: exponential distribution
**: uniform distribution

Conclusion:

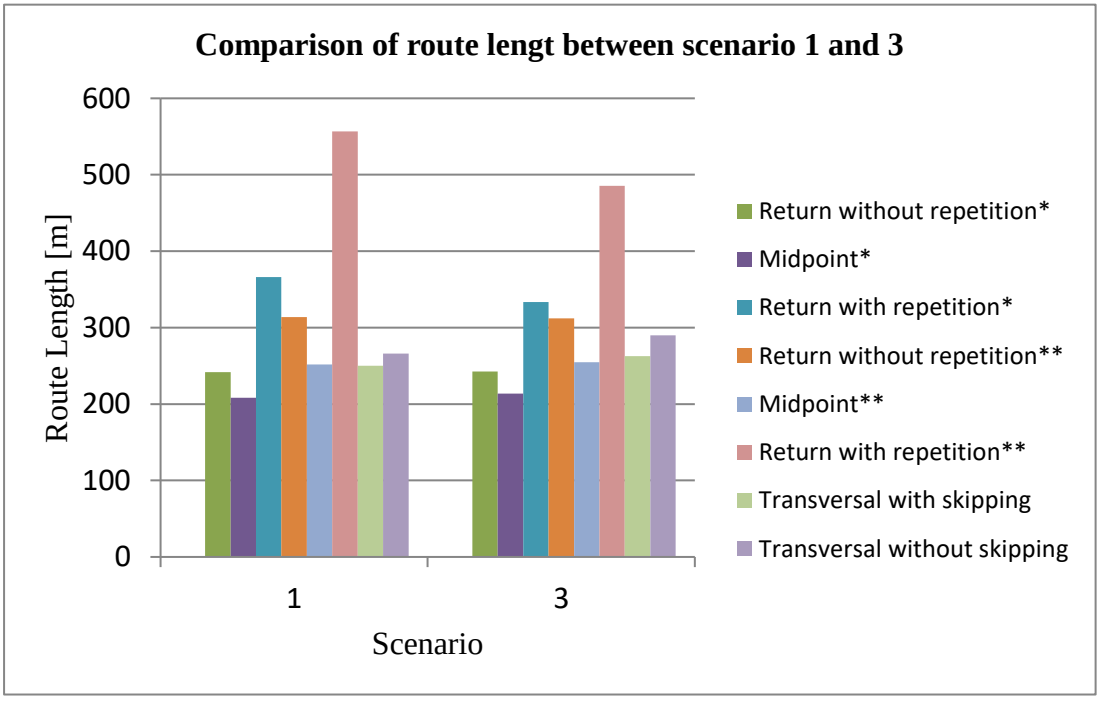
(1) At first, scenario 1 and scenario 2 are compared in Figure 5-8. In scenario 2, the picking route is extremely shortened by increasing the value λ for the methods of return without repetition, midpoint and return with repetition. But the best picking strategy may be obtained with the change of the value λ. In Figure 5-8, the midpoint strategy with exponential distribution is the best picking solution for small λ, and return without repetition with exponential distribution has the shortest picking route with bigger λ.



*: exponential distribution

Figure 5-8 Comparison of route length between scenario 1 and 2

(2) Second, between scenario 1 and 3, with the same amount of product types, we shorten the aisle to 18 meters by adding 2 aisles and the picking route was increased by some picking methods and reduced by the others. Therefore, it cannot be easily decided if shortening the aisle is beneficial for order picking.



*: exponential distribution
**: uniform distribution

Figure 5-9 Comparison of route length between scenario 1 and 3 by using different storage and order picking strategies

Through comparison, we find out that, in ABC storage, the value of λ can be a critical factor for order picking route, and the other factors, such as length of the aisle, may lead to a different picking situation. Thus, a further discuss about these kind of factors in the following research is made.

1. Order picking route analysis under different conditions

(1) Exponential distribution parameter *λ* and picking route:
As mentioned before, exponential distribution parameter *λ* can be calculated based on the cumulative distribution function of the exponential distribution.

Figure 5-10 indicates the results of ABC analysis in 5 scenarios, 20% of the A-article takes possession of a picking rate from 80% to 40%, and the corresponding curvature gets smaller.

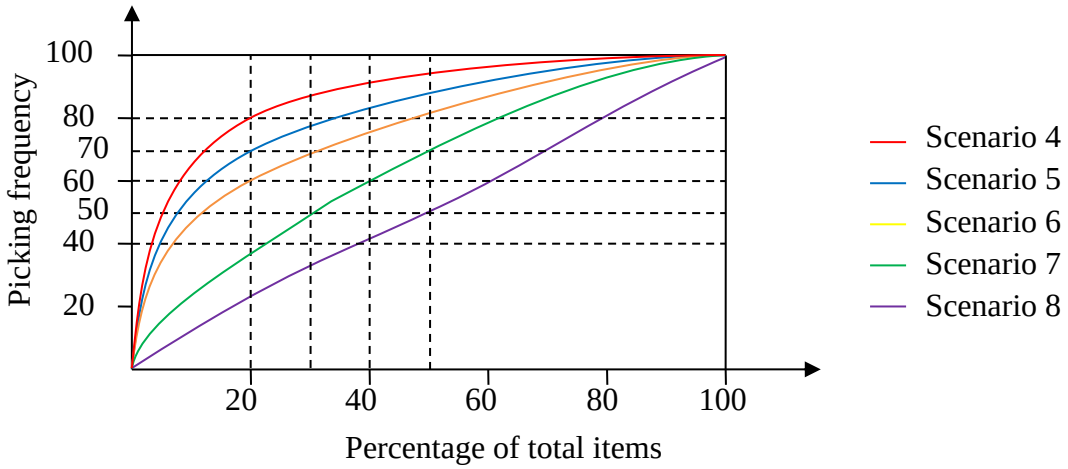


Figure 5-10 Comparison of the result of ABC analysis in 5 scenarios

After calculation, the result of corresponding exponential distribution parameter *λ* is shown as below, depending on ABC analysis, the greater the curvature, the greater the *λ*.

Scenario 4 to 8: based on scenario 1, all scenarios from 4 to 8 have the same factors except factor *λ*, a list of *λ* is shown in the following table.

Table 5-6 Exponential distribution parameter *λ* of 5 order picking scenarios

Scenario	4	5	6	7	8
Percentage of total items	20	20	30	40	50
Picking frequency	80	70	70	60	50
λ	8.047	6.020	4.013	2.291	1.386
1/ *λ*	0.124	0.166	0.249	0.437	0.721

In 5 scenarios, the stock amount and warehouse layout was kept fixed and the detailed scenario factors are shown in Table 5-7.

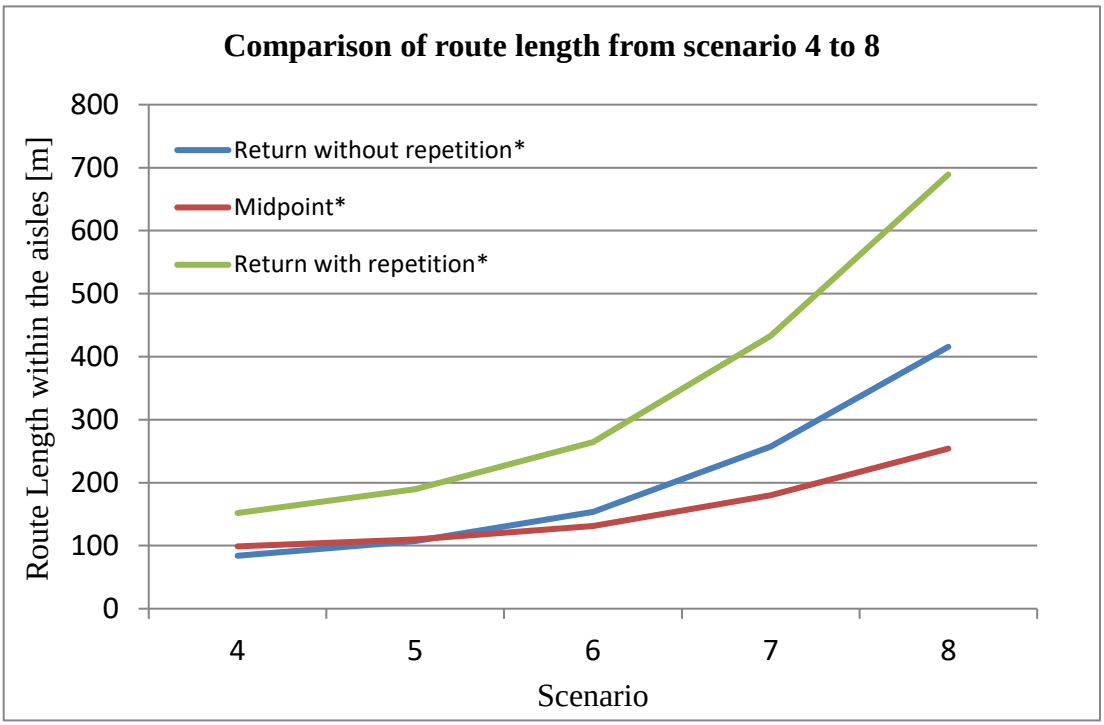
Table 5-7 Parameters of 5 order picking scenarios

Scenario	n	N_A	M_A	M	W_A	L_c	L	λ
4	20	8	50	400	5	1	22.5	8.047
5	20	8	50	400	5	1	22.5	6.020
6	20	8	50	400	5	1	22.5	4.013
7	20	8	50	400	5	1	22.5	2.291
8	20	8	50	400	5	1	22.5	1.386

Because of the fixed number and length of the aisles in the warehouse, correspondingly, the length of the aisle change path s_{ACP} is also the same. Therefore only the order picking route within the aisles S_{AD} needs to be calculated and compared. After calculation, the result of route length for 3 picking methods with exponential distribution is shown in the following table:

Table 5-8 Route length within the aisle in 5 scenarios with exponential distribution

Scenario	s_{AD}		
	Return without repetition	Midpoint	Return with repetition
4	84.00	98.91	151.84
5	107.24	109.79	189.51
6	153.38	131.37	264.26
7	257.46	180.07	432.89
8	415.66	254.09	689.21



*: exponential distribution

Figure 5-11 Comparison of route length within the aisle in 5 scenarios with exponential distribution

Using ABC storage policy and with the decrease of factor λ, the route length within in the aisle increases using midpoint, return with repetition and return without repetition methods. On the contrary, they all have a different increasing rate. The interesting cross point between midpoint strategy and return without repetition at scenario 5 means that, if the exponential factor λ is bigger enough ca. 20 percent of total items contains 70 percent of picking frequency, return without repetition is the best picking solution. Otherwise, midpoint strategy is recommended for smaller λ.

(2) Warehouse layout and picking route:
From the first three scenarios, the conclusion indicates that the amount and the length of the aisle can influence the order picking route. Therefore, in this part another 5 scenarios are compared to figure out how these factors have an impact on route length.

Scenario 9-13: With the same exponential distribution factor λ, 5 different warehouse layouts are compared in these scenarios with different picking strategies. A list of scenario factors is shown in Table 5-8 with the calculated aisle change path S_{ACP}.

Table 5-9 Parameters of 5 order picking scenarios

Scenario	n	N_A	M_A	M	W_A	L_c	L	λ	$1/\lambda$	S_{ACP}
9	20	5	160	800	5	1	72	8.047	0.124	38.10
10	20	8	100	800	5	1	45	8.047	0.124	66.67
11	20	10	80	800	5	1	36	8.047	0.124	85.71
12	20	16	50	800	5	1	22.5	8.047	0.124	142.86
13	20	20	40	800	5	1	18	8.047	0.124	180.95

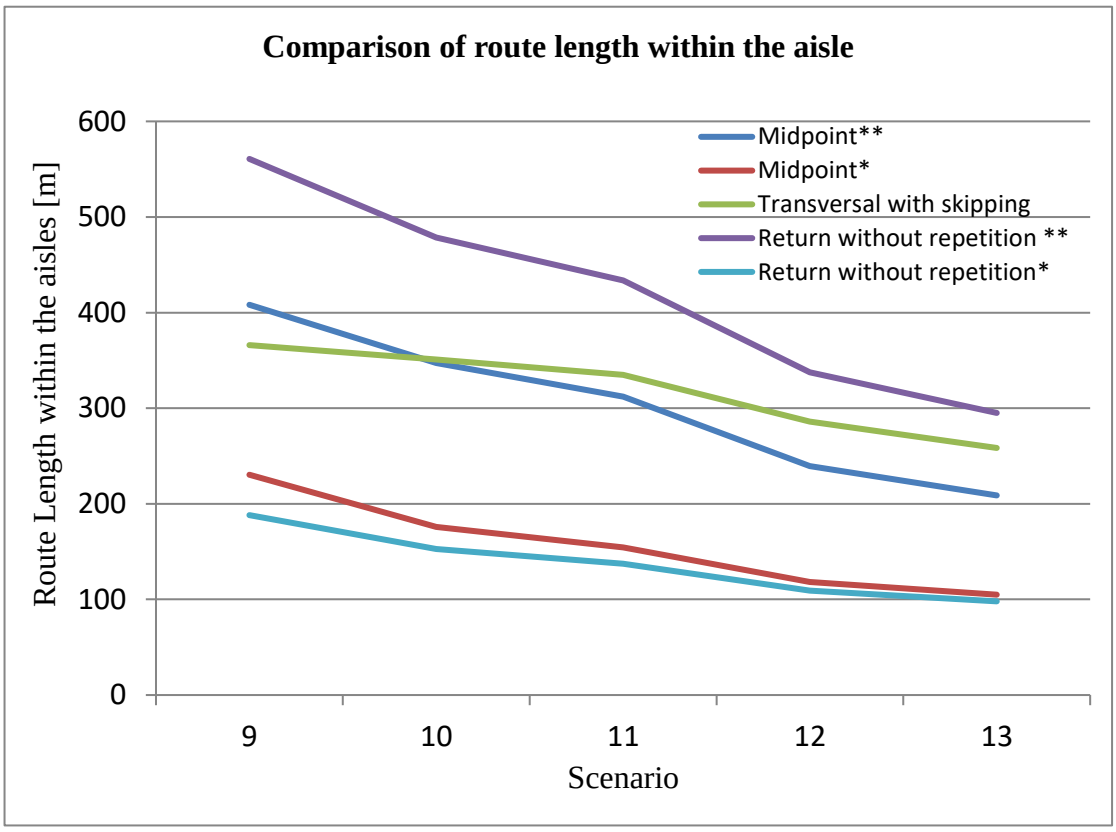
The following results can be calculated with the formula (4.9) to formula (4.16) in Chapter 4.

Table 5-10 Route length within the aisle and total route length in 5 scenarios by using different storage and order picking strategies.

Scenario	s_n (m)	Midpoint**	Midpoint*	Transver-sal with skipping	Return without repetition**	Return without repetition*
9	S_{AD9}	408.19	230.40	365.98	560.75	188.17
	S_9	446.29	268.49	404.08	598.84	226.26
10	S_{AD10}	347.26	175.87	350.86	478.45	152.70
	S_{10}	413.93	242.54	417.53	545.12	219.36
11	S_{AD11}	312.04	154.40	335.02	433.65	137.33
	S_{11}	397.75	240.11	420.74	519.37	223.05
12	S_{AD12}	239.41	118.24	285.90	337.68	109.16
	S_{12}	382.26	261.10	428.76	480.54	252.02
13	S_{AD13}	208.78	104.97	258.42	295.05	98.00
	S_{13}	389.73	285.93	439.37	476.00	278.95
Δ	$\Delta S_{AD12-13}$	30.62	13.27	27.48	42.63	11.16
	ΔS_{12-13}	-7.47	-24.83	-10.61	4.54	-26.93

*: exponential distribution
**: uniform distribution

Under the same exponential distribution factor λ, the picking route within the aisles can be shortened by increasing the aisle amount and reducing the aisle length, see Figure 5-12.



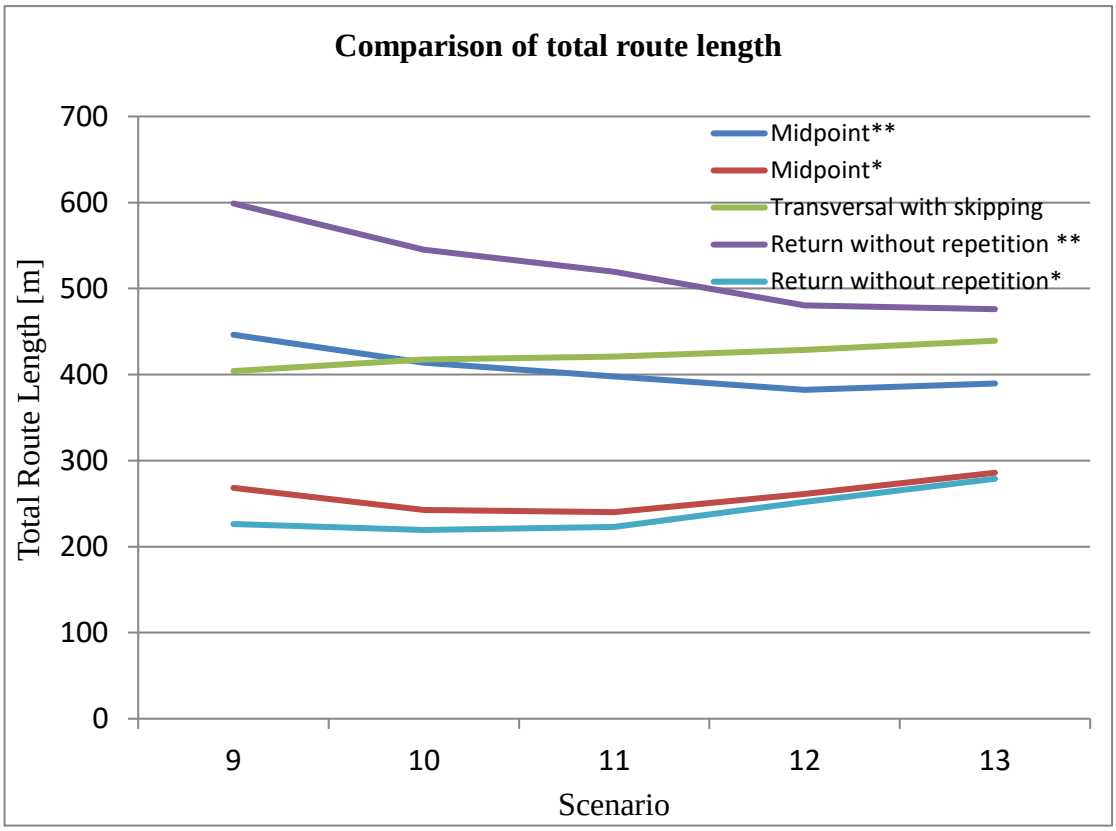
*: exponential distribution
**: uniform distribution

Figure 5-12 Comparison of route length within the aisle

In comparison with the result of the last two scenarios see Table 5-10. The picking route within the aisles can both more or less be reduced by increasing the number of aisles and decreasing the aisle length no matter what picking method is used.

In the case that $S_B = 0$, from the formula (4.1) we get the total picking route $S_n = S_{AD} + S_{ACP}$. According to the formula (4.3) described earlier, in which $W = (N_A - 1) \cdot W_A$, if the number of aisles N_A increases, the aisle change path S_{ACP} also increases correspondingly. Although the picking route within the aisles S_{AD} can be shortened by increasing the aisle amount, the total picking route S_n can also be increased because of the increased aisle change path S_{ACP}. The total picking routes of scenario 12 and 13 are compared in Table 5-10.

From Figure 5-13, the picking route within the aisles is reduced due to the increase in number of aisles, but it did not completely reduce the total picking route.



*: exponential distribution
**: uniform distribution

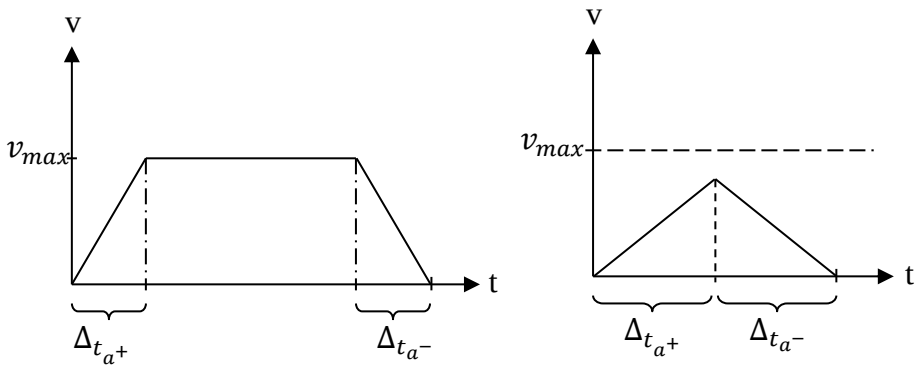
Figure 5-13 Comparison of total route length in 5 scenarios by using different storage and order picking strategies

According to comparison, scenario 10 gets the shortest picking route 219.36m by using the return without repetition strategy with exponential distribution. Therefore, neither the more aisles nor the longer aisles can get a shorter picking route. A reasonable warehouse layout should be designed with suitable picking activities in accordance to the circumstances of warehouse layout and product distribution.

2. Calculation of order picking time

Order picking time can be separated into 3 parts and these are picking time, travelling time and time for remaining activities. Picking time includes searching, confirming and fetching the items. Travelling time is the time it takes for traveling between items and the time for remaining activities includes time for reception of order picking list, preparation of picking instrument etc. Among them about 50% of total order-picking time is spent on travelling [TWBFT 03]. In other words, to minimize the order picking time you would need to shorten the travelling time and this is the most obvious and effective method. The travelling time is dominated by the picking route. Thus, the picking route is also different, depending on different picking strategies, which leads to the different order picking times. In the following part we aim to focus on the calculation of travelling time inside the order picking time.

Volker Sadowsky [SAD 07] demonstrates that in the calculation of the travelling time there are two different speed-time profiles and these are standard moving ramp and peak ramp (Figure 5-14).



(a) Standard moving ramp (b) Peak ramp

Figure 5-14 Two different speed-time profiles [SAD 07]

The calculation of travelling time t_n for the two ramps is determined according to the following formula:

$$t_n = \begin{cases} \frac{s_n}{v} + (n+1)\cdot\frac{v}{a} & for \quad \frac{s_n}{n} \geq \frac{v^2}{a} \\ (n+1)\cdot 2\cdot\sqrt{\frac{s_n}{n\cdot a}} & for \quad \frac{s_n}{n} < \frac{v^2}{a} \end{cases} \qquad (5.1)\ [SAD\ 07]$$

Here s_n is the length of order picking route, v is the velocity, a is acceleration and n is the number of acceleration.

The last 5 scenarios are analyzed and let: $v = 1\frac{m}{s}$, $a = 2\frac{m}{s^2}$. The length of order picking route for them is shown below:

Table 5-11 Total route length in 5 scenarios by using different storage and order picking strategies

Scenario	s_n (m)				
	Midpoint**	Midpoint*	Transversal with skipping	Return without repetition**	Return without repetition*
9	446.29	268.49	404.08	598.84	226.26
10	413.93	242.54	417.53	545.12	219.36
11	397.75	240.11	420.74	519.37	223.05
12	382.26	261.10	428.76	480.54	252.02
13	389.73	285.93	439.37	476.00	278.95

*: exponential distribution
**: uniform distribution

In these 5 scenarios, the value $\frac{s_n}{n}$ is far larger than $\frac{v^2}{a}$, so we can use $t_n = \frac{s_n}{v} + (n+1)\cdot\frac{v}{a}$ in formula (5.1). After calculation, the travelling time is shown in the following table:

Table 5-12 Travelling time in 5 scenarios by using different storage and order picking strategies

t_n (s)					
Scenario	Midpoint**	Midpoint*	Transversal with skipping	Return without repetition**	Return without repetition*
9	456.79	278.99	414.58	609.34	236.76
10	424.43	253.04	428.03	555.62	229.86
11	408.25	250.61	431.24	529.87	233.55
12	392.76	271.60	439.26	491.04	262.52
13	400.23	296.43	449.87	486.50	289.45

*: exponential distribution
**: uniform distribution

Obviously, the travelling time increases due to the length of the order picking route increasing. The result can also be illustrated by the following figure which has the very similar trend in Figure 5-13.

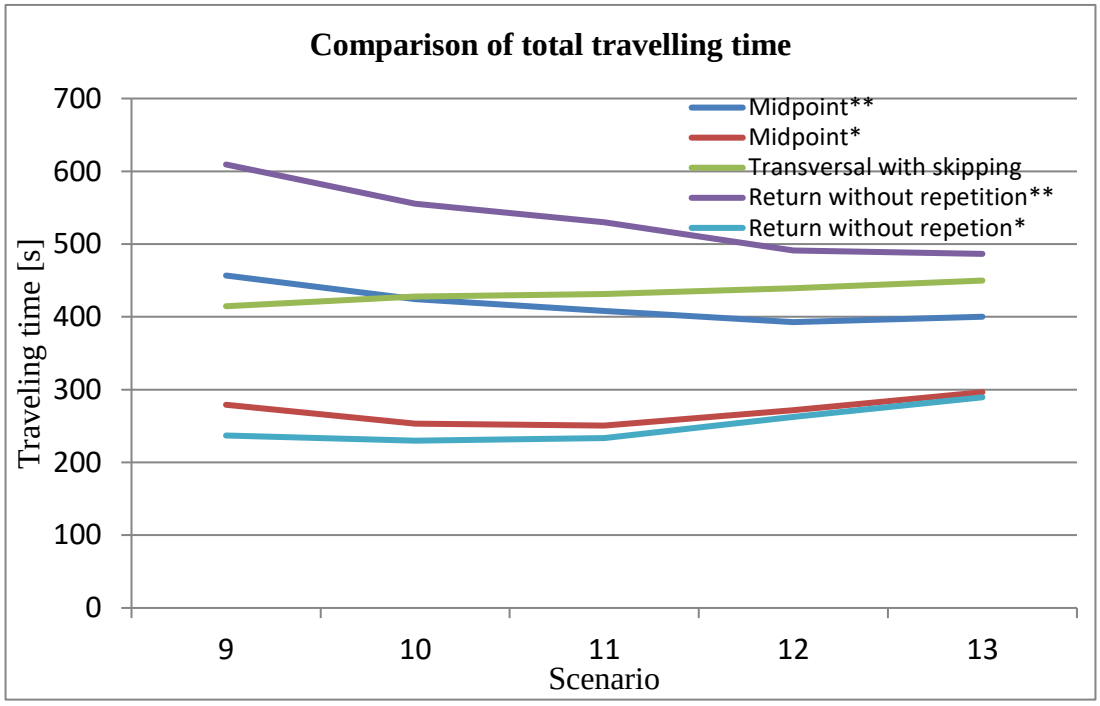


Figure 5-15 Comparison of total travelling time in 5 scenarios by using different storage and order picking strategies

Compared with the longest picking route (609.34s) and the shortest picking route (229.86s), ca. 60% of travelling time is saved on order picking process by using the suitable storage criteria and picking strategy.

In practice, the workload of an employed person in one company is calculated as FTE (Full-time equivalent). For example, a normal working schedule for one year is defined as 220 days with 8 hours per day. In this case, one FTE represents 1760 hours.

Table 5-13 Comparison of FTEs before and after the optimization of picking route

Item	Before	After
Picking time per order [s]	609.34	229.86
Average orders per day in 365 days	200	200
FTE for order picking	7.0	2.6
FTE saved per year	0	4.4

Apparently, in this example, the change of order picking strategy brings the company a lot of profit by saving 4.4 FTEs per year with the same amount of orders. Thus, a further assumption of increasing the amount of orders per day is made to compare the FTEs.

Table 5-14 Comparison of FTEs in consideration of average orders per day

Item	Exp. 1	Exp. 2	Exp. 3	Exp. 4
Average orders per day in 365 days	200	300	400	500
FTE for 609.34s per order	7.0	10.5	14.0	17.6
FTE for 229.86s per order	2.6	4.0	5.3	6.6
FTE saved per year	4.4	6.5	8.7	11

The Table 5-14 indicates that more FTEs are saved between the longest and the shortest route if there are more orders per day to process.

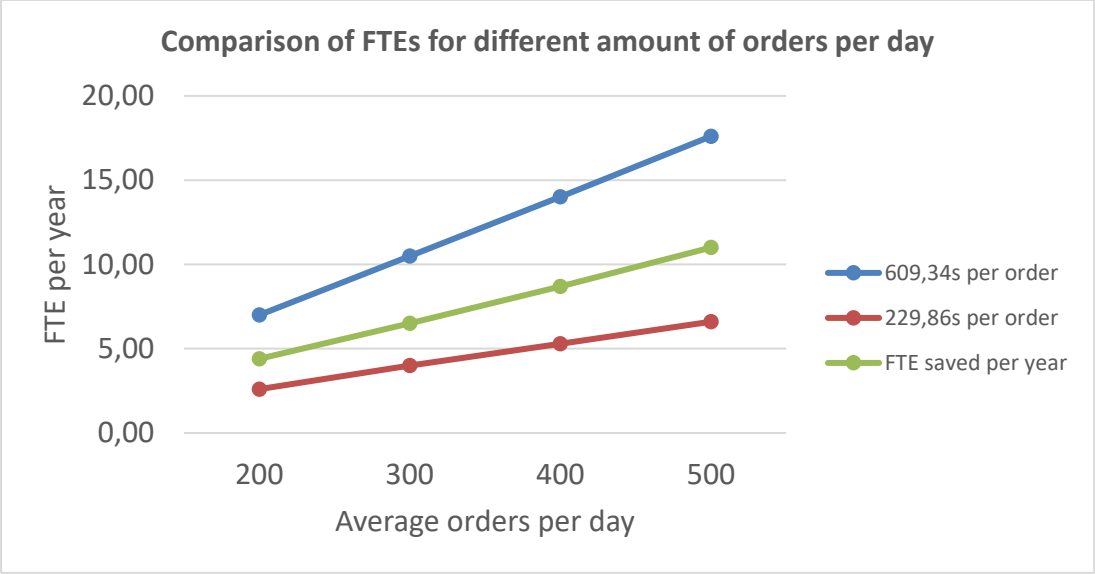


Figure 5-16 Comparison of FTEs for different amount of orders per day

The FTEs increase with the increase of orders per day are linearly and therefore, according to Figure 5-16, three linear curves represent the longest, the shortest and the difference between two picking strategies. In consideration of the factor FTE, a suitable picking strategy apparently makes a great benefit for online business companies.

3. Influence of number of products

As mentioned, with the development of online business, the number of products increases and therefore, the warehouse should also be expanded with more shelves. The following scenarios demonstrates picking route with the change of number of products.

In exponential distribution, the factor λ keeps constant for 8.047 which means 20% of A-article takes possession of 80% picking rate.

Table 5-15 Parameters of 5 order picking scenarios

Scenario	n	N_A	M_A	M	W_A	L_c	L	λ
14	20	4	100	400	5	1	45	8.047
15	20	8	100	800	5	1	45	8.047
16	20	16	100	1600	5	1	45	8.047
17	20	32	100	3200	5	1	45	8.047
18	20	64	100	6400	5	1	45	8.047

After calculation with different picking strategies, the result of each method are shown in the following table. In these scenarios, only the picking strategies with exponential distribution are considered.

Table 5-16 Route length in 5 scenarios by using different storage and order picking strategies

Scenario	Return without repetition*	Midpoint*	Return with repetition*	Transversal with skipping	Transversal without skipping
14	135.66	164.57	292.25	216.07	218.00
15	219.37	242.54	330.35	417.53	446.00
16	337.46	348.47	406.54	689.66	902.00
17	519.86	519.40	558.92	1003.73	1814.00
18	842.84	834.58	863.69	1413.76	3638.00

*: exponential distribution

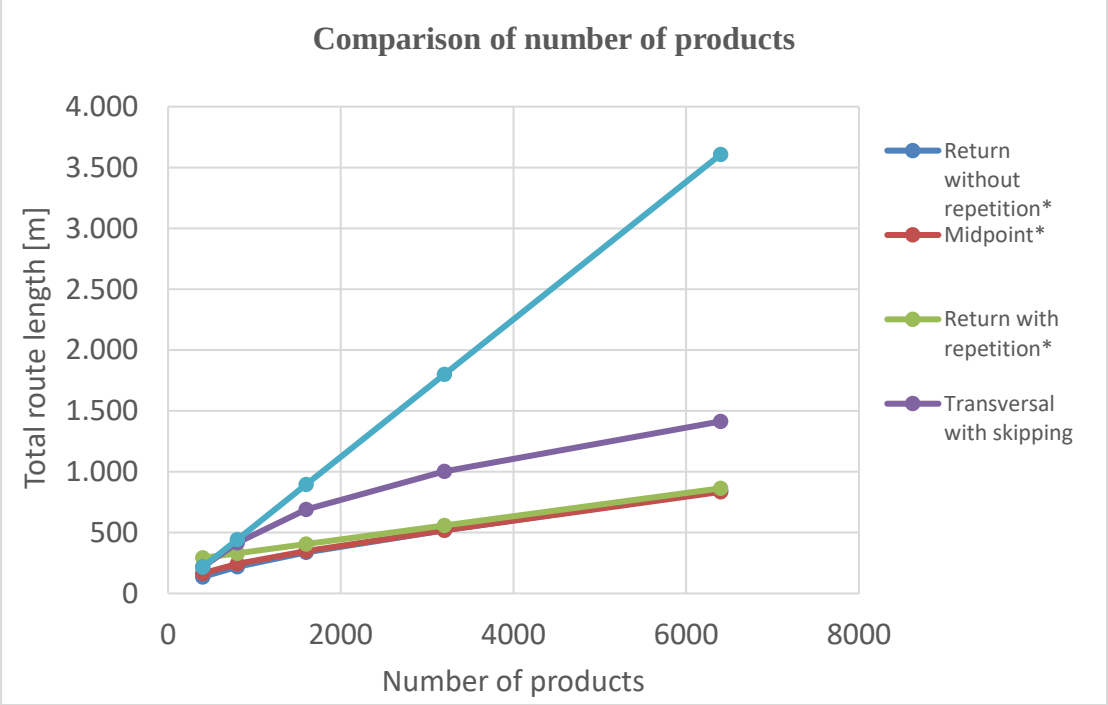


Figure 5-17 Comparison of total route length in 5 scenarios with different number of products

In Figure 5-17, return without repetition seems the best picking strategy before cross point, which happens at scenario 17, the midpoint strategy is the best picking strategy after the cross point. It is obvious that the picking route increases also with the increase of the number of products and the trend turns to be lineal without the upper limitation. In general, the warehouse can be expanded with the same exponential factor in the aisles. Nevertheless, practically, the warehouse is divided into different sectors in which different storage facilities are set up to meet the pick frequency of the products. For instance, for A-article, a push-through rack would extremely enhance the picking performance and for B, C-article the normal shelving rack would be sufficient. This also challenges the order picking system to handle multi-order and becomes at the end a consolidation point for customer orders.

4. The size of orders

The customer orders can be collected and categorized based on the number of products per order. For end customers, the orders are relatively small with few varieties and, in most cases, such orders contain one or two products. Business customers, in contrast with end customers, order big amounts and a great variety of products instead. The following experiment demonstrates the effect of order size on the picking route.

Table 5-17 Parameters of 5 order picking scenarios

Scenario	n	N_A	M_A	M	W_A	L_c	L	Tour	λ
19	1	8	100	800	5	1	45	20	8.047
20	2	8	100	800	5	1	45	10	8.047
21	5	8	100	800	5	1	45	4	8.047
22	10	8	100	800	5	1	45	2	8.047
23	20	8	100	800	5	1	45	1	8.047

After calculation with different picking strategies, the result of each method are shown in the following table. In these scenarios, only the picking strategies with exponential distribution are considered.

Table 5-18 Route length in 5 scenarios by using different storage and order picking strategies

Scenario	Return without repetition *	Midpoint *	Return with repetition *	Return without repetition**	Midpoint **	Return with repetition**	Transversal with skipping	Transversal without skipping
19	963.68	2693.88	963.68	1640.00	2947.50	1640.00	1640.00	8920.00
20	720.94	1518.34	730.35	1367.02	1766.35	1406.67	1348.43	4460.00
21	462.70	714.81	497.01	1028.92	946.99	1173.33	967.30	1784.00
22	323.92	411.65	390.96	786.10	620.49	1067.27	683.04	892.00
23	219.37	242.54	330.35	545.12	413.93	1006.67	417.53	446.00

*: exponential distribution
**: uniform distribution

In Figure 5-18, with the increase of the number of products per picking there is a decrease in the total picking route. It means that the order picking route of a big order is shorter than many small orders. Therefore, it is more efficient to combine small

orders such as one or two article orders. Furthermore, if the bottom area of the diagram is enlarged, as shown in Figure 5-19, return without repetition is the best picking strategy in this experiment, but there are still many cross points that can be detected. Just the same as former experiments, the best picking strategy changes with the change of other parameters and there is no absolute best picking strategy in all conditions.

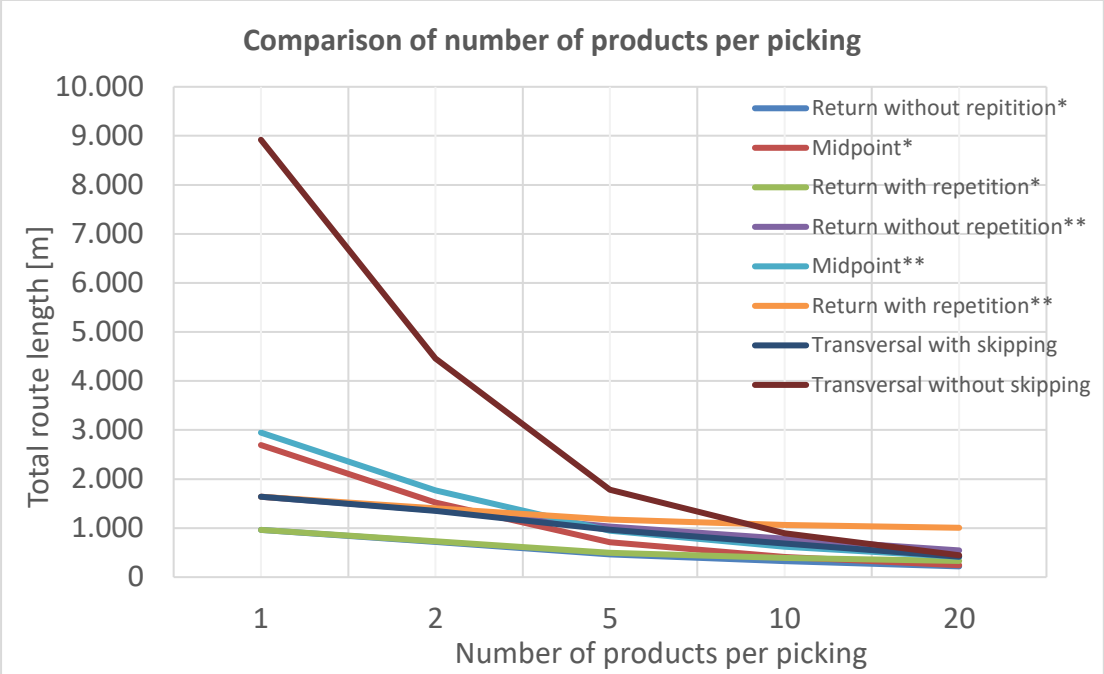


Figure 5-18 Comparison of total route length in 5 scenarios with different number of products per picking (Part 1)

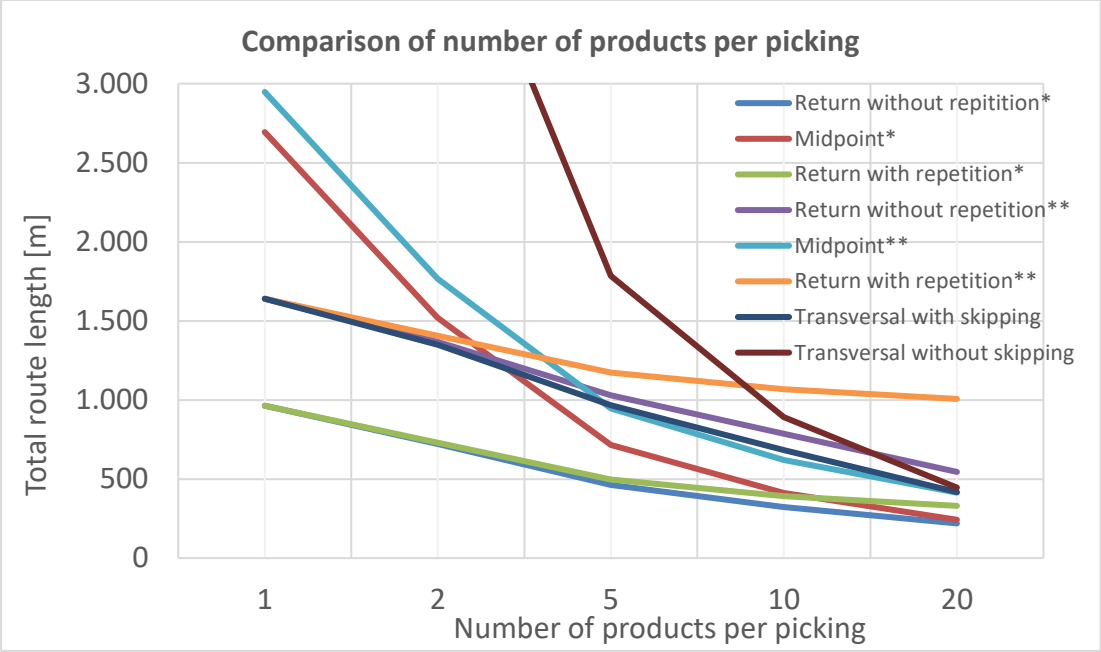


Figure 5-19 Comparison of total route length in 5 scenarios with different number of products per picking (Part 2)

In practical terms, in B2C e-commerce, the customer orders are mostly with fewer order lines and a wider range of product categories. Depending on the experiment above, it is more efficient that one article order and two article orders are combined as one super order to reduce the picking route dramatically.

Some other discussion may lead to discuss which kind of orders can be combined together in the situation that at one picking position more articles can be picked at one time to reduce the repeat visit of the same position. This concept is also discussed in the former chapter with the explanation of a strategic simulation model.

5. The size of orders in one picking process

The total amount of products are fixed in the above experiments. By adjusting the number of products per picking the picking lengths can be compared by using different picking strategies. Furthermore, if the total amount of products is changing in one picking process then the following experiments demonstrate the picking lengths in different picking strategies.

Table 5-19 Parameters of 4 order picking scenarios

Scenario	n	N_A	M_A	M	W_A	L_c	L	Tour	λ
23	20	8	100	800	5	1	45	1	8.047
24	30	8	100	800	5	1	45	1	8.047
25	40	8	100	800	5	1	45	1	8.047
26	50	8	100	800	5	1	45	1	8.047

The result of each method are shown in the following table after calculation with different picking strategies. In these scenarios, only the picking strategies with exponential distribution are considered.

Table 5-20 Route length in 5 scenarios by using different storage and order picking strategies

Scenario	Return without repetition*	Midpoint*	Return with repetition*	Return without repetition **	Midpoint **	Return with repetition **	Transversal with skipping	Transversal without skipping
23	219.37	242.54	330.35	545.12	413.93	1006.67	417.53	446.00
24	255.52	268.22	463.26	621.87	483.00	1477.74	437.42	446.00
25	281.43	287.55	595.65	665.43	530.71	1948.29	442.73	446.00
26	301.51	302.79	727.83	692.74	564.66	2418.63	444.25	446.00

*: exponential distribution
**: uniform distribution

It is obvious, that with the raise of product amount per picking that the picking route is getting longer for all picking strategies and that for different picking strategies that the curve has different gradient. For the picking strategy return with repetition in uniform distribution is the picking length extremely increased with the raise of products per picking. On the contrary, the picking strategy return without repetition in exponential distribution stays the shortest route length among others.

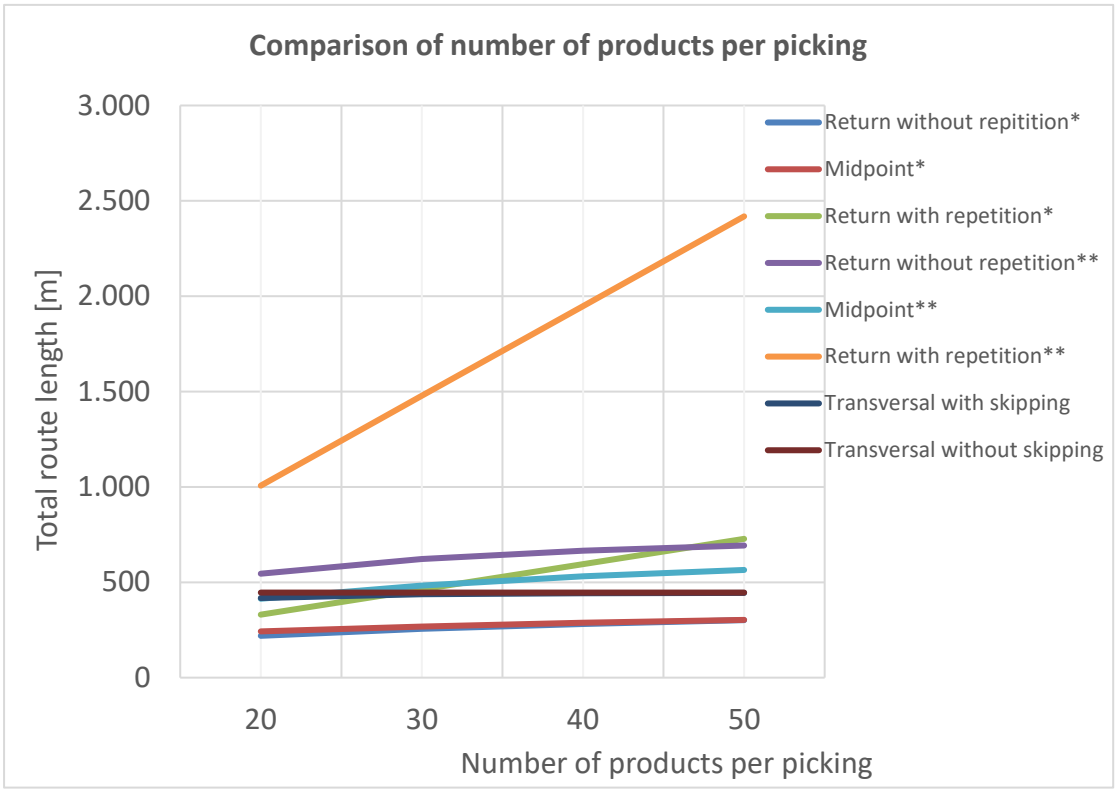


Figure 5-20 Comparison of total route length in 4 scenarios with different number of products in one picking process

It is obvious that, the more products per picking increases the length of the picking route. On the contrary, the picking route per product is reduced. But in this case, the order throughput time is extremely increased. In the meantime, if the order is combined with others, it should be seriously taken into consideration on how to carry so many products per picking and to distinguish each order in different carriers.

Summary of all experiments

According to the result of all experiments, a brief list can be summarized in the following table.

Table 5-21 Summary of all experiments

Experiment	Scenario	Description	Best strategy
1	1-3	General factors are introduced, such as λ, N_A, M_A	Return without repetition*/Midpoint*
2	4-8	Exponential factor λ as parameter	Return without repetition*/Midpoint*
3	9-13	Fixed number of products, N_A, M_A as parameters	Return without repetition *
4	14-18	Fixed number of products in an aisle, M, N_A as parameters	Return without repetition*/Midpoint*
5	19-23	Fixed layout and number of products per picking, n, number of tours as parameters	Return without repetition *
6	23-26	Number of products in one picking as parameter	Return without repetition *

*: exponential distribution

Conclusion

In the warehouse planning, it starts with data analysis, for instance ABC analysis, average order lines per order etc. In the beginning phase of online business the volume of order information is not so high and, with the help of common data processing tools like Microsoft Excel and Access, it is easy to make the evaluation of orders and the man-to-good picking strategy is mostly used in this phase. It brings a great benefit for order picking systems only by adjusting the storage criteria and picking strategy.

As the development of online business continues, a great number of products are expected with short life cycle furthermore the volume of customer orders can be extremely high in a specific time window and even the picking frequency of products may change from time to time. This challenge makes the information processing system to handle more customer order lines and refresh the analysis result in a short period. Some larger and more complicated information processing systems are preferred such as SQL databank and SAP.

The planning of the warehouse focuses on the concentration on warehouse capacity in different storage areas, transport vehicles and labour. However, when the logistic planner struggles with geometric restriction of warehouse construction then the benefit of suitable warehouse layout is sometimes overlooked.

5.5 Risk management in matrix

5.5.1 Risk identification and analysis

A specific risk description with the quantified likelihood and impact is listed below. Some discussion around a certain risk is definitely accepted and depends on the different business experience. Some extreme situation and hypothetic condition should also be taken into account.

The likelihood and impact can be defined in categories to quantify the risk level according to the business situation.

Likelihood: 1 - Unlikely: occur occasionally, one or two times per year
2 - Likely: high probability, one or two time per quarter
3 - Almost certain, one or two times per month

Impact: The impact of one risk can be described in 3 categories in Table 5-22

Table 5-22 Category of risk impact

Level	Time	Cost	Quality
1 - low	Delay within 3 days	< 5% Cost increase	Quality degradation is acceptable or barely noticeable
2 - middle	Delay within one week	5% - 10% Cost increase	Quality may be accept through mitigation or agreement
3 - high	Delay over one week	> 10% Cost increase	Quality does not meet the following safety aspect, constructability, operability, maintainability

Therefore, the risk can be quantified as follows according to the description of likelihood and impact.

Table 5-23 Risk description and quantification

Risk ID	Risk category	Likelihood	Impact	Score	Risk rate
Ⅰ	**Operational Risks**				
1	**Supplier/Manufacturers risks**				
1.1	Unqualified foreign suppliers/manufacturers	1	2	2	Low
1.2	Products not satisfied to the quality requirements	1	3	3	Medium
1.4	Product supply delay	3	3	9	High
1.5	Paid products undelivered	1	1	1	Low
1.6	Lack of delivery services	1	1	1	Low

1.7	Documentation and specification error	1	1	1	Low
1.8	Supplier changes	2	3	6	High
1.9	Supplier collapse	1	1	1	Low
2	**Transportation risks**				
2.1	Volatile transportation costs	1	2	2	Low
2.2	Transport delay	2	2	4	Medium
2.3	Products damaged and loss during transport	1	1	1	Low
2.4	Wrong products amount and type deliver	1	1	1	Low
2.5	Inappropriate transport modes selected	1	1	1	Low
2.6	Lack of transport vehicles and equipment	1	1	1	Low
2.7	Lack of carriers- and service providers	2	2	4	Medium
2.8	Traffic accidents	2	3	6	High
3	**Storage risks**				
3.1	Unsuitable storage condition	1	1	1	Low
3.2	Underestimate storage demands	2	2	4	Medium
3.3	Inappropriate operation	1	3	3	Medium
3.4	Storage or handling equipment breakdown	2	3	6	High
4	**Customers and Orders**				
4.1	Customer order change with specific demand	1	2	2	Low
4.2	Communication misunderstandings	2	3	6	High
4.3	Customer information error or loss	2	2	4	Medium
4.4	Customer order failure	2	2	4	Medium
4.5	Order reception delay	2	2	4	Medium
5	**Information risks**				
5.1	Outdated online information processing system	1	2	2	Low
5.2	Information processing and storage equipment damaged	1	3	3	Medium
5.3	Data recording or processing error	3	2	6	High

5.4	Information loss by hacker attack	2	2	4	Medium
Ⅱ	**Employee risks**				
1	Underestimate of manpower demands	1	1	1	Low
2	Volatile labor costs	2	2	4	Medium
3	Employee health and safety problem	1	1	1	Low
4	Employee unable to work at extended time	2	2	4	Medium
5	Product loss because of employee theft	1	1	1	Low
Ⅲ	**Financial risks**				
1	Interest rates changes	1	1	1	Low
2	Foreign exchange rates risk	2	2	4	Medium
3	Delay in Banking processes	1	1	1	Low
4	Delay in payments	1	2	2	Low
5	Non-payment by customers	2	2	4	Medium
Ⅳ	**Strategic and economic risks**				
1	Price influence by market fluctuation	2	2	4	Medium
2	Trade strategy change between China and EU	1	3	3	Medium
3	Market proportion decrease because of more business competitors	2	3	6	High
4	Unsuitable customer group	1	2	2	Low

The following table summarizes the risk in main- and subcategories. For the help of risk statistics, the dangerous risks can be easily located in the operational area especially when emphasized on supplier/manufacturers and transportation.

Table 5-24 Statistics of risk evaluation

Risk ID	Risk Description	Risk statistics			
		Low	Medium	High	Sum
Ⅰ	**Operational Risks**	**13**	**10**	**6**	**29**
1	Supplier/Manufacturers risks	5	1	2	8
2	Transportation risks	5	2	1	8
3	Storage risks	1	2	1	4
4	Customers and Orders	1	3	1	5
5	Information risks	1	2	1	4
Ⅱ	**Employee risks**	**3**	**2**	**0**	**5**
Ⅲ	**Financial risks**	**3**	**2**	**0**	**5**
Ⅳ	**Strategic and economic risks**	**1**	**2**	**1**	**4**
	Sum	**20**	**16**	**7**	**43**

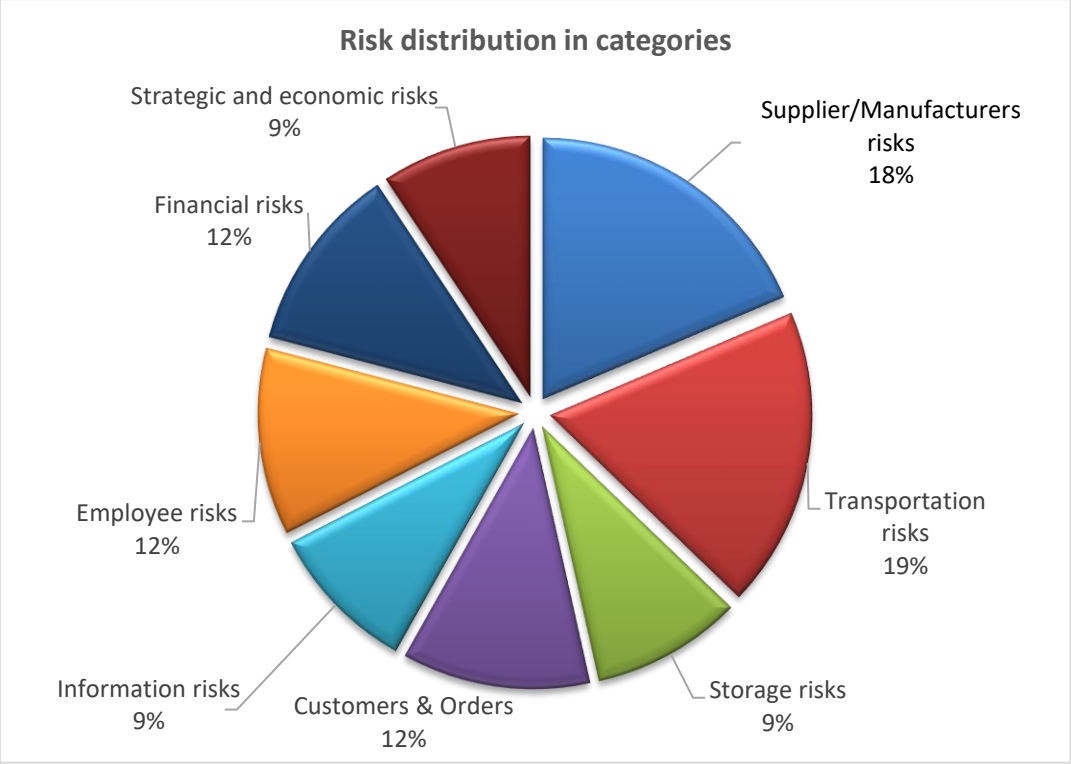


Figure 5-21 Risk distribution in categories

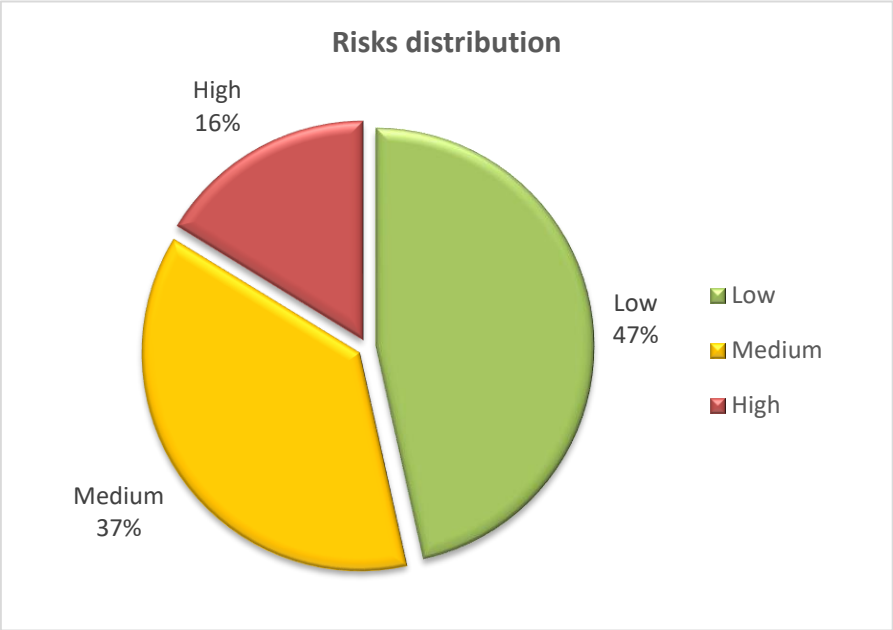


Figure 5-22 Risk distribution in severity

5.5.2 Solutions and scenarios

- One to one solution

Some specific solutions should be developed against the predictable loss with a focus on the high alert occurrence. As listed below, a one to one solution covers each high risk.

Table 5-25 One to one solution for high risks

Risk	One to one solution
Product supply delay	1. Increase the safety inventory 2. Multi suppliers in contact 3. Order in advance
Supplier changes	1. Strengthen the cooperation of contracted suppliers 2. Multi suppliers in contact
Traffic accidents	1. Transport schedule in consideration of traffic situation 2. Backup route and vehicle 3. High assurance to transfer the risk
Storage or handling equipment breakdown	1. Routine maintenance and information backup 2. High quality equipment is preferred
Communication misunderstandings	1. Written confirm applied 2. High qualified co-worker with sufficient language skills
Data recording or processing error	1. Reduce manual data processing 2. Automatic data receiving and processing
Market proportion decrease because of more business competitors	1. Exploit new market 2. Strengthen the competitive power

- Scenario respondence

Some scenarios which cover the most of low and medium risks are also discussed in this sector in the form of material flow, information flow, capital flow and strategic decision.

Table 5-26 Scenarios of low and medium risks

Scenario	Trigger	Respondence
Short of desired product	Supply delay Transport delay Unsuitable inventory condition	1. Suitable safety inventory and storage condition 2. Sophisticated transport schedule with consideration of traffic, weather, route and mode 3. Customer discount and negotiation
Lack of sufficient information	Equipment defect Information error	1. Routine maintenance and backup 2. High quality equipment is preferred
Short of money	Exchange rate fluctuation Custom adjustment Delay of money transfer	1. Bank credit 2. International circulation currency preferred 3. Enough circulating fund
Order reduction	Hard competition Loss of customer credit Unsuitable market goal	1. Strengthen customer communication and service 2. Exploit new market

5.6 Online business observation

An online shop (Deltatrax) with positive customer feedback of around 6000 which was shut down due to a lack of work force is reopened and observed for selling computer accessories. Our experiment would include:

- Changing the products according to trend
- To check if the shipping cost affects selling
- Determine the percentage of profit over the products
- Sell without killing the market

The first month the products brought out for selling in the shop were webcams (1.3 megapixels), Headsets, CD covers, and DVD covers. The profit over these products is 85%. So naturally the product price goes up. For example: Webcams imported for a very small price in bulk purchase from China are sold for a comparatively high price plus shipping costs on which also a suitable profit margin is set.

5.6.1 Observation 1:

The selling starts not with auction but with click and buy. Enquiries from customers included on why the shop had been closed for more than six months, why are the shipping costs so high and also how the product cost had been brought down. Competitors sell the same product for a cheaper price but we concentrate now not on the market or the product but on our profit. We sold products and customers feedback was terribly high compared to the quality of the product also the shipping costs are more expensive than the product itself.

The selling goes slower than normal with such prices and profit margins. But still selling was going on just because of the website design and professional product pictures and information. It can be concluded selling was dependent only on eye washing customers. In other words customers think that the quality of the website reflects the quality of the product. We also have to keep in mind the positives number of feedbacks which also has an effect on the selling process.

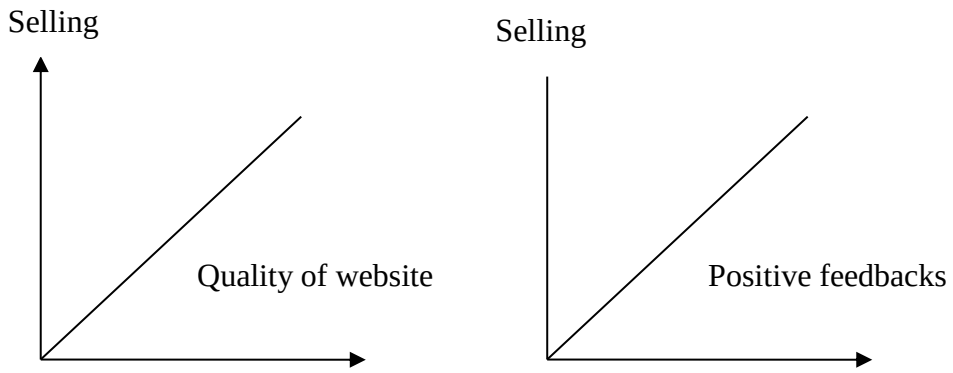


Figure 5-23 Relationship between selling and quality of website as well as positive feedbacks

5.6.2 Observation 2:

The second phase of selling was done with the same price and profit margins but with a very minimal percentage of profit on shipping costs. We can see that the selling increases considerably with in regards to time and price. With a number of the first month's positive feedbacks now the customers learn that the seller is active. So comparing the shipping costs with competitors the customers preferred our shop regardless of the price of the article. It is again only because of the website design and professional photographs that the customer thinks the products are worth the penny they are spending. Customer feedback includes product and price was not so appreciated but still okay. Shipping cost is good and enabled more enquires for latest designs and updated megapixels for the webcam. The products the shop had been selling were 1.3 megapixels webcams, Headsets, Microphones, CD and DVD cases.

5.6.3 Observation 3:

Based on queries and feedbacks from customers small alterations are made on product price and new products so as to say upgraded versions of products are put out for selling. Webcams with higher pixels and more LEDs, Headset with built in microphones are

some of the upgraded versions of the previously sold products. It was noted that there is always market no matter about the cost and competition but for latest products trends. We can see that the selling also considerably increased with upgraded products.

5.6.4 Observation 4:

A small experiment on the shop had been done during the fourth phase of selling. The price or the products were not altered but the customer service was brought down. In other words emails and queries from the customers were not answered frequently. Customers emails regarding incorrect receipt of articles and pending deliveries for paid products were not being processed. We observed a perfect slide on the graph of selling and the reputation of the shop went also down with negative feedbacks from customers. Thus we conclude selling with a strong customer service is also a vital part in online selling. Customers expect the seller not only to sell latest products for best rates but also be active as an online selling buying community. Regular attendance to customers queries to built up a good reputation with the customers in terms of trust. So selling online is not only just selling but also involving with the customers as an online community.

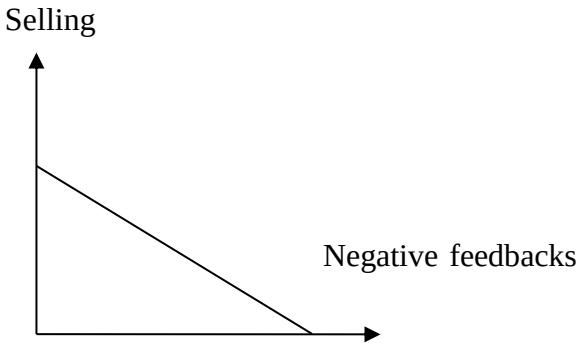


Figure 5-24 Relationship between selling and negative feedbacks

5.6.5 Observation 5:

Keeping in mind the vital role of customer support the shop continued selling the same products and price. As a fifth phase the experiment was on a positive approach when the customer support is more interactive with the aforementioned customers. Email enquiries and problems from customers are answered in a more friendly way and problems are looked at immediately to find a solution. The most common problems customers face are:

1. Incorrect product received: The customer would have ordered a particular webcam and we would have sent another model. This happens mainly due to the carelessness and fatigue faced by the packing department.
2. Paid money but no product received: The customer would have transferred the money but due to incorrect eBay account information from the customer side sometimes the customer cannot be identified and the products are not booked in the shipment list. It can also be that the customer would have given a wrong delivery address while filing his or her billing address by eBay.
3. Damaged Products: The customer would have received a damaged product. This happens mostly due to rough handling by the transport services.

So all these problems are solved at once receiving email from the customers. We saw the selling increased even more than the third phase selling proving that with a good customer support selling can increase more. This customer support can be extended to telephone support too.

5.6.6 Observation 6:

The sixth phase selling involved summing up all valuable experiences we had from the first four phases of selling. The products were updated in respect with the trend and technology.

We started selling with such updated products. The profit margin of 50% is over the product price and a small percentage of profit on the shipping costs.

The selling hits the chart the highest with a higher number of positive feedbacks from the customer as PERFECT. To conclude online selling can be made really interesting and profitable only if we match with the trend and treat customers with respect. We also observed the importance of warehouse management in the process of online selling. In this phase of selling we observed that we could not really be on time with the delivery of goods just because of too many customers.

Chapter 6 Summary and further research work

6.1 Research summary

Online business derives from offline business and combines internet function. Therefore, an online-business-driven logistic system is again a combination of traditional logistic system and information source from online business which pushes the material moving faster, more frequent and more customer-oriented. All motivating forces impel the development of an integrated logistic system with specialized online business function.

This research involves above all a product analysis as breakthrough point dedicated to summarize a thorough concept of a logistics system for online business and further extends three strategic phases along the development of e-commerce where the commonness and individuality coexist in different fields of business. A long-term and steady business strategy plays a critical role from the strategy point of view. Secondly, in the center position of a logistics system for e-business, the warehouse is undoubtedly the focus of all important issues. This includes not only the key figures of warehouse structure, order structure and article structure, but also the method of the order picking system and the treatment of material return flow which in recent market research constituted a high proportion of total material flow. In addition, the financial strategy is also involved to balance cash flow and manage logistic cost to complete this concept. At the end, a risk management breaks down every single factor in the logistic system to detect the risks and find solutions for extreme scenarios.

Under this concept, a concrete online business model is founded to prove and expand the theoretical system. During a decade of practical operation of online business, the knowledge and experience are collected to present this research. In conclusion, the essence of this research can be summarized in the following points:

1. Logistics system design can consist of many business aspects, from product procurement to reverse logistics, from transportation chain design to warehouse layout planning, every single factor along the supply chain can be critical to business success. On the other hand, the e-commerce business model should be adjusted in different phases in order to fulfill the business requirement and this change can be distinguished from B2C to B2B.

2. Never underestimate the reverse flow of e-commerce. A better logistics system can not only forward products to customers, but also solve the reverse flow properly.

3. Simulation is proved as one of the best tools in the logistics planning. Even without physical material flow, a strategic simulation model can still be very helpful to rearrange the picking orders and thus bring a great benefit to the business.

4. Besides standard risk management, a perspective factor differs from person to person. A person in the position of business administration concentrates more on the financial aspect than a mechanical engineer but on the contrary, a

machine breakdown caused by untrained staff seems more critical to a technician.

5. Intermodal transport offers many options for intercontinental freight transportation. Each transport has its advantage and disadvantage and should be properly used in different business phases.

6. Crisis can be a double-edged sword, as it seems to bring a negative benefit to most of the companies. Nevertheless, a suitable adjustment in business strategy can reduce the damage and/or the probability of occurrence.

7. E-commerce has no limit in time and space and it is open to every single person with internet connection. Many challenges should be confronted from national and international competitors, local shops and online and offline business operators in the new trend. It is strongly recommend in this research work to improve the service level, strengthen the product spectrum, enhance the customer satisfaction and in the meantime reduce the operation cost.

8. There is no fixed picking strategy for order picking. It changes with the change of warehouse layout, product structure, picking process etc. Many picking strategies are in detail discussed in this research work and the formulas for calculating the picking route are proved and updated.

As time goes on, the trading trend slides gradually and inevitably from offline business to online business, as the market turns larger and mature. A big step has been taken in the past decade to build the foundation of online business. In the near future, as the development of information technology, acceleration of information exchange and consolidation of internet security, the online functions are in any case the powerful growth point not only to trigger the logistics revolution, but also to drive multifarious industry progress.

Looking back the logistics system for online business regarding how to make e-commerce easier, faster and more automatic, there are always challenges for logistics experts to conquer the barriers and realize new thoughts.

6.2 Future research work

- Smart information solution

An integrated logistic system with more intelligent information technology is the focus of our future research work. During a decade of operation in online business, a network-based information system is getting more and more important. Usually, the online transactions are implemented through the interface between online handler and customer and in the warehouse, the order information is transferred to WMS to fulfill the order picking process. However, the barrier between two interfaces as well as the information exchange between online handler and delivery service provider is obvious. The optimization of information processing in each individual area makes the local environment into an information island. The online business handlers have rarely manufacturing in their business structure, but the warehouse activities driven by online sales is a 24/7 service which does indeed require a smart information solution for all business activities.

- Efficient warehouse auxiliary facilities

Not all online business enterprises can afford a automated high-bay warehouse or a small parts warehouse. Manual order picking with the help of terminal equipment seems a favorable and affordable solution, but this man-to-good order picking strategy has an unstable picking route especially in the multi-aisle warehouse and this despite the fact that the calculation of the picking route can be done in advance.

The research of tracking the logistic object with cameras and identification barcode is another direction. The goal of this research is to reorganize the picking route in order to minimize the order picking time and further increase the efficiency of order picking.

- Efficient automated storage and retrieval system

Warehouse with a full automated storage and retrieval system is not the necessity for all online business handlers but it is truly a high performance storage system. Traditional AS/RS system storages and retrieves objects with the help of a vertical pole to move back and forth, in the meantime a tray-formed feeding device goes up and down so that the object can be located in any position in the storage zone.

Instead of a vertical pole, the research of forwarding the object with intensified ropes fastened at each corner of the aisle demonstrates a new perspective and provides another alternative effectively moving the object with less energy consumption and a faster movement.

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Appendix I Sales data analysis

Table I.1 Annual sales data of product A

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
A							
A01	1100	1400	1600	1950	2350	1975	1385
A02	1800	2055	2125	2570	3125	2400	1175
A03	1350	1450	1455	1675	1800	1125	775
A04	550	575	650	750	965	575	295
A05	350	400	425	425	345	300	240
A06	325	350	375	345	295	250	165
A07	300	325	350	350	265	225	175
A08	200	250	240	225	225	175	150

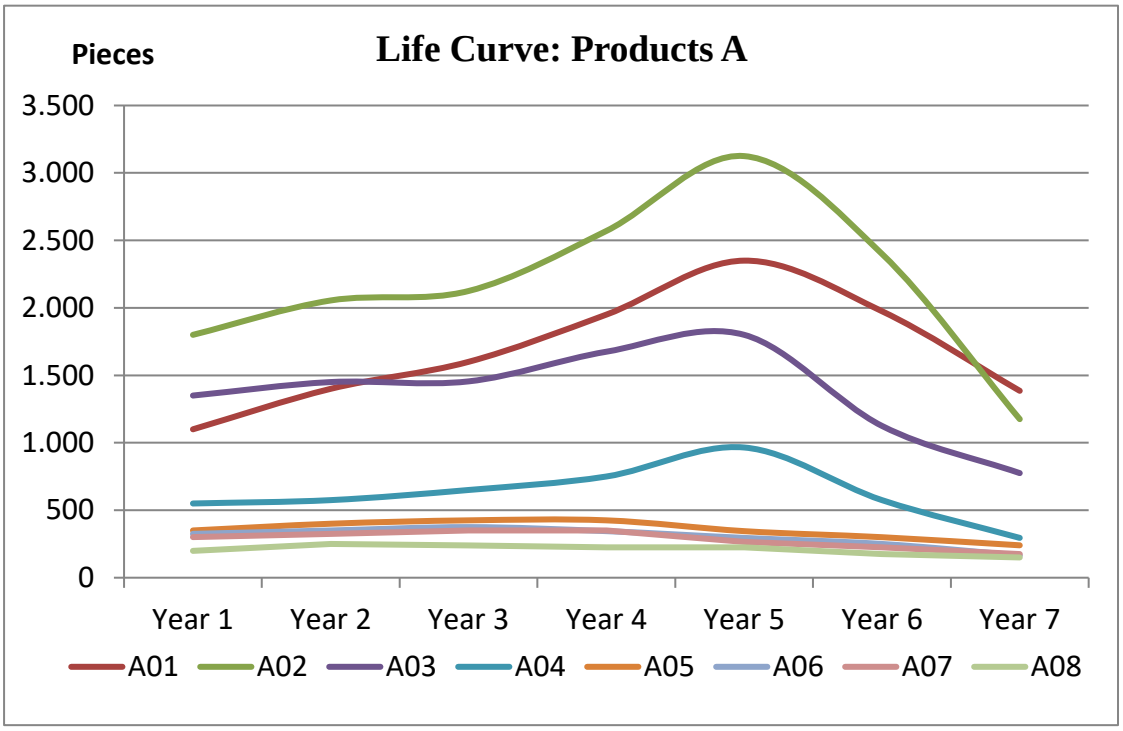

Figure I.1 Life curve of product A

Table I.2 Annual sales data of product B

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
B							
B01	1150	2125	2675	4165	4155	3800	3555
B02	1100	1975	2600	3545	3855	3450	2745
B03	350	555	650	565	775	595	445
B04	325	385	415	360	345	320	295
B05	240	255	285	245	225	215	210
B06	210	245	245	225	175	170	180
B07	200	215	215	210	200	180	175
B08	160	105	180	190	180	170	165
B09	140	165	175	135	155	150	145
B10	950	1775	2350	3650	4050	3550	3375
B11	900	1595	2150	3400	3550	2150	2055
B12	800	1150	1450	1775	1800	1750	1375
B13	675	1050	1375	1750	1675	1600	1155
B14	1100	1350	1575	1835	1875	2400	2455
B15	1100	1350	1450	1835	1850	1965	2550

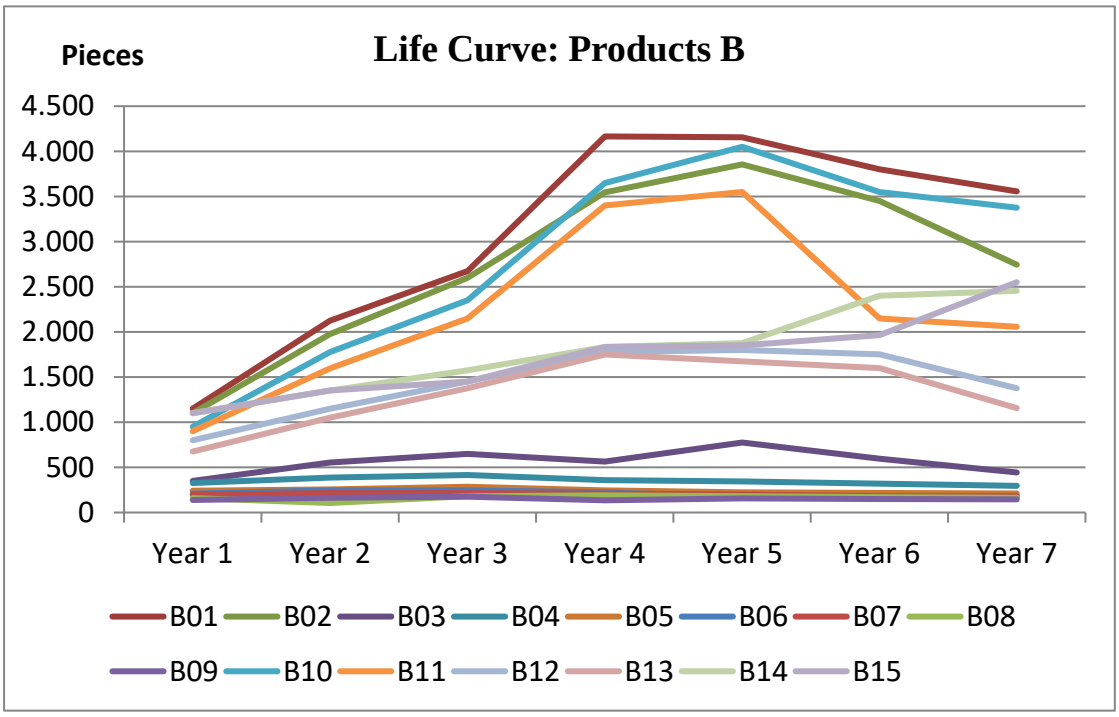

Figure I.2 Life curve of product B

Table I.3 Annual sales data of product C

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
C							
C01	1520	1600	1850	1500	1250	950	800
C02	375	625	625	350	300	250	200
C03	1250	1750	2100	2100	2300	2200	2100
C04	775	1100	1550	1800	2300	2800	2750
C05	182	200	225	250	225	250	300
C06	80	70	70	60	45	45	25
C07	1600	1900	2250	1950	1550	1450	1200
C08	1400	2000	2550	1900	1500	1450	1100
C09	350	400	425	420	350	300	325
C10	300	450	425	380	375	325	350
C11	1450	1850	2300	2550	2800	2400	2000
C12	1300	1875	2350	2550	2800	2300	1800
C13	1200	1550	1800	2150	2950	3400	3800
C14	1100	1550	1850	2200	2900	3600	3600
C15	200	160	155	135	120	95	75
C16	175	170	140	130	125	85	80
C17	80	120	180	200	225	225	275
C18	70	120	180	195	215	245	300
C19						500	1000
C20						185	200
C21						180	240
C22						175	210
C23	500	700	1000	1150	1000	900	700
C24	250	500	950	1200	1550	1600	2400
C25	700	730	800	600	425	375	325
C26	650	725	875	575	450	400	325
C27	120	125	125	140	135	120	120
C28	110	125	120	140	140	120	100
C29	375	420	600	850	950	800	550
C30	350	400	650	875	950	750	500
C31	180	220	275	500	1200	1550	1800
C32	200	25	300	500	1050	1650	1950
C33						400	800

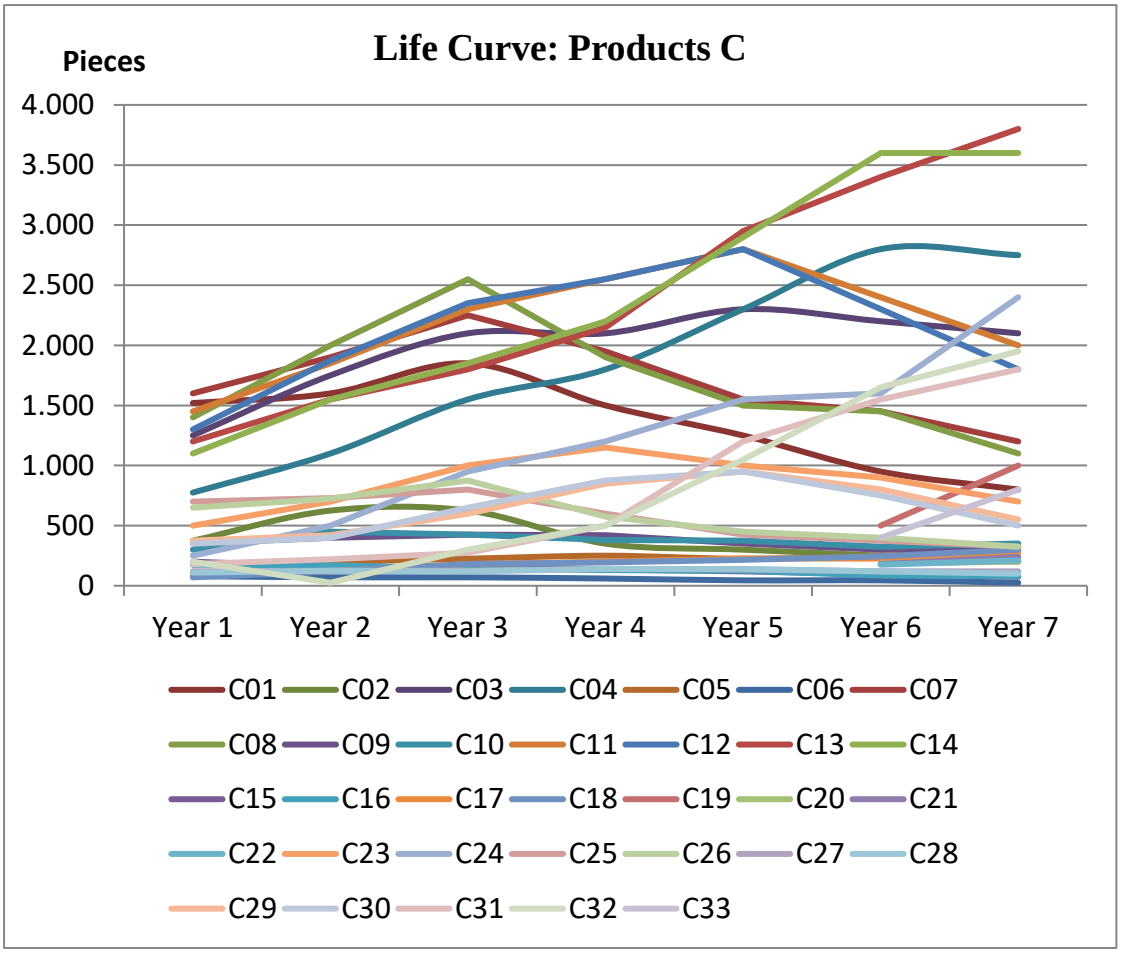

Figure I.3 Life curve of product C

Table I.4 Annual sales data of product D

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
D							
D01		120	190	280	3600	2750	2000
D02		65	145	250	3000	3600	2700
D03			75	85	1900	2750	3400
D04				70	775	2500	2850
D05				35	550	2000	2550
D06					250	1200	1600
D07					120	900	1350

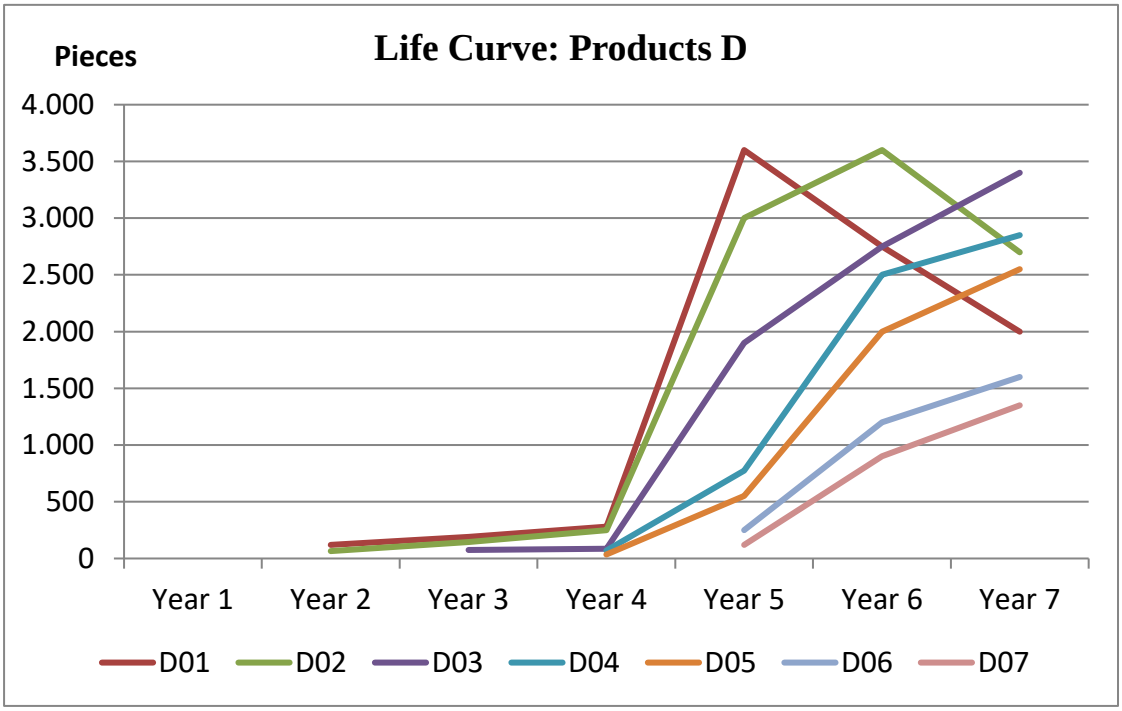

Figure I.4 Life curve of product D

Table I.5 Annual sales data of product E

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
E							
E01		110	225	275	3400	2500	1800
E02		60	100	170	3400	3550	1850
E03			80	100	2200	2850	3750
E04				55	1000	1200	1800
E05						400	500
E06		120	225	240	3550	2250	1600
E07		80	100	150	2950	3500	2400
E08			55	70	2000	2600	3200
E09				35	800	1150	1200
E10						600	600
E11		105	200	300	2800	2400	1600
E12		75	120	250	2400	1800	2400
E13			80	85	850	1200	2600
E14				75	800	1350	1550
E15						300	450
E16		100	220	245	3350	2250	1550
E17		65	120	145	2750	3550	2400
E18			95	75	1200	2500	3500
E19				35	950	1200	1800
E20						600	750
E21		120	125	160	2200	2350	1200
E22		80	120	140	1900	2900	1800
E23			40	45	1150	1150	1600
E24				25	550	1250	1750

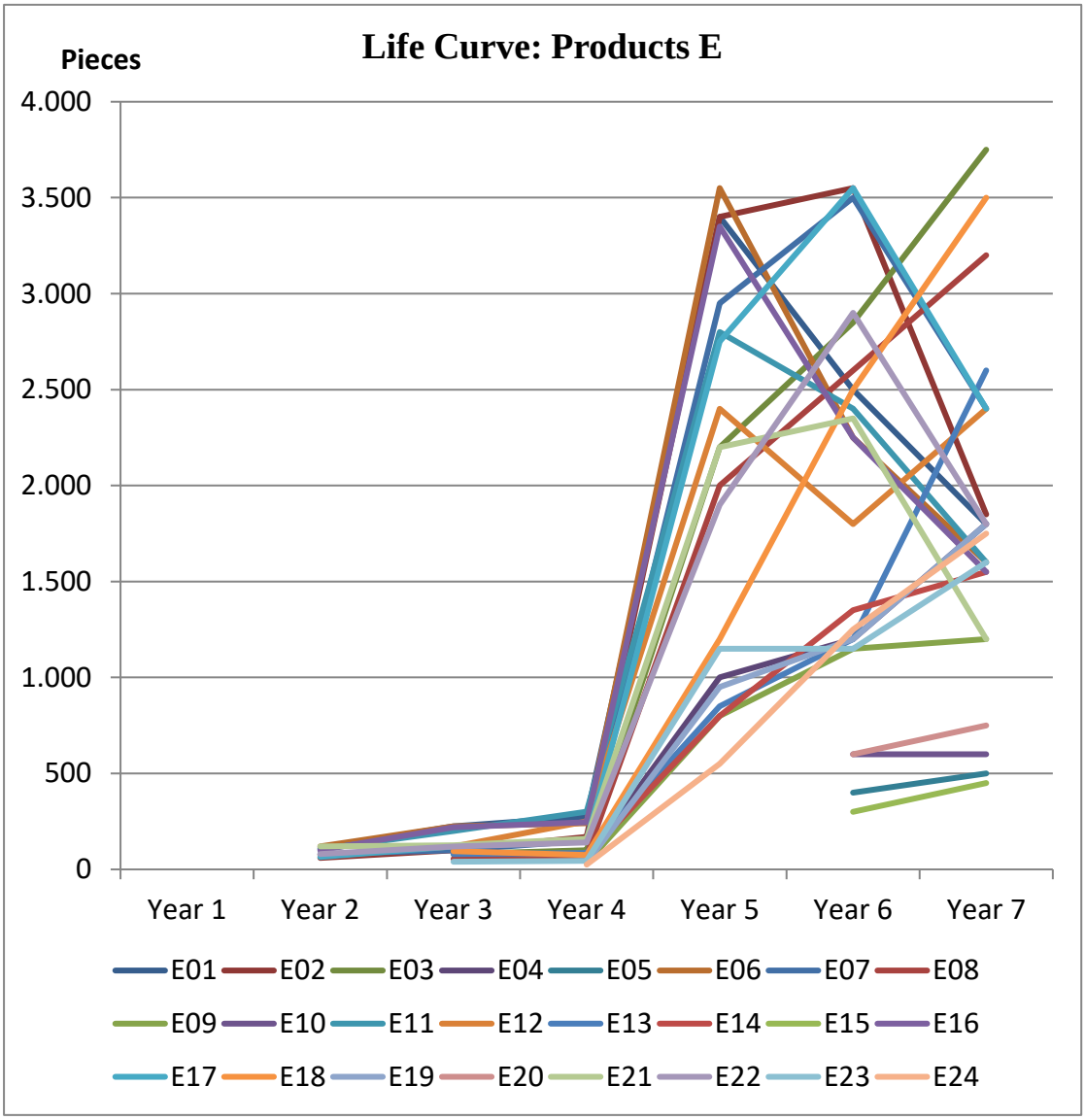

Figure I.5 Life curve of product E

Table I.6 Annual sales data of product F

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
F							
F01	190	285	450	400	345	125	75
F02	220	325	475	425	405	175	120
F03	180	245	385	350	310	120	70
F04	215	300	445	425	350	145	75
F05	95	170	200	220	150	120	70
F06	115	175	165	125	125	100	70
F07	145	145	120	110	110	105	60
F08	120	125	105	90	90	90	50
F09	175	150	155	120	115	105	105
F10	135	130	130	115	105	105	50
F11	425	550	610	675	675	625	525
F12	385	475	570	650	600	575	550
F13	200	160	160	150	125	120	60
F14	575	800	1100	1200	1220	1050	750
F15	550	775	1075	1200	1075	1050	700
F16	745	950	1150	1350	1250	1200	975
F17	695	895	1100	1200	1050	1025	900
F18	975	1350	1500	1600	1725	1500	1050
F19	800	1100	1250	1425	1500	1200	950
F20	945	1100	1175	1325	1325	1300	1000
F21	885	1055	1140	1275	1200	1225	900
F22	1175	1425	1550	1700	1600	1175	1050
F23	1050	1350	1450	1500	1575	1165	1025
F24	1150	1275	1425	1400	1050	775	500
F25	975	1050	1075	1100	1025	625	450
F26	945	975	1050	1000	950	550	350
F27	950	1050	1075	1150	1020	625	400
F28	195	145	140	135	130	115	100
F29	175	145	130	105	105	100	75
F30	1450	1525	1775	2075	2350	2025	1650
F31	1375	1475	1750	2000	2325	1950	1550
F32	500	465	445	350	345	305	275
F33	445	375	350	350	330	305	225
F34	1575	2025	2250	2650	2475	2250	1600
F35	1400	2050	2075	2350	2165	2200	1450
F36	875	1025	1150	1220	1125	1050	425
F37	850	1000	1150	1185	1135	1045	500
F38	900	975	1050	1175	1160	950	535
F39		1350	1550	1675	2350	2250	2050
F40		1275	1500	1600	1975	2100	2025
F41		1275	1500	1615	1950	2025	2015
F42		1285	1550	1600	1275	1550	1575
F43		550	700	1150	1050	900	775
F44		550	635	750	1025	850	675
F45		545	640	800	925	900	700
F46		525	650	775	925	875	675
F47		515	585	600	650	550	425
F48		550	600	625	625	545	450

F49	45	65	65	60	45	40	20
F50	40	70	60	55	40	35	25
F51			1125	1550	1875	2450	2150
F52			1050	1475	1750	2200	1775
F53			1050	1525	1775	2100	1775
F54			1025	1475	1700	2020	1750
F55			1015	1500	1750	1340	1020
F56			925	1025	1050	845	745
F57			900	1025	1025	775	750
F58			900	1000	1050	825	735
F59				1550	2175	2250	3150
F60				1350	2050	2150	3025
F61				1350	2015	2050	3010
F62				1405	2005	2050	3035

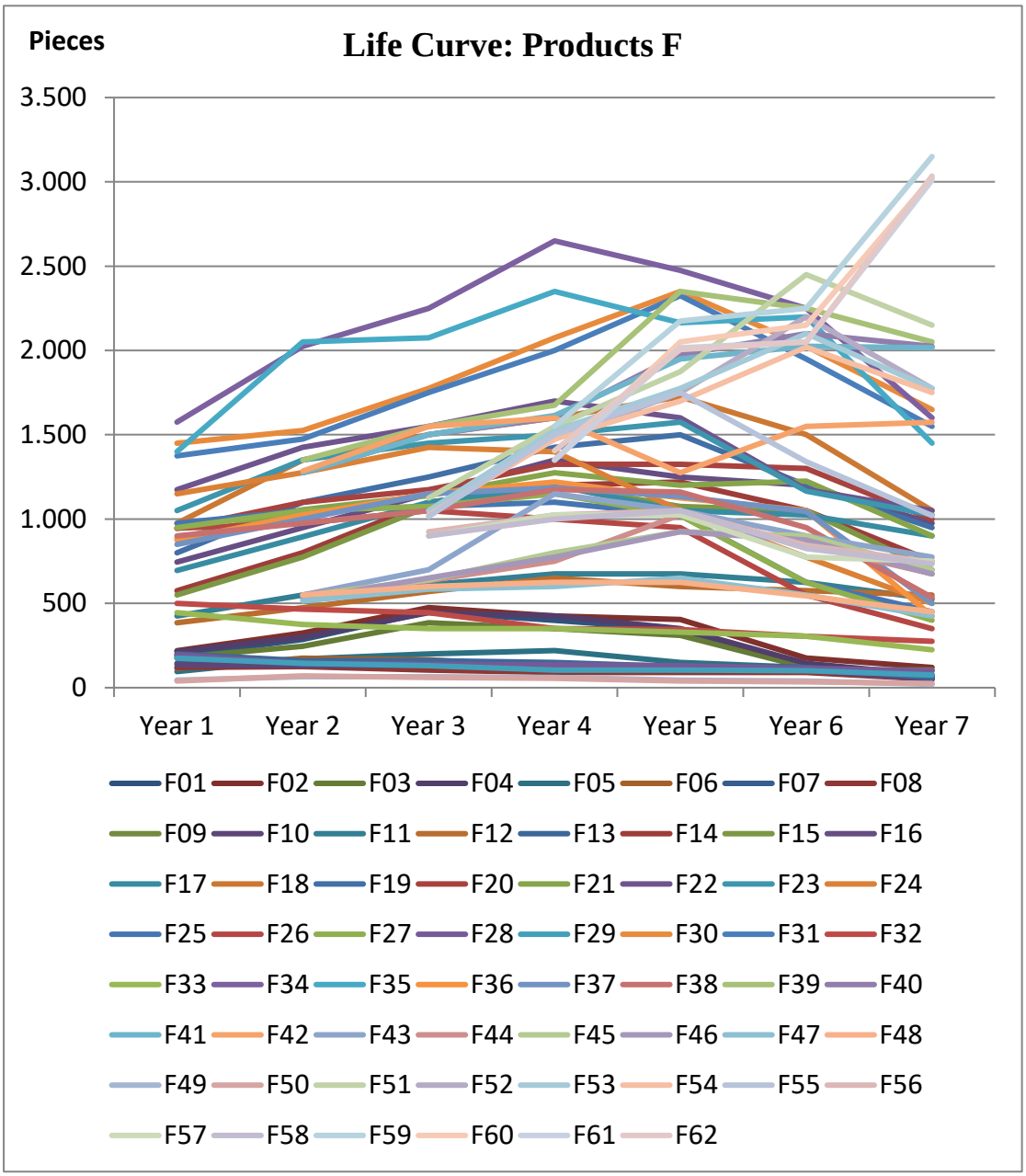

Figure I.6 Annual sales data of product F

Table I.7 Annual sales data of product G

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
G							
G01	1150	1275	1425	1325	1050	775	545
G02	995	1025	1050	1200	1025	645	450
G03	945	975	1025	1050	850	550	360
G04	950	1050	1075	1145	950	635	450
G05	500	450	400	325	345	325	250
G06	445	400	350	345	335	305	220
G07	375	350	315	295	250	240	205
G08	1375	1375	1550	1565	1650	1550	1100
G09	1200	1250	1250	1300	1545	1225	950
G10	1525	1800	2050	2250	2035	1745	1150
G11	1450	1745	2025	1350	1950	1650	1050
G12	1125	1245	1350	1400	1100	775	525
G13	950	1035	1150	1125	950	625	425
G14	980	955	1025	1025	950	550	375
G15	875	1030	1050	1125	1010	625	420
G16			1175	1550	1865	2450	2150
G17			1050	1450	1705	2200	1775
G18			1100	1400	1635	2100	1775
G19			1100	1475	1645	2050	1700
G20			1050	1450	1545	2150	1750
G21	75	70	65	40	45	30	10
G22	45	60	60	35	30	30	5

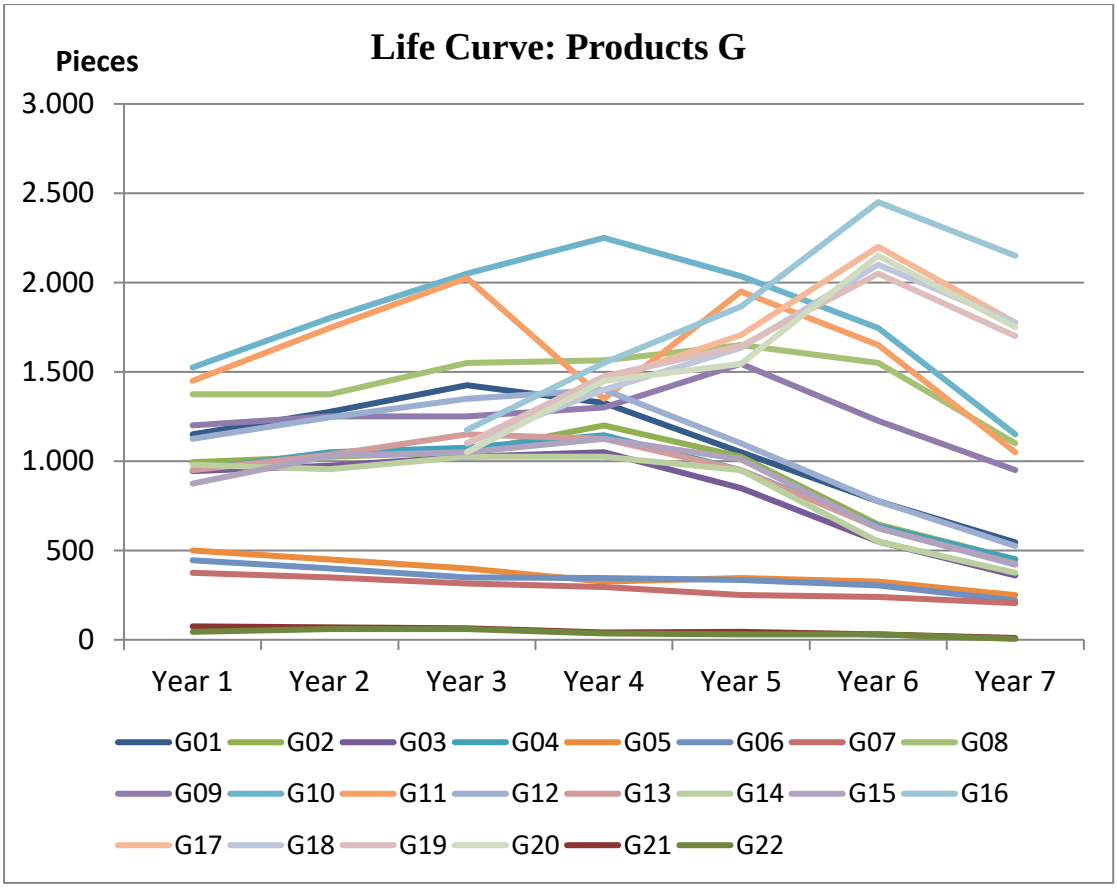

Figure I.7 Annual sales data of product G

Table I.8 Annual sales data of product H

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
H							
H01	89	70	65	60	50	45	40
H02	75	90	105	85	75	70	35
H03	115	145	145	170	120	105	105
H04	125	155	165	220	220	210	180
H05	115	140	150	210	210	175	160
H06	225	270	275	275	320	325	360
H07	215	250	250	250	320	330	345
H08	210	220	225	215	225	210	175
H09	260	325	345	345	325	330	250
H10	240	350	325	325	365	375	390
H11	170	220	225	250	275	275	275
H12	165	175	200	200	225	230	245
H13	115	120	140	195	245	225	260
H14	120	120	145	145	140	125	120

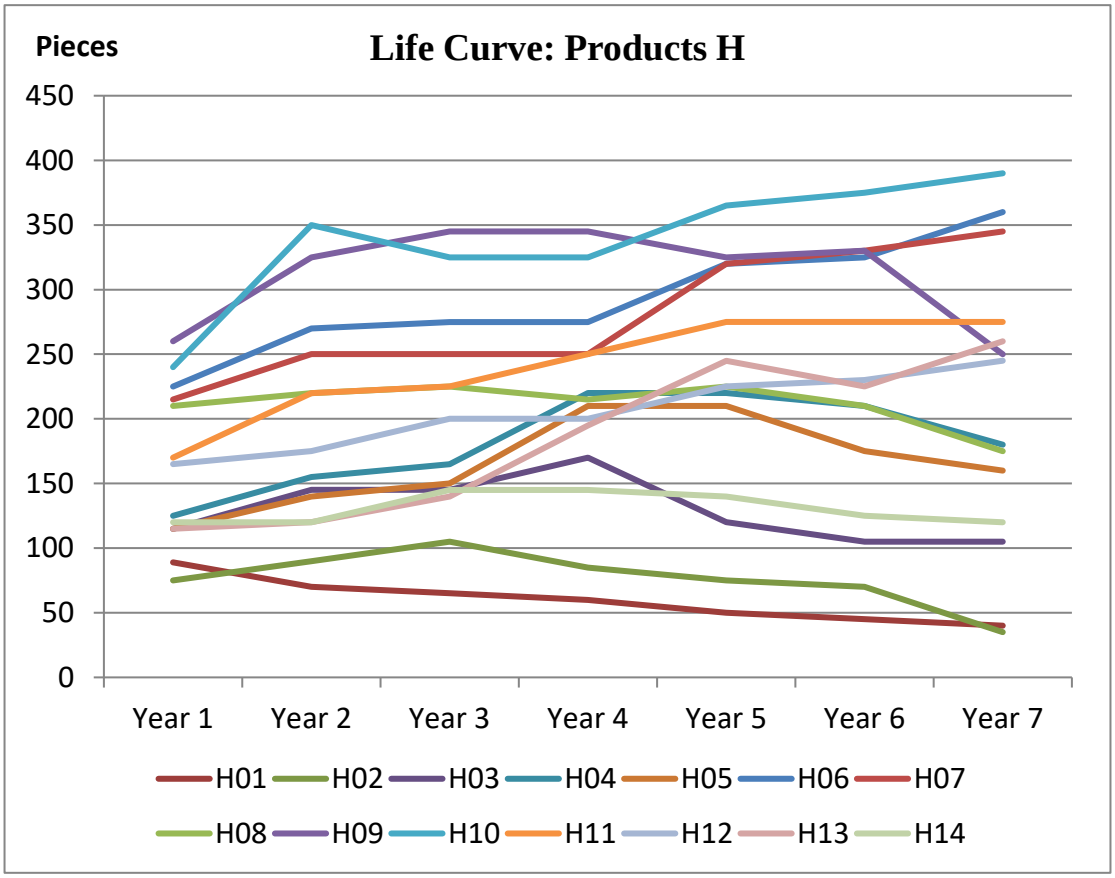

Figure I.8 Annual sales data of product H

Table I.9 Annual sales data of product I

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
I							
I01	115	125	125	105	95	90	90
I02	120	140	155	175	155	105	100
I03	220	245	275	275	305	325	345
I04	205	225	225	250	285	310	315
I05	50	65	75	65	55	55	50
I06	60	75	90	105	80	75	75

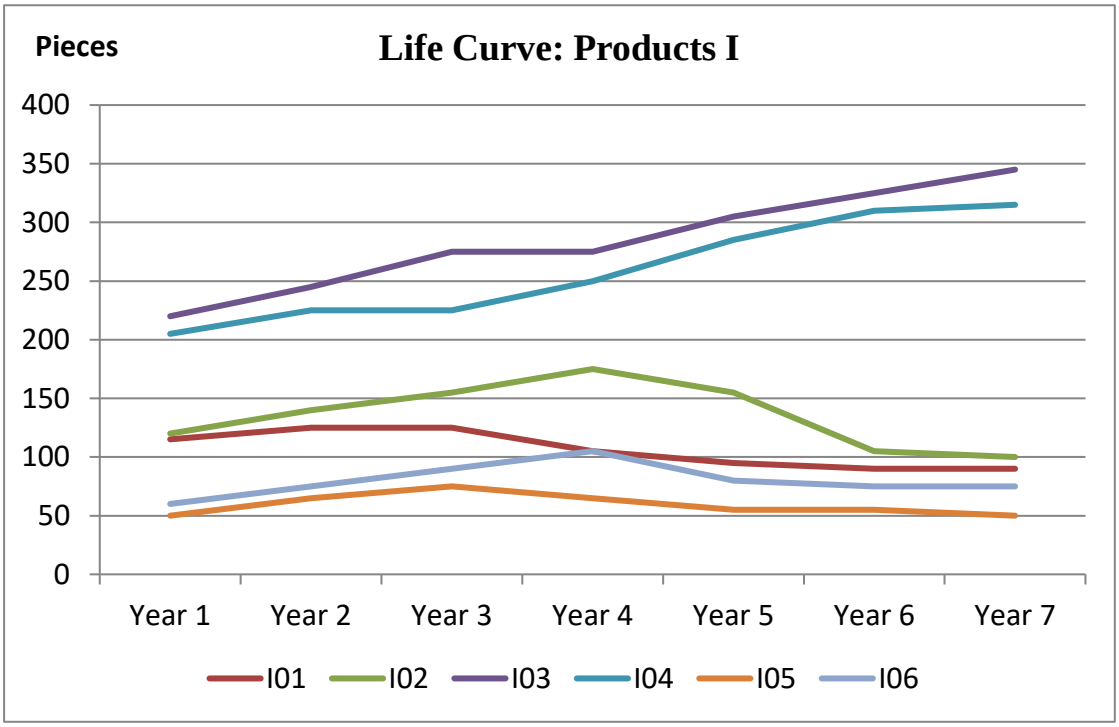

Figure I.9 Annual sales data of product I

Table I.10 Annual sales data of product J

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
J							
J01		1150	1325	1425	1325	1050	725
J02		950	1070	1075	1200	1025	615
J03		900	980	1000	1025	800	575
J04		900	1000	1050	1125	950	625
J05			1250	1400	1400	1050	775
J06			1000	1050	1150	1025	625
J07			1005	1150	1025	950	550
J08			1035	1100	1175	1025	630
J09				1175	1375	1400	1575
J10				1050	1100	1375	1500
J11				1075	1024	1425	1525
J12				1100	1050	1375	1500

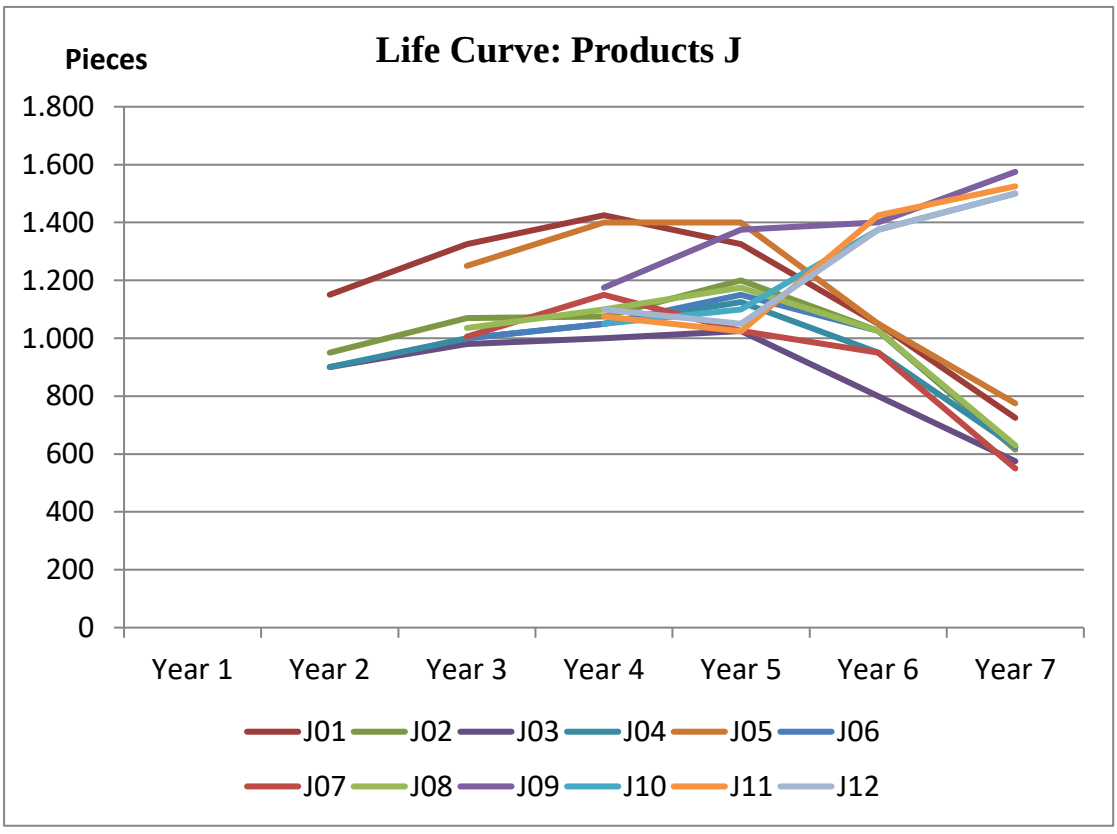

Figure I.10 Annual sales data of product J

Table I.11 Annual sales data of product K

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
K							
K01	245	275	250	285	325	330	350
K02	220	225	245	275	300	315	345
K03	240	250	265	250	250	305	325
K04	210	250	260	250	305	320	325
K05	175	220	275	275	330	360	415
K06	150	175	250	250	305	355	405
K07	140	200	220	225	270	305	375
K08	145	210	240	250	250	300	350
K09			125	150	170	155	150
K10			110	140	150	150	120
K11			110	135	145	145	125
K12			105	105	135	130	110

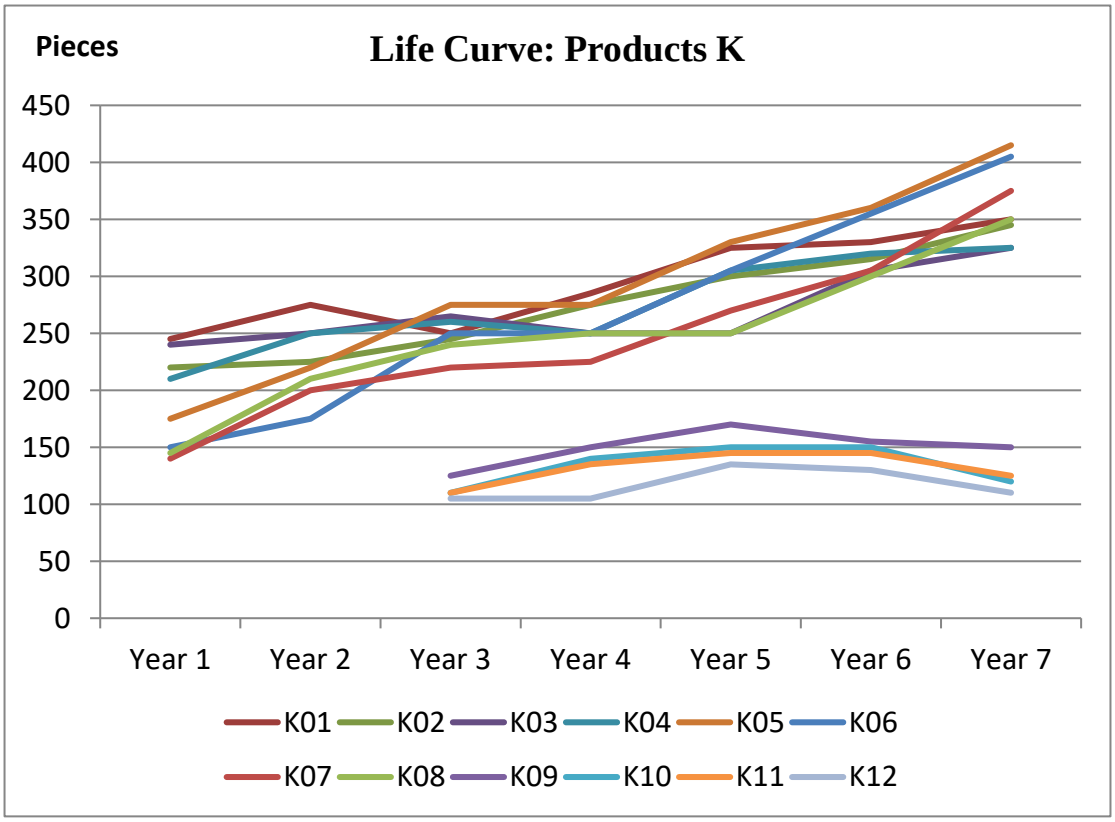

Figure I.11 Annual sales data of product K

Table I.12 Annual sales data of product L

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
L							
L01	120	180	200	220	160	155	145
L02		75	125	150	250	320	310
L03		105	150	225	195	190	170
L04			90	205	250	325	325
L05			525	750	1225	1475	2250

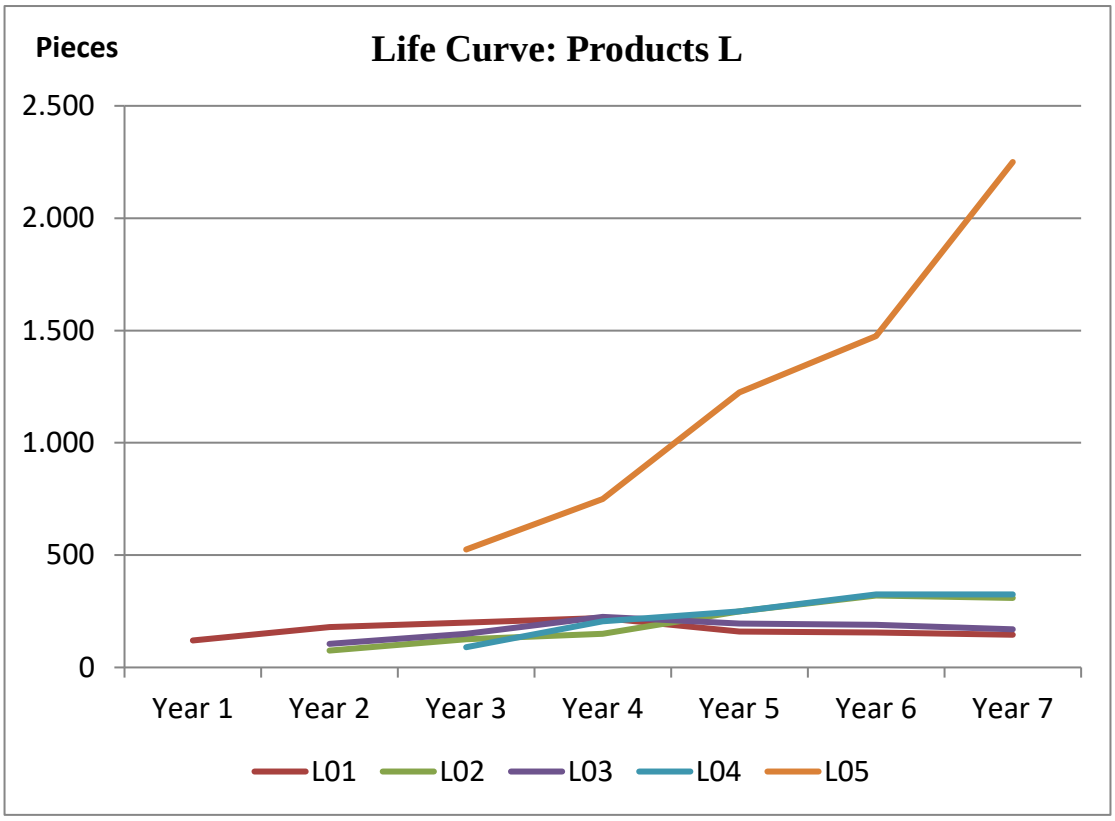

Figure I.12 Annual sales data of product L

Table I.13 Annual sales data of product M

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
M							
M01	1350	1775	2350	1875	1550	1575	1100
M02	1750	2350	3150	3550	3750	3150	2550
M03	1925	2450	3775	4150	4055	3750	3450
M04	1775	1800	2125	2345	1800	1400	1125
M05	765	1575	1750	2355	1635	1425	1100
M06	1150	2350	2150	1785	1800	1400	825
M07		1575	2750	3150	3250	2825	2050
M08		1300	2875	3450	4150	3575	3150
M09		1225	2400	2550	2850	2750	1400
M10			775	1150	1600	1400	1150
M11			575	1145	1400	1200	950
M12			400	1245	1200	1050	775
M13			375	745	1025	900	725

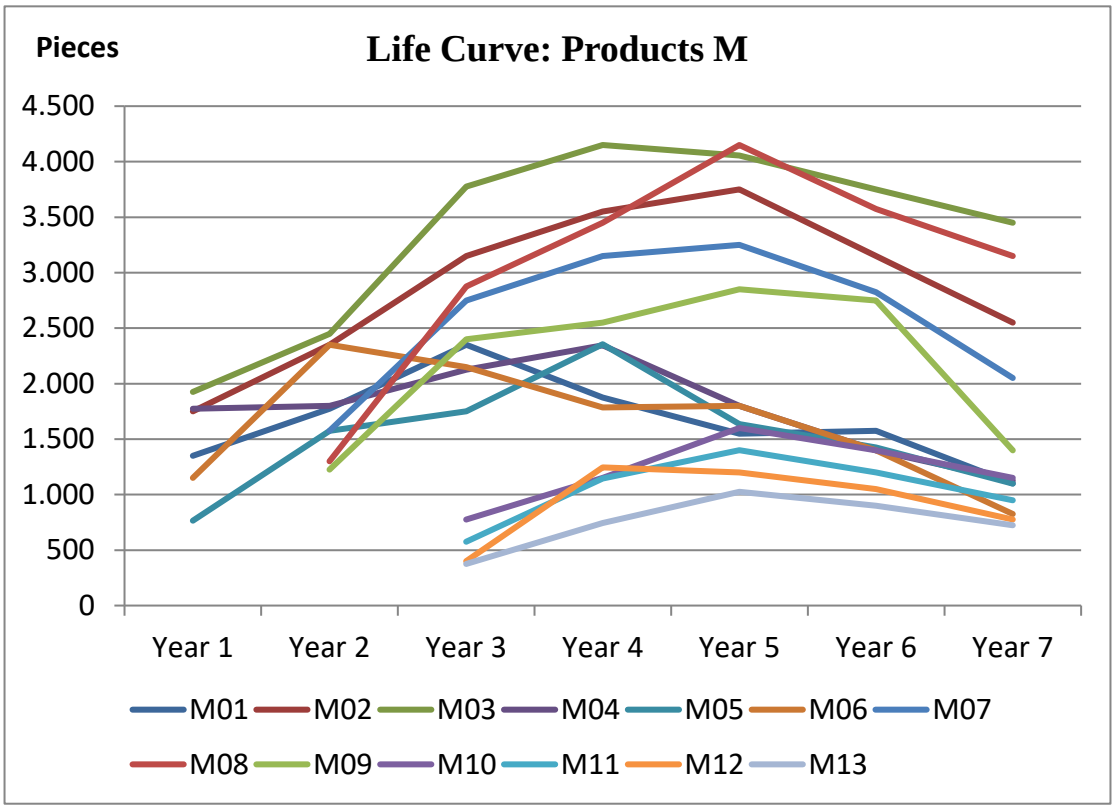

Figure I.13 Annual sales data of product M

Table I.14 Annual sales data of product N

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
N							
N01	775	1150	1230	1325	1050	775	725
N02	1150	1550	1650	1750	1875	1125	1050
N03	1355	1575	1775	1875	1900	1600	1365
N04	1575	1775	2150	2550	2775	1765	1635
N05		1645	2365	2750	3150	3125	1775
N06		1155	1560	1700	2775	2745	1750
N07		785	1130	1600	1800	1835	1400
N08		635	840	1150	1050	1050	1050
N09			720	1050	1225	1150	1200
N10			580	750	925	875	775
N11			430	600	725	775	750
N12			370	445	625	575	450

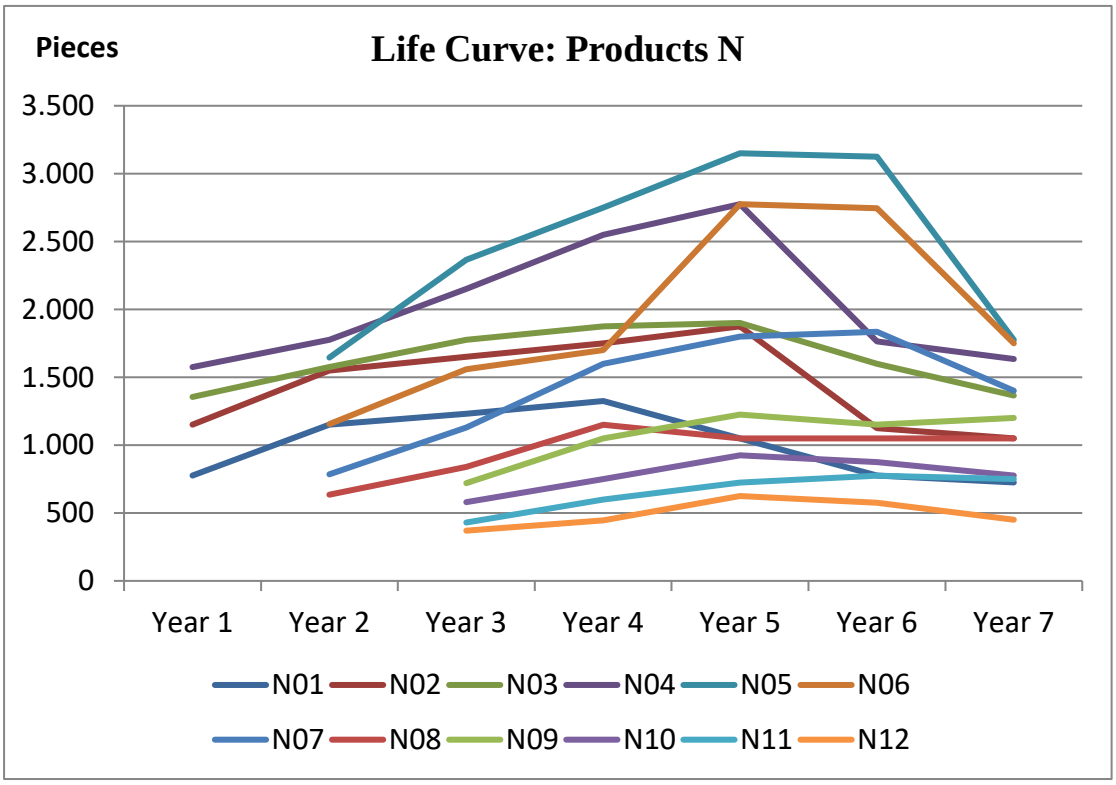

Figure I.14 Annual sales data of product N

Table I.15 Annual sales data of product O

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
O							
O1				1875	3150	3750	5250
O2			1775	2350	2750	3150	3600
O3	1150	1595	1765	2100	3150	2750	2450
O4	750	1165	1875	2150	3550	3135	2355
O5			585	800	1150	1050	775
O6				1650	2350	2775	3125
O7		1100	1230	1400	1775	1250	1145
O8		1025	1120	1250	1735	1150	1165
O9	225	345	370	575	245	185	145
O10	275	335	330	300	235	195	135
O11			575	1150	1795	2395	3125
O12			425	875	1200	1535	2400
O13				445	750	1200	1450
O14		575	775	2245	2675	1450	3650
O15			700	1450	3170	3550	4250
O16			750	1575	3280	3600	4350
O17	175	385	575	1350	1655	2275	2800
O18			750	1200	1565	2275	2775
O19			575	1150	1765	1775	2850

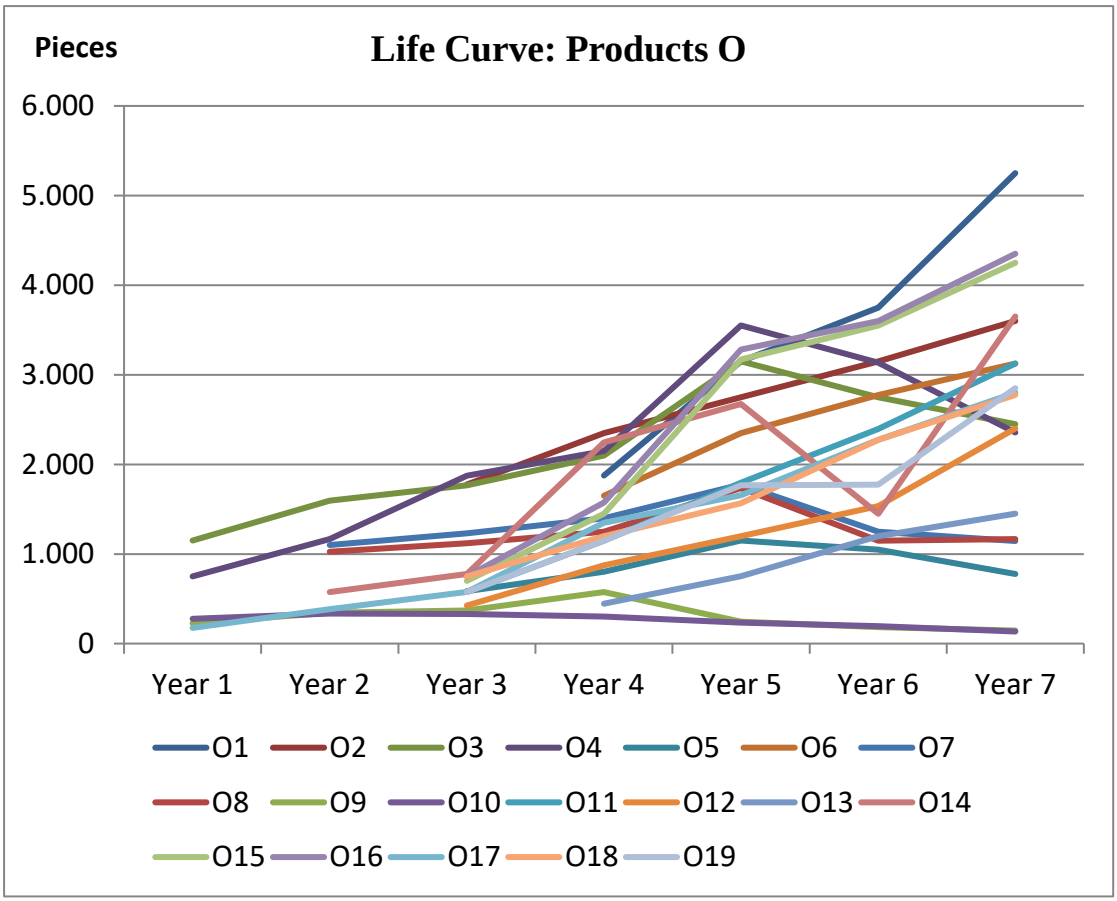

Figure I.15 Annual sales data of product O

Table I.16 Annual sales data of product P

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
P							
P01	835	945	1050	1150	1150	1050	1350
P02	1575	1875	2150	2250	2750	2750	3150
P03	335	375	445	350	300	575	745
P04	315	405	380	445	550	400	635
P05	135	255	350	435	250	200	385
P06	225	275	335	225	100	445	375
P07	455	745	570	775	450	345	445
P08	565	1150	1760	2350	2750	2775	2950
P09	445	550	1140	1120	1400	1550	2050
P10	300	375	440	340	275	450	445
P11	265	445	870	440	305	325	435
P12	800	1150	1550	3145	3145	3750	3865
P13	1150	1750	2450	2450	2550	3150	4075
P14	600	545	700	445	775	375	645
P15	400	345	540	735	445	145	450
P16	600	825	440	225	845	745	285

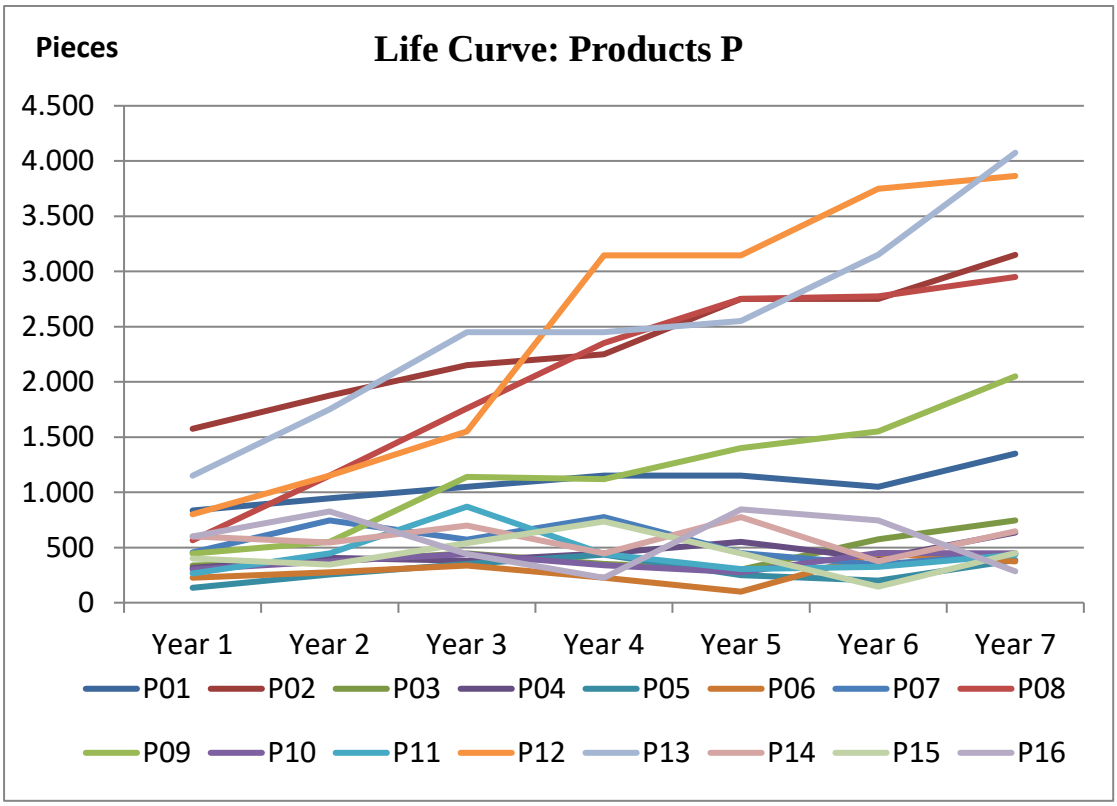

Figure I.16 Annual sales data of product P

Table I.17 Annual sales data of product Q

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Q							
Q01	225	275	430	575	550	675	725
Q02	325	425	470	640	635	725	850
Q03	145	145	180	230	175	145	195
Q04	200	335	380	480	445	575	635
Q05	400	820	1150	1620	1750	2150	2250
Q06	450	530	570	640	500	650	750
Q07	225	320	440	380	250	250	250
Q08	150	245	275	375	250	245	175
Q09	350	580	775	1150	750	735	625
Q10	400	870	285	225	275	575	225
Q11	250	445	565	745	445	225	195
Q12	225	435	445	575	375	775	375
Q13	325	425	725	750	775	1150	1225
Q14	575	750	1375	2750	2250	2750	3125
Q15		1170	1575	1775	2350		3145
Q16		775	1150	1350	1750	2150	2250
Q17		560	850	1150	1600	1735	2075
Q18		380	575	450	445	345	225
Q19		240	450	740	575	445	375
Q20		445	550	780	1150	1345	1775
Q21		375	535	745	1050	1335	1655

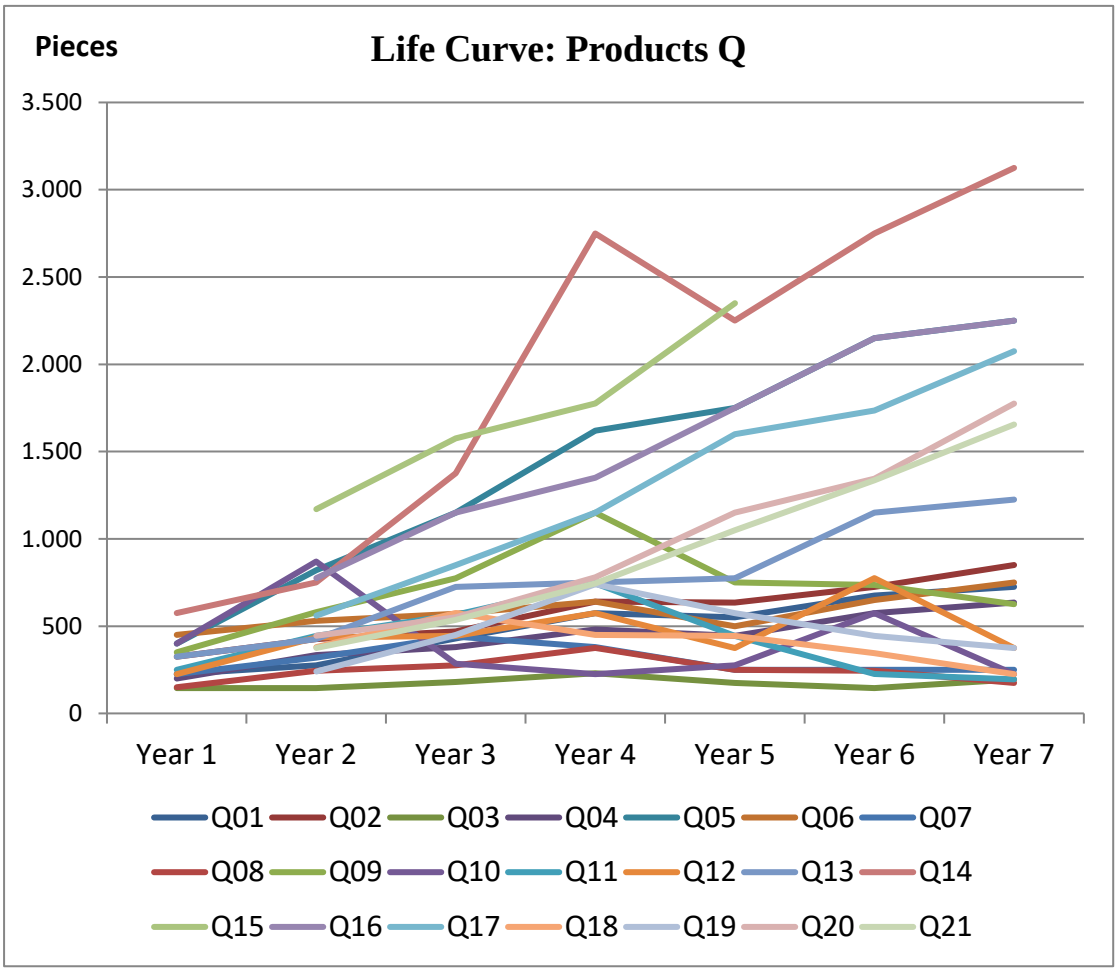

Figure I.17 Annual sales data of product Q

Table I.18 Annual sales data of product R

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
R							
R01	775	1150	1775	2150	1775	1375	1150
R02	985	1350	2150	2550	2150	1750	1375
R03	845	1250	1900	2400	1875	1500	1385
R04	1100	1475	2250	2850	2350	1850	1575
R05		1150	1550	2350	2750	3150	2750
R06		1350	1750	2750	3150	3450	3150
R07			1775	2250	3200	3550	3750
R08			2150	2550	3350	3750	4150
R09			1145	1400	1250	1150	750
R10			975	1550	1850	1450	850
R11				1150	1775	2350	2150
R12				975	1775	2775	3155

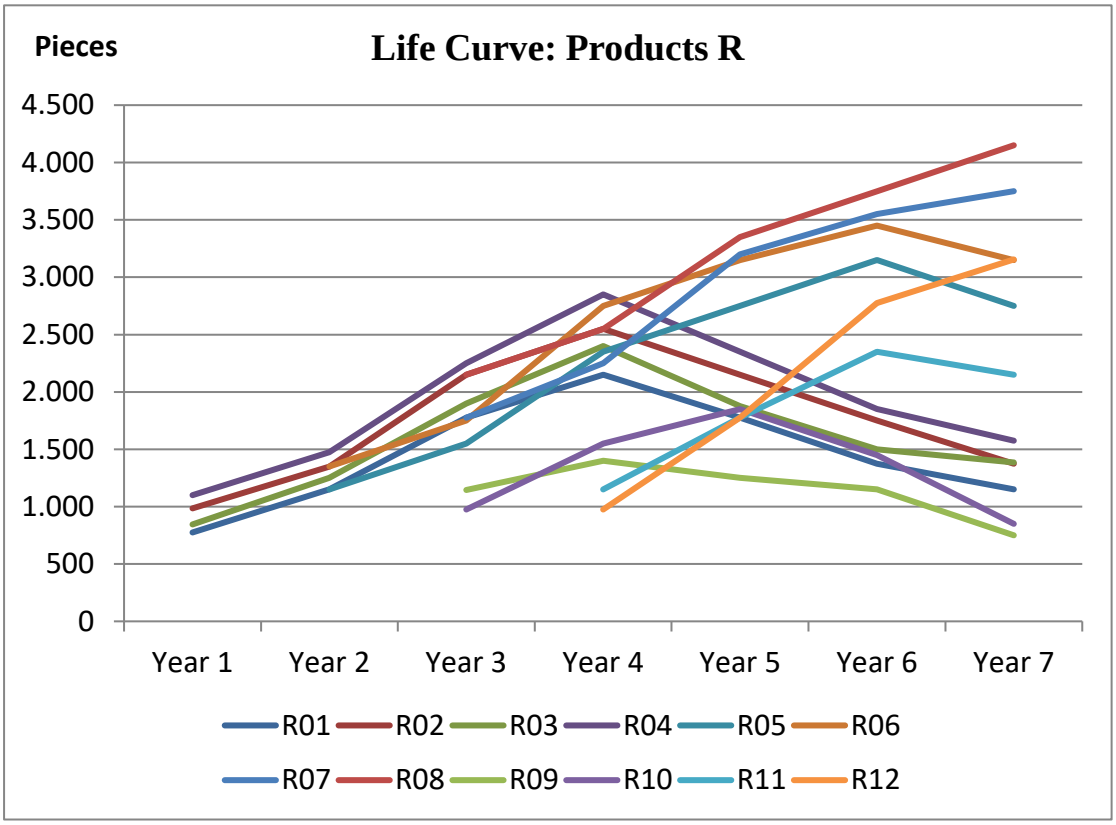

Figure I.18 Annual sales data of product R

Table I.19 Annual sales data of product S

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
S							
S01		245	335	585	765	775	725
S02	175	335	385	375	300	255	250
S03		385	575	775	1150	1150	1050
S04	235	315	565	875	1100	955	850
S05			375	765	1175	1050	1050
S06		365	575	750	585	325	275
S07				1145	1345	1550	1700
S08			245	295	445	550	750
S09		365	535	750	435	325	175
S10				1145	1545	1750	1800
S11			1135	1365	1550	1650	1750
S12		375	785	550	425	375	265
S13				1150	1750	1850	1945
S14			245	445	450	400	345
S15					550	1150	1775
S16				175	350	250	225
S17				225	300	550	335
S18			155	375	350	275	235
S19					175	350	750

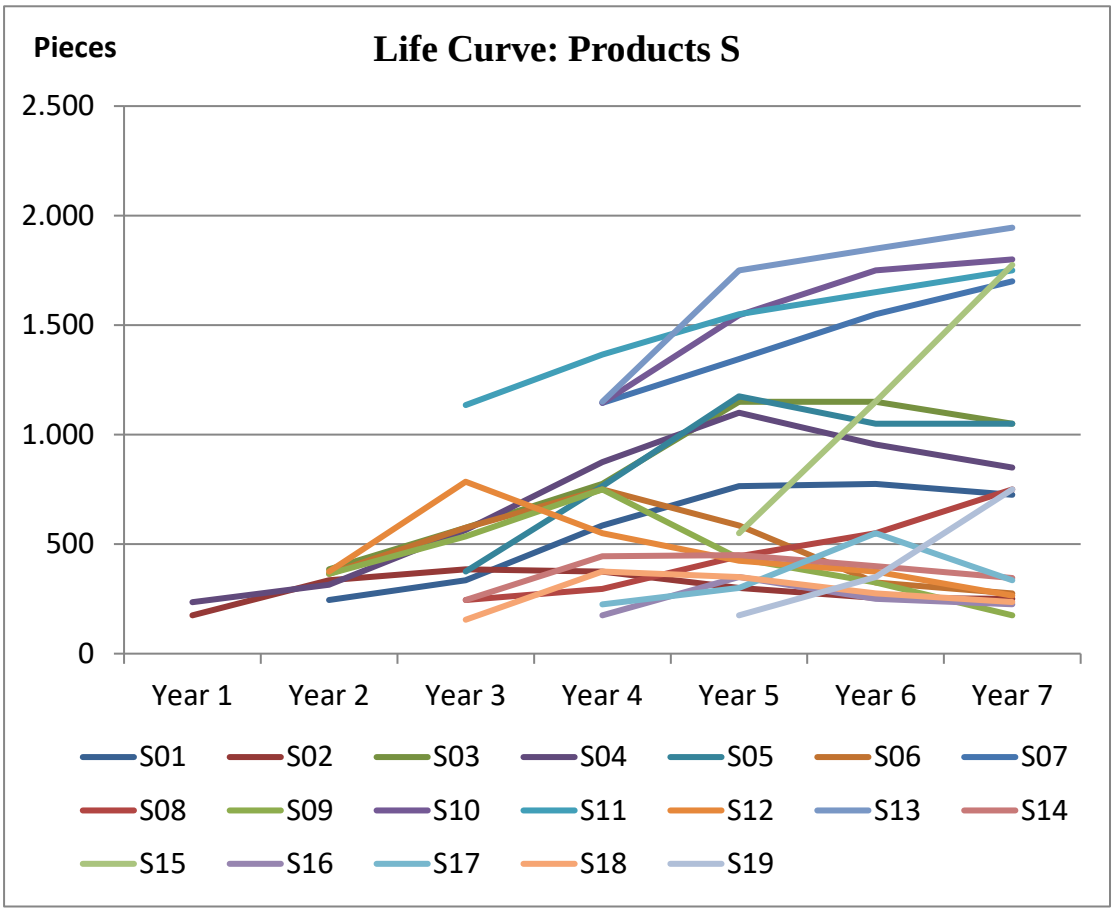

Figure I.19 Annual sales data of product S

Table I.20 Annual sales data of product T

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
T							
T01		375	575	795	250	145	45
T02		275	350	705	550	195	75
T03		155	450	845	1150	690	150
T04			275	575	1350	760	225
T05			225	550	1595	870	250
T06				155	585	755	325
T07				135	345	1150	375
T08					150	565	775
T09					295	735	1150
T10						750	1150
T11						345	750
T12	85	335	785	1150	1550	1750	2345
T13		545	1150	1750	2350	2345	1775
T14					1155	2150	2345
T15					75	1150	1575

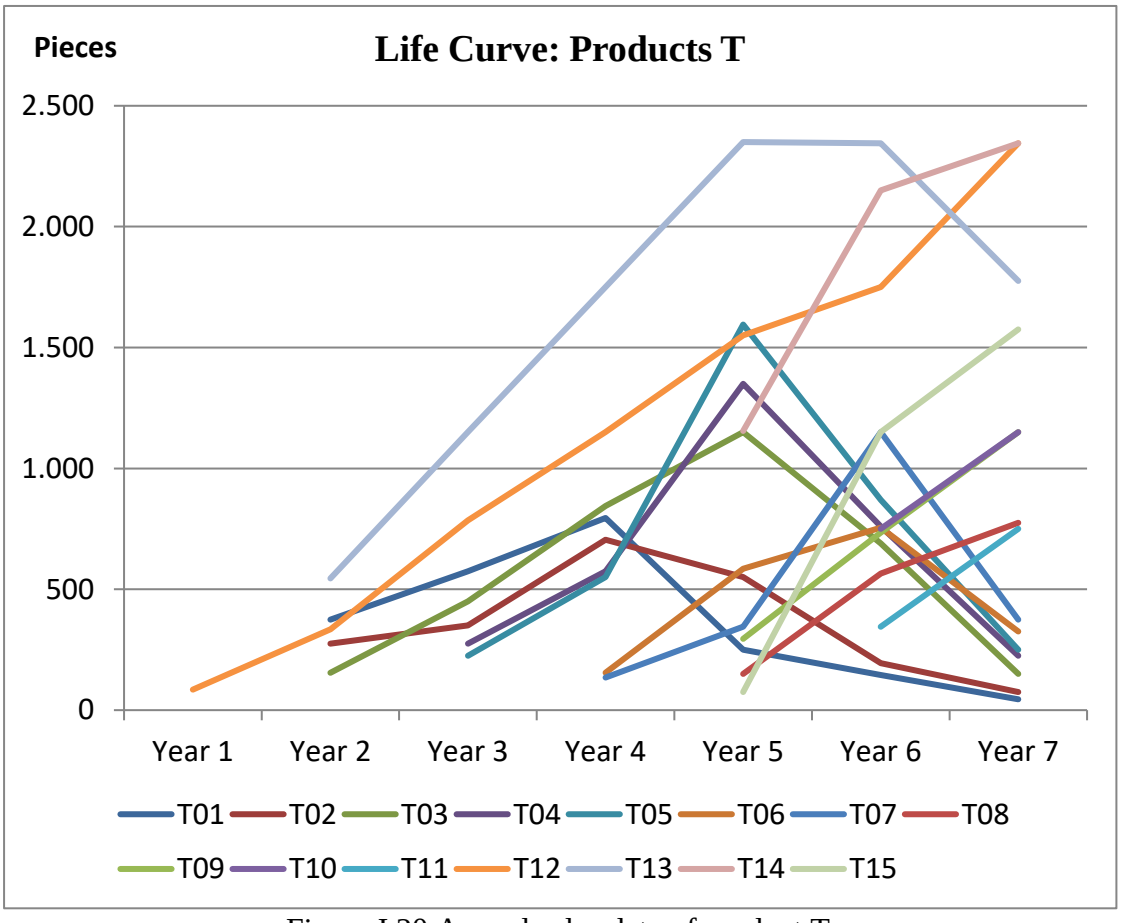

Figure I.20 Annual sales data of product T

Table I.21 Annual sales data of product U

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
U							
U01	775	1150	1350	775	355	175	85
U02		1150	1550	1550	775	375	175
U03			1375	2145	2350	1350	1250
U04	675	1150	1575	740	375	145	70
U05		1050	1350	1560	1150	1150	770
U06			1150	1575	2150	2250	1770
U07		750	1080	750	350	225	145
U08		575	760	1135	1150	775	570
U09			380	585	575	425	330
U10			280	560	875	775	650
U11				280	475	675	750
U12	345	585	560	450	355	345	245
U13	575	775	1150	775	650	575	465
U14		770	1050	1750	2350	3150	4150
U15		570	750	1135	1750	2250	3200
U16			145	375	550	575	745
U17			335	775	1150	1750	2050
U18				185	375	550	745
U19			290	585	875	1350	2345
U20				145	345	575	655
U21					145	275	375

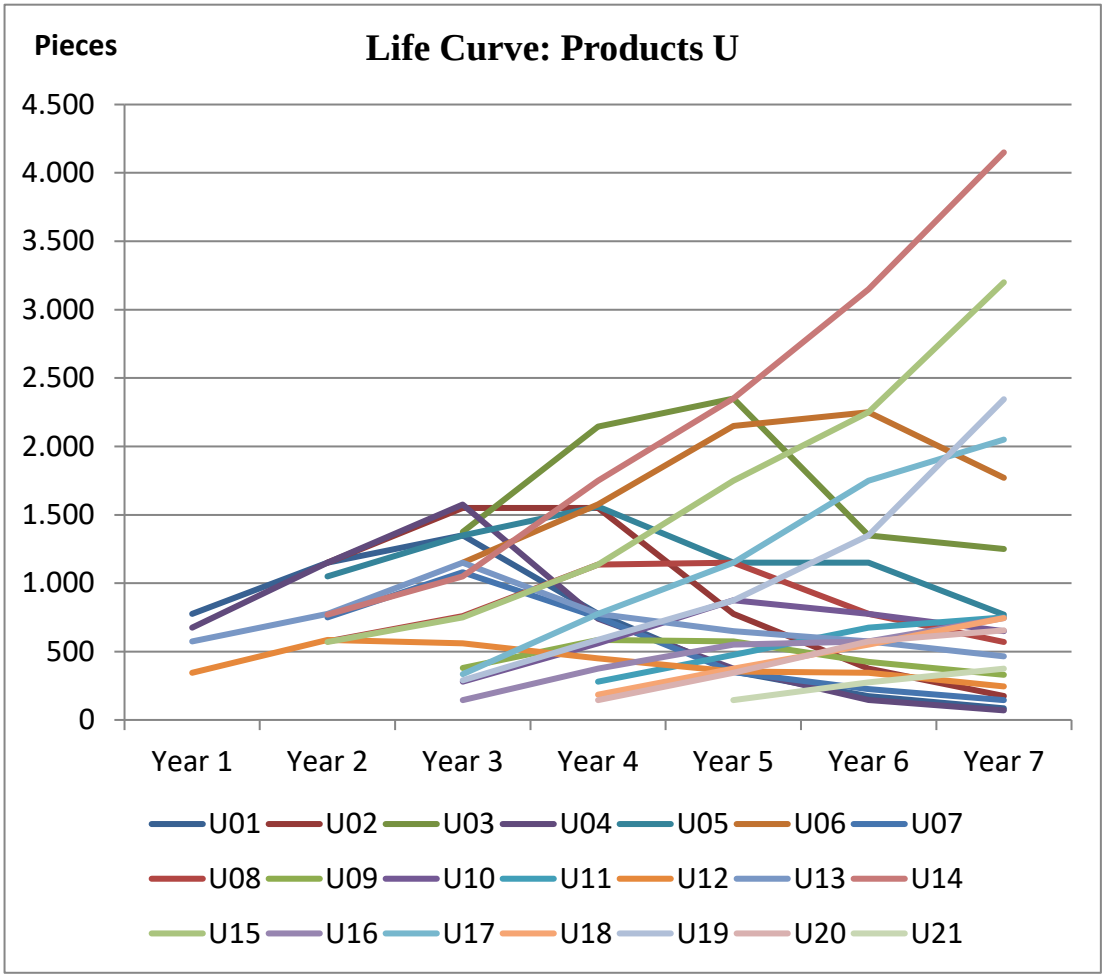

Figure I.21 Annual sales data of product U

Table I.22 Annual sales data of product V

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
V							
V01	975	1345	775	575	345	245	75
V02	1050	1750	1550	745	375	335	145
V03	550	775	375	350	145	70	40
V04	745	760	775	450	245	145	45
V05	375	550	350	245	120	70	30
V06	1350	1750	1350	1145	775	380	175
V07	1750	2350	1750	750	575	440	175
V08	645	800	445	245	155	80	50
V09	825	935	645	350	275	120	50
V10	445	560	335	145	95	45	25
V11		1550	2350	1150	750	350	180
V12		2050	2345	1550	1150	550	320
V13		850	1150	565	275	150	80
V14		825	1145	545	225	80	70
V15			2550	2750	1350	775	375
V16			2650	3145	1750	1050	540
V17			2750	3350	1550	850	530
V18			2800	3375	2050	1150	445
V19				3550	4150	2250	1150
V20				3700	4350	2550	1350
V21				4150	4505	2150	1250
V22				4350	4650	2350	1450
V23					5360	6255	6450
V24					5750	7465	8150

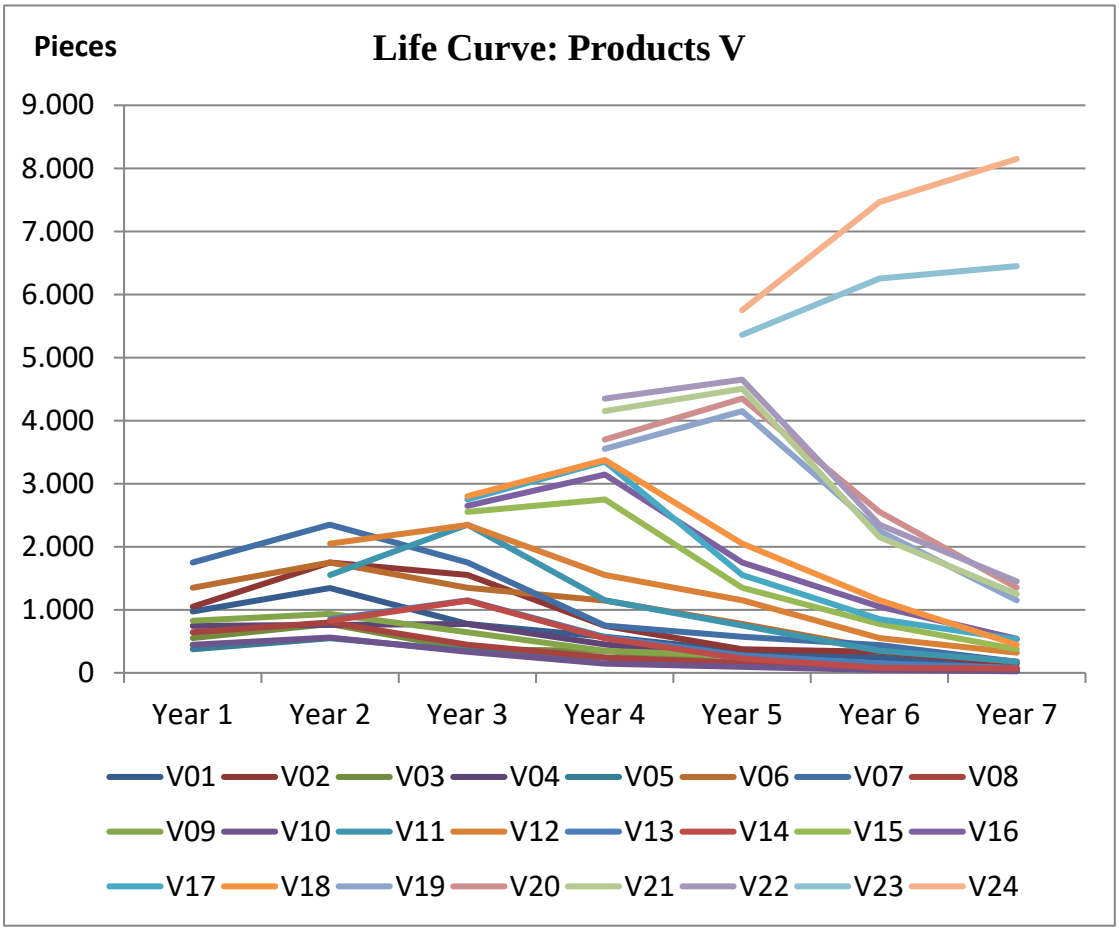

Figure I.22 Annual sales data of product V

Table I.23 Annual sales data of product W

Product Category	Annual sales (Piece)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
W							
W01	580	1350	1750	1150	775	745	375
W02		1565	2150	2240	1775	1150	1150
W03		1050	1100	1345	1225	775	550
W04			1350	1765	2150	1750	1750
W05				155	375	550	750
W06				145	225	400	655
W07				95	120	325	445
W08				45	120	175	300
W09					175	345	675
W10					350	775	1150

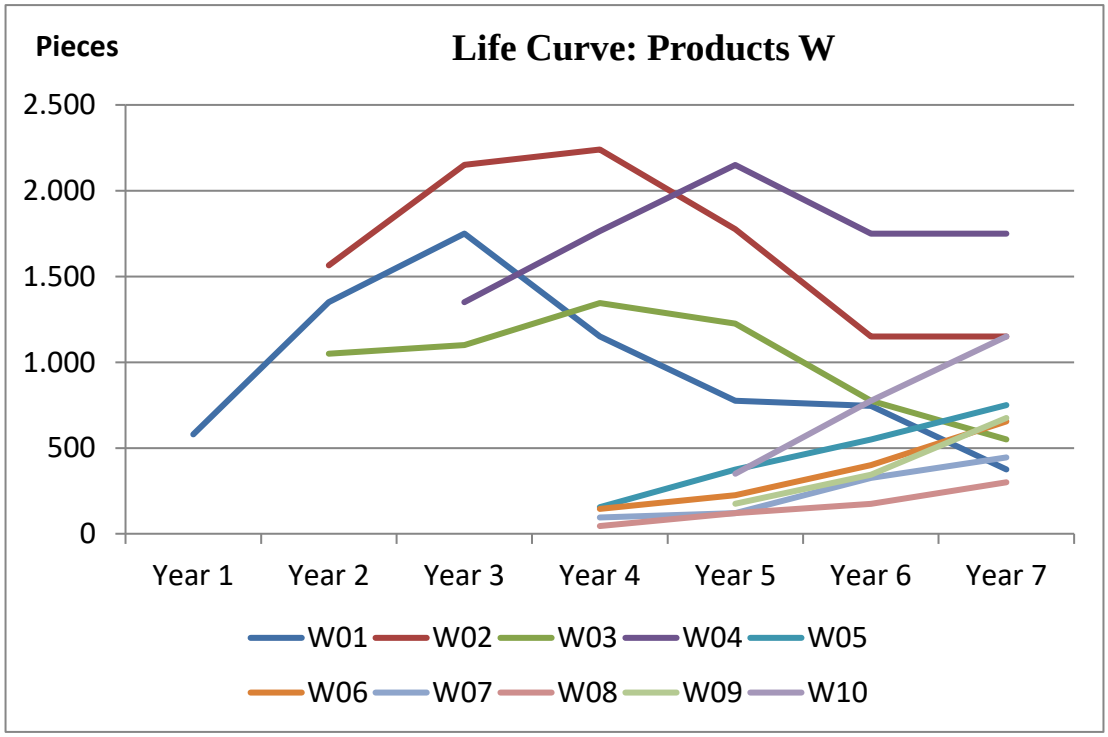

Figure I.23 Annual sales data of product W

Table I.24 Summary of annual products sales

Product Category	Annual sales (Units)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
A	5975	6805	7220	8290	9370	7025	4360
B	9400	14295	17790	23885	24865	22465	20880
C	16842	21460	26720	27350	30180	32075	32300
D	0	185	410	720	10195	15700	16450
E	0	915	1905	2675	40200	45400	43650
F	24840	38145	51375	63410	67770	62945	55595
G	14960	16090	22690	24225	24465	23230	17640
H	2239	2650	2760	2945	3115	3030	2940
I	770	875	945	975	975	960	975
J	0	3900	8665	13650	13974	13450	11220
K	1525	1805	2455	2590	2935	3170	3395
L	120	360	1090	1550	2080	2465	3200
M	8715	16400	25450	26390	30065	26400	20350
N	4855	10270	14800	17545	19875	17395	13925
O	2575	6525	14175	25890	37945	39445	47795
P	9000	12010	15170	16880	18040	19030	22285
Q	4245	10545	13750	18125	18345	18980	23100
R	3705	7725	17420	24925	27250	28100	26190
S	410	2385	5910	11745	14745	15535	16250
T	85	1685	3810	6660	11400	14355	13310
U	2370	8525	15130	17830	19125	19715	21540
V	8710	16850	26090	37180	40970	29905	23150
W	580	3965	6350	6940	7290	6990	7800
Total	121921	204370	302080	382375	475174	467765	448300

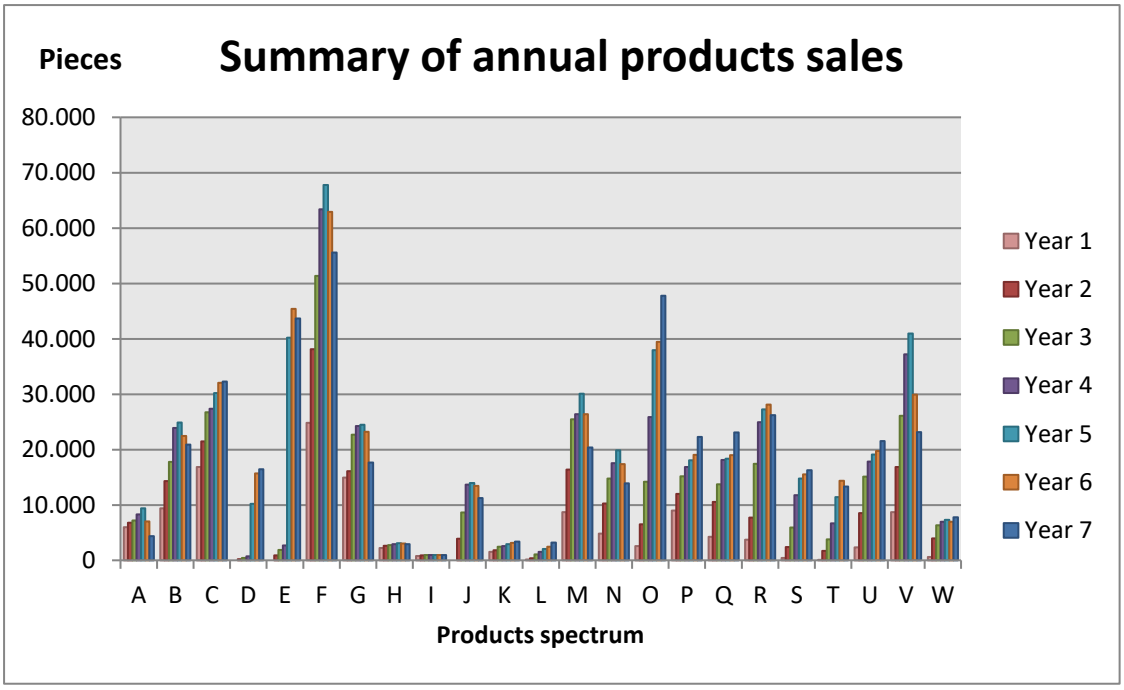

Figure I.24 Summary of annual products sales

Appendix II Product examples

Table II.1 USB Webcams

	USB Webcam 10 Mio. Pixel 8 LED
	USB Webcam 5 Mio. Pixel 6 LED

Table II.2 Headsets

	KOMLAND Headset HS-103
	Headset Stereo USB-Anschluss 308 v. KOMLAND

Table II.3 CD and DVD Cases

	CD –Single Case (Black) (100 Pieces)
	CD - Single Case (Transparent) (100 Pieces)
	CD – Double Case (Black) (100 Pieces)

	CD - Double Case (Transparent) (100 Pieces)
	CD – Four Case (Black) (100 Pieces)
	CD – Six Case (Black) (100 Pieces)
	DVD -Single case (Black) (100 Pieces)
	DVD -Single case Slim 7mm (Black) (100 Pieces)
	DVD -Single case Slim 9mm (Black) (100 Pieces)
	DVD -Double case (Black) (100 Pieces)
	DVD -Double case Slim 7mm (Black) (100 Pieces)
	DVD – 3 Case (Black) (100 Pieces)
	DVD – 4 Case (Black) (100 Pieces)

	DVD – 6 Case (Black) (100 Pieces)

DOI: 10.17185/duepublico/70820
URN: urn:nbn:de:hbz:464-20191203-093559-5