International Journal of Engineering Business Management

OPEN ACCESS ARTICLE

A New Paradigm for Packaging Design in Web-based Commerce

Regular Paper

Regattieri Alberto[1,*], Santarelli Giulia[2], Gamberi Mauro[2] and Mora Cristina[1]

1 Department of Industrial Engineering, Bologna University
2 Department of Management and Engineering, University of Padua
* Corresponding author E-mail: alberto.regattieri@unibo.it

Received 18 Mar 2014; Accepted 27 Jun 2014

DOI: 10.5772/58825

Abstract E-commerce is one of the most important features to have emerged from the presence of the Internet. It allows people to exchange goods with low time or distance barriers. E-commerce creates new opportunities; meanwhile, it also presents new challenges in terms of supplying chain management, particularly regarding the packaging system. Packaging functions have had to develop along with the new requirements enforced by e-commerce (i.e., increased amounts of packaging materials for each product, an increased need to protect items, end-life management, environmental sustainability, etc.).
In this paper, the authors propose an original reference framework for the design of a product packaging system that can be applied to e-operations. According to the framework, the authors have developed a mathematical model for evaluating the cost that a company has to sustain when partaking in e-commerce business. In conclusion, the paper discusses the application of both the framework and the mathematical model to a case study in order to develop an innovative packaging solution for e-commerce.

Keywords Framework, Packaging System, E-commerce, Case Study, Green Packaging

1. Introduction

The paper focuses on the impact of packaging in web operations (i.e., e-operations). During recent decades, companies have begun considering packaging as a critical issue for improving their global performance and minimizing their costs. The first function of packaging tends to concern logistics, since packaging should protect products in transit [1-3]. One of the basic reasons for incurring the added expense of packaging is to reduce the occurrence of damage, spoilage, or loss through theft or misplaced goods [1]. Several issues have increased the profile of packaging in as it concerns logistics. For instance, the increased use of information technology and automation in warehousing and in handling materials has increased the importance of packaging. Good packaging might have a positive impact on supply chain management as a whole [4,5,6]. The second function of packaging is essentially a marketing function, which is related to sales promotion, customer service and brand communication [5]. In the 1990s, additional demands were placed on packaging, especially in relation to the environment. Consumers are increasingly demanding more environmentally-friendly

packaging, e.g., reduced packaging or packaging that is recyclable or that can be re-used.

The role and functions of packaging have changed with the introduction of web-operations [8]. Electronic commerce (i.e., e-commerce) is a promising information technology application that has in recent years seen significant development. It has enormous potential for manufacturing, retail and service operations and is revolutionizing supply chain management, as well as the packaging system [6], moving away from the traditional "shop window" approach to become a new means of product protection and containment.

Amongst all operations in the supply chain, web operations are taking on an important role in global purchasing process trends. In recent years, ever more people have begun to use the Internet and buying a wide range of goods online [9].

As the Internet continues to gain popularity, e-commerce promises to become a mainstay of modern business [10; 11]. The large scope of e-commerce applications includes banking, shopping in online stores and malls, buying stocks, finding employment, conducting an auction and collaborating electronically on research and development projects [12].

The authors of this paper propose an original reference framework for the design of a packaging system that can be applied to e-operations. Using the framework parameters, a mathematical model for evaluating the costs linked to e-commerce business was defined. Both the framework and the mathematical model were applied to a case study in order to develop an innovative packaging solution for e-commerce, taking into account the new and specific characteristics required of packaging applied to e-operations (e.g., the protection of items, the use of packaging at its end-of-life, attention to environmental sustainability).

The paper has a twofold purpose: first, to analyse the link between e-commerce and packaging, underlining the changes that the packaging system face in order to embrace online shopping requirements. The second aim is to optimize the packaging solution defined for a company selling online, based on the framework proposed and the mathematical model developed.

The article is organized as follows. Section 2 provides a description of packaging and e-commerce in web operations. Section 3 presents an original reference framework for e-commerce packaging, while the mathematical model developed for computing the e-commerce costs of a company is presented in Section 4. Section 5 describes the experimental study and the conclusions. Future research is presented in Section 6.

2. Literature review

E-commerce is an emerging business that encompasses the process of trading goods, information, or services via computer networks [10; 12-14]. It is a new sales tool, with which consumers are able to participate in all the stages of the purchasing decision, while going through processes electronically rather than in a real shop [10,12,13]. E-commerce can further be distinguished from the broader concept of e-business, which refers to any business operation conducted through information networks, such as customer services, enterprise resource planning (ERP) and knowledge sharing [10].

Currently, there is no internationally accepted definition of e-commerce. However, the British Department of Trade and Industry [15] has proposed a working definition, namely: *using an electronic network to simplify and speed up all stages of the business process, from design and making to buying, selling and delivery, e-commerce is the exchange of information across electronic networks, at any stage in the supply chain, whether within an organisation, between business, between business and consumers, or between the public and private sectors, whether paid or unpaid.*

Kalakota and Whinston [16] defined e-commerce from four perspectives: (a) communication perspective (e-commerce is the deliverer of information, products/services or payments over telephone lines, computer networks or any other electronic means); (b) business process perspective (e-commerce is the application of technology towards the automation of business transactions and work flows); (c) service perspective (e-commerce is a tool that addresses the desire of firms, consumers and management to cut service costs while improving the quality of goods and increasing the speed of service delivery); (d) online perspective (e-commerce provides the capacity to buy and sell products and information on the Internet as well as other online services).

With the growth of commerce on the Internet, people can shop online 24 hours a day, seven days a week and without any limitations [14]. Nowadays, people are presented with many choices when they want to buy a particular product and are able to choose from a range of similar products. Consequently, it can be difficult to make a decision. As a result, manufacturers have to make sure they are able to meet the customer's needs in order to sell their products [15].

E-commerce channels have changed the operations and business strategies of traditional companies. This impact has been highlighted by three main issues: integration, customization and internationalization. First, e-commerce networks improve value chain

integration by reducing transaction costs, facilitating "just in time" delivery and improving information collection and processing [10]. Secondly, e-commerce databases and direct links between producers and customers support high levels of product and service customization [17]. Finally, the Internet's international scope allows small companies to reach customers worldwide [18; 19].

According to Gunasekaran et al. [20], e-commerce supports functional activities in organizations. For example, the advent of e-commerce has changed marketing practice. E-commerce systems should be easily accessable, overcome time differences in terms of business, location and language between suppliers and customers, and at the same time support the entire trading process in business to business e-commerce [21]. Communication and data collection constraints are reduced with the web-based production of goods and services. Using database management, data warehouse and data mining technologies, the web can facilitate interaction with customers and suppliers, data collection, as well as the data analysis process [22].

The advent of e-commerce has also had a significant impact on the packaging system and its functions. According to Kathman [23], the Internet is a "highly self-select environment", with a new packaging design strategy that must be different from traditional thinking for gaining a greater market share of e-commerce [8]. In addition, Visser [8] stated that it is difficult to translate the existing packaging design used for the traditional way of buying in a real shop and marketing tactics into online retailing. *E-commerce requires a new paradigm for the entire product packaging system*. For example, in a real shop, traditional primary packaging is a good agent for all products, not only because of the text descriptions, but also for its visual communication. It can effectively deliver product information and brand identity, and it is a good cognitive agent for recognition. In an online shop, users cannot directly see the package nor touch the product; however, other characteristics such as protection and re-usability for an efficient take-back of products take on great importance [9]. The function of packaging the product in an attractive manner therefore becomes less important [24; 25]. The changing role of packaging for e-commerce in the purchase of a product makes it desirable and possible to provide more attention to the consumer's perception of a brand and less attention to its shelf presentation [8].

The main packaging requirements that a company should consider before starting an e-commerce business are:

- Protection: products contained in packages have to be protected from mechanical shock, vibrations, electrostatic discharge, compression, etc.. This is usually achieved through to the use of accessories (e.g., Bubblewrap , air pillows, polystyrene chips, etc.). According to Korzeniowski [25], the primary role of packaging in e-commerce is to protect goods from mechanical, chemical and biological damage. Adequate protection of goods can be ensured by selecting proper packaging materials, packaging design and packaging accessories. For proper protection, packages need to have adequately tight and durable closures that open and close easily, which is particularly important in cases where goods do not meet customer expectations and need to be repacked and returned [25].
- Handleability: the ergonomic aspect, that is, everything related to adaptations to the human physique and behaviour when using the product, has to be considered. A study conducted by Regattieri et al. [24] on the perception of packaging by end consumers stated that the main requirement a package should guarantee is that of handleability (e.g., ease of handling, ease of opening, user-friendly, etc.).
- Security: packages must ensure secure shipping. It could be necessary to install identification technologies such as RFID tags or barcodes [26] in packages in order to reduce theft, increase security and minimize time spent on the traceability of products.
- Respect for the environment: e-commerce produces more waste materials than traditional commerce, because of more frequent orders in smaller quantities. In order to have a minimal environmental impact, it may be necessary for companies to try to recycle packages and minimize dangerous substances emitted when packaging waste is disposed of.
- Re-use: ever more companies have begun re-using packages to ship products to end consumers to minimize both environmental impact and costs. The re-use of packages could also increase customer satisfaction as a result of the low level of environmental pollution produced.

According to these new packaging requirements, the next section presents an original framework for e-commerce packaging.

3. A new paradigm for packaging for e-commerce

Packaging for e-commerce is essentially based on three pillars: *design*, *logistics* and *environment*. Figure 1 reports the reference framework for packaging for e-commerce.

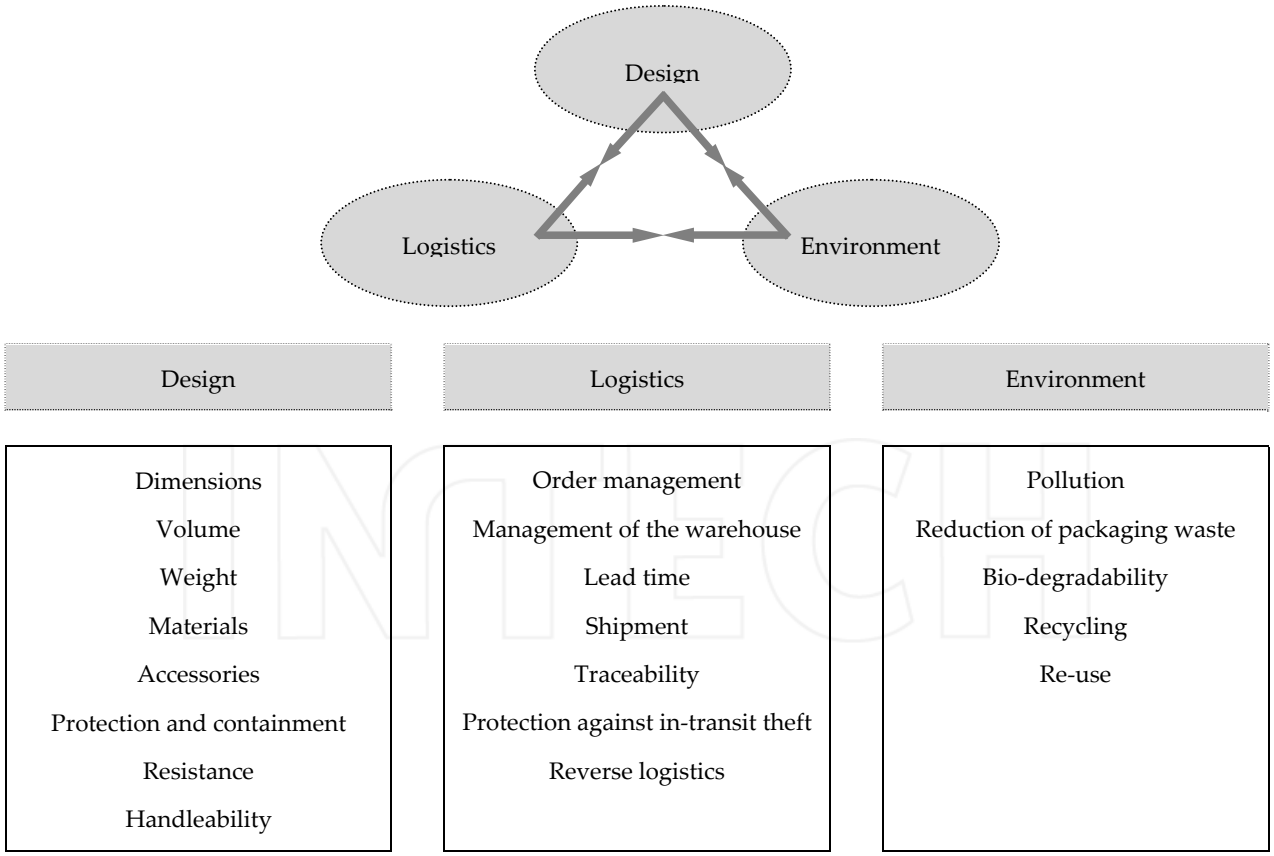


Figure 1. Framework for packaging for e-commerce

Packaging *design* is a fundamental pillar for the definition of a reference framework for packaging for e-commerce; in this instance, physical and mechanical characteristics should be taken into account.

Dimensions, volume and weight are three fundamental aspects to consider when designing packaging: a package for e-commerce should have narrow and standard dimensions, low weight and minimal void space in order to minimize the number of shipments and vehicles, and consequently the environmental impact and costs. Packaging materials constitute another important aspect: the package should be mono-material in order to facilitate the recycling of products and bio-degradable to reduce pollutant emissions. Another class of information required deals with the accessories used to protect and contain products: it may be important to minimize the number of accessories used and thereby the environmental impact produced by using them (e.g., using easily recyclable components). The accessory function is of fundamental importance, since if they are not designed correctly, the package could reach customers in a poor condition, which could consequently reduce customer satisfaction and trust in the company.

From a mechanical point of view, a package for e-commerce should cover traditional functions, such as the protection and containment of products and high resistance to vibration and shock. Another important aspect to consider is handleability. From a study conducted by Regattieri et al. [27] on the perception of packaging from a customer point of view, it has come to light that handleability (e.g., ease of handling, ease of opening, user-friendly, etc.) is an important characteristic that packages should guarantee. Thus, it is necessary to design a package while taking this aspect into account.

A framework for packaging for e-commerce must consider the *logistics* aspect. The first important characteristic is relative to e-commerce orders: compared to traditional commerce, they are more frequent and comprise a higher number of different products in smaller quantities. The small quantities of products to distribute and the high frequency of the orders could modify the picking, which could lead to a new allocation of products within the warehouse and consequently, to a review of warehousing management. Moreover, customers buying online request quick product delivery; thus, the lead time should be reduced in order to promptly respond to market requirements.

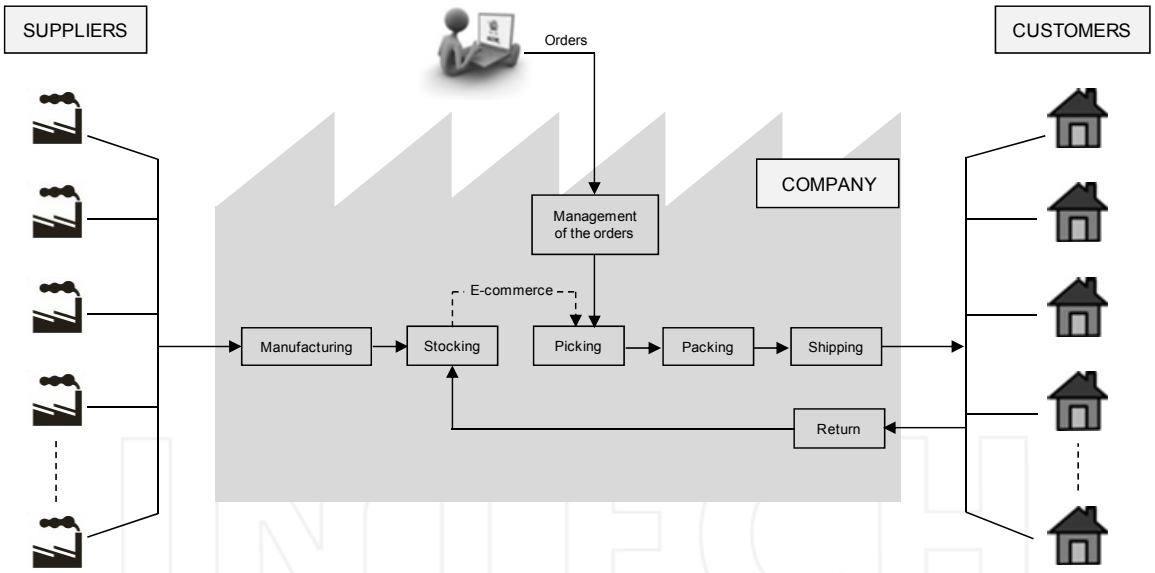


Figure 2. Diagram of the e-supply chain

With the advent of e-commerce, the number of shipments and consequently, the number of vehicles, have increased. Thus, it is of fundamental importance to analyse the distribution of products, try to optimize the number of vehicles and routes, and reduce wasted trips. In recent years, the traceability of packages and protection against in-transit theft has become important requirements. During transport, packages can be subject to theft; as such, it may be necessary to evaluate the possibility of tracing packages throughout distribution and to use some expedients for preventing thefts.

In the e-commerce business, customers return unwanted and/or faulty products more frequently; therefore, companies should analyse the reverse logistics aspect.

The third fundamental pillar concerns the *environment*. Packages should be developed using as little material as possible to reduce waste and minimize pollutant emissions once package waste is incinerated or landfilled. Other classes of information required deal with the possibility of recycling and/or re-using packages. This could lead to a reduction in pollutant emissions and costs. Packaging for e-commerce is a relatively new topic and the entire framework in Figure 1 could represent an original reference framework for companies that decide to initiate e-commerce business.

Based on the framework parameters, the authors have defined a mathematical model for the evaluation of costs for a company selling online. The model is presented in the next section.

4. The new mathematical model

In order to evaluate e-commerce business in terms of costs, the authors have developed a complete mathematical model, based on data defined by Regattieri et al. [26] for the evaluation of total packaging costs along the supply chain.

The proposed model could represent a valid tool for analysing the impact of packaging in the e-supply chain in a complete and systematic way, as well as for determining critical aspects and areas for improvement. Figure 2 shows a diagram of the e-supply chain.

When a company receives an online order, it picks the requested products, packs them in a package (i.e., box, pallet, etc.), which may be new or recycled and ships the order to the end consumer. The new mathematical model takes into consideration the possibility that the consumer might return the product because it is damaged and/or not congruent with what the consumer requested.

Tables 1, 2 and 3 describe the indices, variables and parameters used in the model.

Index	*Domain*	*Description*
I	1,…,m	Products to be sold online
J	1,…,n	Orders
K	1,…,s	Packages used for shipping
R	1,…,q	Accessories used to protect and contain products in the package

Table 1. Indices of the mathematical model

Variable	*Unit*	*Description*	*Domain*
$C_{ACC\,jr}$	[€/piece]	Cost of accessories for filling packages. Purchasing cost of the accessory *r* used to protect the product of the order *j*.	j=1,…n r=1,…,q
$C_{DISP\,jk}$	[€/piece]	Cost of disposal. Cost to dispose of the package *k* if the customer requests a new package for the order *j*.	j=1,…n k=1,…,s
$C_{MAN\,i}$	[€/piece]	Cost of the products. Manufacturing costs of the product *i*.	i=1,…,m
$C_{PACK\,jk}$	[€/piece]	Cost of package. Purchasing cost of the package *k* to contain the order *j*.	j=1,…n k=1,…,s
$C_{PALL\,i}$	[€/pallet location]	Cost of a pallet location. Cost of pallet locations to store product *i*.	i=1,…,m
$C_{RET\,j}$	[€/return]	Cost of the return. Cost of the return shipment of the order *j*.	j=1,…n
$C_{SHIP\,j}$	[€/shipment]	Cost of the shipment. Cost to ship the order *j*.	j=1,…n
N_i	[pieces/year]	Number of products of type *i* produced by the company.	i=1,…,m
$N_{ACC\,jr}$	[pieces/year]	Number of accessories of type *r* used to arrange the order *j*.	j=1,…,n r=1,…q
$N_{PACK\,k}$	[pieces/year]	Number of packages of type *k* bought by the company to contain the products.	k=1,…,s
$N_{PALL\,i}$	[pallet locations/year]	Number of pallet locations to allocate product *i*.	i=1,…,m
$T_{PICK\,j}$	[h/order]	Time to pick. Average time to pick the order *j* from the shelves.	j=1,…n
$T_{STOCK\,i}$	[h/piece]	Time to store. Average time to store the product *i*.	i=1,…,m
$T_{WRAP\,j}$	[h/order]	Time to pack. Average time to pack the order *j*.	j=1,…n
x_{jk}	[1;0]	1, if the customer requests a new package *k* for the order *j* 0, otherwise	j=1,…n k=1,…,s
y_j	[1;0]	1, if the customer sends back the order *j* 0, otherwise	j=1,…n

Table 2. Variables of the mathematical model

Equation (1) introduces the general formula for the model, while equation (2) presents the complete mathematical model, explaining each cost parameter in detail.

$$C_{TOT} = C_{WEB\,SITE} + C_{UP} + C_{ORD} + C_{MAN} + C_{STOCK} + C_{PICK} + C_{WRAP} + C_{PACK} + C_{ACC} + C_{SHIP} + C_{RET} + C_{DISP} \quad (1)$$

$$\begin{aligned} C_{TOT} &= C_{WEB\,SITE} + (N_{UP} \cdot C_{UP}) + (N_{ORD} \cdot C_{ORD}) + \left(\sum_{i=1}^{m} N_i \cdot C_{MAN\,i}\right) + \left[\left((C_{h\,OP1} + C_{h\,TR1}) \cdot \sum_{i=1}^{m} T_{STOCK\,i}\right) + \left(\sum_{i=1}^{m} N_{PALL\,i} \cdot C_{PALL\,i}\right)\right] \\ &+ \left[(C_{h\,OP2} + C_{h\,TR2}) \cdot \sum_{j=1}^{n} T_{PICK\,j}\right] + \left[\left(C_{h\,OP3} + C_{h\,EQ}\right) \cdot \sum_{j=1}^{n} T_{WRAP\,j}\right] + \left(\sum_{j=1}^{n}\sum_{k=1}^{s} N_{PACK\,jk} \cdot C_{PACK\,jk} \cdot x_{jk}\right) \\ &+ \left(\sum_{j=1}^{n}\sum_{r=1}^{q} N_{ACC\,jr} \cdot C_{ACC\,jr}\right) + \left(\sum_{j=1}^{n} C_{SHIP\,j}\right) + \left(\sum_{j=1}^{n} C_{RET\,j} \cdot y_j\right) + \left(\sum_{j=1}^{n}\sum_{k=1}^{s} C_{DISP\,jk} \cdot x_{jk}\right) \end{aligned} \quad (2)$$

The mathematical model allows companies to have a complete tool for analysing their total costs for e-commerce business in order to understand possible cost reductions and improvements.

5. A real case

The framework and the mathematical model have been applied to a company that has decided to sell its products online, too. The company is changing its approach to the market and manufacturing through the introduction of the world class manufacturing system [29].

Traditionally, the company receives goods from suppliers in the receiving area; the goods are unpacked, sorted and stored in the warehouse. When a retailer asks for products, they are picked from the shelves, packed and dispatched to the retailer, who in turn sells the products to end consumers in "real shops".

When the company began selling online, some of its main activities changed. Figure 3 shows a diagram of the company's activities.

Parameter	*Nomenclature*	*Unit*	*Description*
C_{ACC}	Cost of accessories	[€]	Cost of the accessories used to protect and contain products inside the package.
C_{DISP}	Cost of disposal	[€]	Cost to dispose of packages.
Ch_{EQ}	Hourly cost of equipment	[€/h]	Hourly cost of the equipment required to pack products.
Ch_{OP1}	Hourly cost of the operator to store products	[€/h]	Hourly cost of the operators responsible for storing products.
Ch_{OP2}	Hourly cost of the operator to pick products	[€/h]	Hourly cost of the operators responsible for picking products.
Ch_{OP3}	Hourly cost of the operator to pack products	[€/h]	Hourly cost of the operators responsible for packing products.
Ch_{TR1}	Hourly cost of the trolley to transport products to store	[€/h]	Hourly cost of the trolleys that transport products to be stored.
Ch_{TR2}	Hourly cost of the trolley to transport picked products	[€/h]	Hourly cost of the trolleys that transport picked products.
C_{MAN}	Manufacturing cost	[€]	Cost to produce the products to be sold online.
C_{ORD}	Cost of the order	[€/order]	Cost to manage the orders received by the customers. This includes labour costs.
C_{PICK}	Cost to pick the order	[€]	Cost to pick the order. This includes labour costs and the depreciation of the infrastructure.
C_{RET}	Cost of the return	[€]	Cost of the return order. This includes labour costs, the depreciation of the vehicle and the costs relating to the entire process of re-using or disposing of packages.
C_{SHIP}	Shipping costs	[€]	Cost to ship the order. This includes labour costs and the depreciation of the vehicle.
C_{STOCK}	Stocking costs	[€]	Cost to stock products. This includes the cost of pallet location, labour costs and the depreciation of infrastructure.
C_{UP}	Cost to update the website	[€/update]	Cost to update the website (e.g., modifying the selling catalogue). This includes labour costs.
C_{WRAP}	Cost to pack the order	[€]	Cost to pack the order. This includes labour costs and the depreciation of the equipment used.
$C_{WEB\ SITE}$	Cost to create the website	[€]	Cost to create the website. This includes labour and operating costs. It is an investment cost.
N_{ORD}	Number of orders	[orders/year]	Number of online orders received from customers.
N_{UP}	Number of updates	[updates/year]	Number of updates made by an operator to update the website.

Table 3. Parameters of the mathematical model

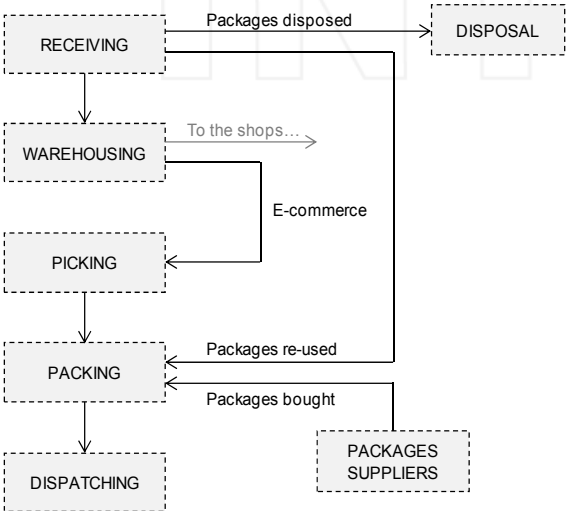


Figure 3. The company's activities for e-commerce business

The company has identified the need for studying a new packaging system for e-commerce in terms of the size of secondary packages and accessories used for protecting and containing products.

The new packaging solution should be able to optimize the costs and logistics aspects (i.e., protection of the product, security during shipment and re-use of packages). According to Visser [8], the marketing aspect is not held in much consideration during the creation of a packaging solution for e-commerce. This is mostly because the company is only responsible for the secondary packaging (it receives the products from manufacturers and cannot decide on the primary packaging); moreover, secondary packaging does not greatly influence consumer choice in terms of buying products.

Order	No. Box	Gross weight [kg]	Pack weight [kg]	Volume [dm^3]	Package saturation [%]
1	1/3	1.23	0.45	6.37	12%
	2/3	6.91	0.51	20.71	57%
	3/3	2.45	0.51	17.73	48%
2	1/2	7.98	0.52	27.50	40%
	2/2	12.11	0.40	25.61	91%
3	1/1	6.36	0.66	14.50	45%
4	1/3	6.55	0.60	27.40	80%
	2/3	5.61	0.45	26.65	74%
	3/3	6.64	0.52	15.49	42%
5	1/1	5.96	0.52	17.44	44%

Table 4. Primary data of some "typical" orders

The main activities performed by Authors are described below.

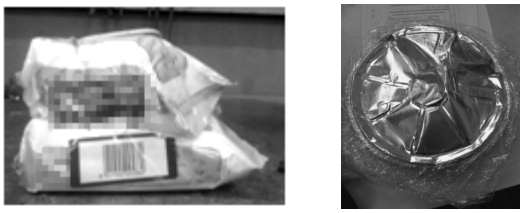
Package analysis. In order to define a new packaging solution for e-commerce, it is necessary to analyse the packages and accessories currently offered by the market, and evaluate the possibility of re-using incoming secondary packages designed to contain products in order to create the accessories for protecting the products.

The company has defined some "typical" orders useful for identifying the size of the secondary packages, as well as for evaluating the possibility of re-using incoming secondary packages, in order to reduce costs and environmental impact. Table 4 shows the primary data of some "typical" orders identified by the company.

From the analysis of the volume, weight and packaging saturation of the orders, three standard packaging dimensions have been identified; the dimensions of the incoming secondary packages were also applied in the identification:

- Small package [cm]: 22x22x25 (h)
- Medium package [cm]: 26x38x30 (h)
- Large package [cm]: 26x38x40 (h)

Shipping test. In order to analyse the conditions in which the products reach the consumers, the company sent a collection of orders to the Laboratory of the DIN Department at the University of Bologna, some of which arrived in a poor condition (Figure 3a and Figure 3b). These tests highlighted the need for defining functional accessories to protect the products inside the packages.



(a) (b)

Figure 3. Examples of products upon arrival at the Laboratory of the DIN Department at the University of Bologna

Definition of accessories. Several accessories were studied; new accessories were analysed (e.g., Bubblewrap , air pillows, etc.), as well as those created by re-using incoming secondary packages (e.g., cardboard strips, cardboard dividers, etc.). Four different accessories were tested in order to understand the advantages and disadvantages of each:

1. The use of small thin cardboard strips made by cutting up advertising leaflets (Figure 4).

Figure 4. Cardboard strips made by cutting up advertising leaflets and used as accessories

No products arrived damaged, but the configuration led to an excessive amount of dust and it may be difficult to find small products inside the package, because of the large number of strips. Moreover, the solution is not aesthetically pleasing.

2. The use of small cardboard strips made by cutting up incoming secondary packages (Figure 5).

Figure 5. Cardboard strips made by cutting up incoming secondary packages and used as accessories

No products arrived damaged and the solution was better than the previous one. The aesthetics were pleasing; however, this solution also created a large amount of dust, although less so than in the previous solution.

3. The use of polystyrene chips bought from packaging suppliers (Figure 6).

Figure 6. Polystyrene chips used as accessories

No products arrived damaged; there was no trace of dust and the solution was aesthetically pleasing. However, it is not convenient for end consumers to empty the polystyrene chips out of the packages.

4. The use of air pillows bought from packaging suppliers (Figure 7).

Figure 7. Air pillows used as accessories

No products arrived damaged; there was no trace of dust, the solution was aesthetically pleasing and convenient for end consumers.

The new packaging solution. According to the application of the reference framework regarding packaging for e-commerce and the evaluation of different alternatives in terms of costs, the choice was mad to re-use incoming secondary packages for the distribution of products. Despite this, the company wishes to maintain the possibility of using new secondary packages for customers that request them.

As accessories, the air pillow solution was chosen (both for technical and economic reasons) for the protection of products during transport. Air pillows are an excellent filling solution, as they are resistant to humidity and provide excellent protection. One important characteristic is their recyclability: they are 99% air and 1% plastic material. End consumers will appreciate this environmentally friendly feature. From a company point of view, air pillows are a space saving solution, since they are bought in reels and blown up only when necessary.

In order to address the problem concerning the possible theft of products during transport, the company decided to seal secondary packages with a customized strip.

The implementation of the solution. The new packaging solution has been implemented by the company and has yielded several benefits: an increase in sales, a reduction in transaction costs and an increase in customer satisfaction due to the environmentally friendly packaging.

6. Conclusions and further research

Out of all the operations present in supply chains, web operations are taking on an important role in global purchasing process trends [7]. E-commerce can be defined as an emerging business that encompasses processes directly and indirectly related to the buying, selling and trading of products, services and information via computer networks [15].

When a company decides to initiate e-commerce business, it should take a range of factors into account, first and foremost logistics and environment [21] and their implications within the packaging system.

The role of packaging has changed to satisfy e-commerce requirements: more attention is being paid to logistics and environmental aspects and less to marketing, because the function of packaging the product in an attractive manner has become less important [24; 25]. Packaging assumes the primary role of protecting products during transport through the use of ad hoc packages and accessories. From an environmental point of view, packaging for e-commerce should be recyclable and/or re-usable.

From the definition of the main requirements of packaging for e-commerce, the authors have developed an original reference framework regarding packaging for e-commerce in order to evaluate the main characteristics to take into account during the study of a packaging system for e-commerce. The three most fundamental pillars are: *design*, *logistics* and *environment*. According to the framework, the evaluation of costs linked to e-commerce in general and to packaging for e-commerce in particular, has to be considered. From the mathematical model for the evaluation of the total packaging costs, based on a traditional supply chain developed by Regattieri et al. [28], the authors have defined a mathematical model for analysing all costs

concerning e-commerce that can represent added value for companies that want to sell online.

Both the framework and the model have been applied to a case study and have identified the need for changing the packaging system for a company that wishes to initiate e-commerce business, the results of which are due to different packaging requirements compared to traditional commerce. The company has made choices concerning the type of packages for shipment (e.g., in terms of size, the possibility of re-using incoming secondary packages, etc.), protection accessories (e.g., new accessories or accessories made by re-using incoming secondary packages) and the security level of the shipment (e.g., the introduction of a customized ribbon to seal the package). After in-depth analysis of several configurations of packages and accessories, and the application of the mathematical model to the different alternatives presented, the company chose to re-use secondary packages coming from its suppliers and to use air pillows as accessories. Despite this, the company wishes to maintain the possibility of using new secondary packages for customers who request them.

Several modifications should be considered for future considerations of online packaging. Additionally, the ability to attract consumers' attention and incite their curiosity about products is an important factor for analysis in order to increase the potential development of packages for online shopping.

Further research should focus on the definition of a packaging solution for other sectors (e.g., luxury products, high-tech products, etc.). Thus, it might be interesting to compare packaging solutions developed for low and high value goods.

7. References

[1] Dyllick T., 1989, Ecological marketing strategy for Toni yoghurts in Switzerland, Journal of Business Ethics, 8(8), 657-662.

[2] Hellström D., Saghir M., 2006, Packaging and logistics interactions in retail supply chains, Packaging Technology and Science, 20(3) 197-216.

[3] Twede D., 1992, The process of packaging logistical innovation, Journal of Business Logistics, 13(1) 69-94.

[4] Prendergast G., Pitt L., 1996, Packaging, marketing, logistics and the environment: are there trade-offs?, International Journal of Physical Distribution & Logistics Management, 26(6), 60-72.

[5] Manzini R., Gamberi M., Gebennini E., Regattieri A. 2008, An integrated approach to the design and management of a supply chain. International Journal of Advanced Manufacturing Technology, 37(5-6), 625-640.

[6] Manzini R., Ferrari E., Gamberi M., Persona A., Regattieri A. 2005. Simulation performance in the optimisation of the supply chain. Journal of Manufacturing Technology Management, 16(2), 127-144.

[7] Underwood R.L., 2003, The communicative power of product packaging: creating brand identity via lived and mediated experience, Journal of Marketing Theory and Practice, 11(1) 61-65.

[8] Visser E., 2002, Packaging on the web: an underused resource. Design Management Journal, 62-67.

[9] Huang K.L., Rust C., Press M., 2009, Packaging design for e-commerce: identifying new challenges and opportunities for online packaging, College of Digital Design, Visual Communication Design Graduate School of Digital Content and Animation.

[10] Da Silvera G.J.C., 2012, Towards a framework for Operations management in e-commerce, International Journal of Operations & Production Management, 23(2), 200-212.

[11] Altmiller J.C., Nudge B.S., 1998, The future of electronic commerce law: proposed changes to the uniform commercial code, IEEE Communication Magazine, 36(2) 20-22.

[12] Turban E., Lee J., King D., Chung H.M., 2000, Electronic commerce: a managerial perspective. Prentice-Hall International (UK) Limited, London.

[13] Fraser J., Fraser N., McDonald F., 2000, The strategic challenge of electronic commerce, Supply Chain Management: An International Journal, 5(1) 7-14.

[14] Barwise P., Elberse A., Hammond K., 2000, Marketing and Internet: a research review, London Business School.

[15] HM Customs and Excise, UK, What is e-commerce? http://www.hmce.gov.uk/business/tradinginternet/tradinter-3.htm Accessed on 20 Feb 2003.

[16] Kalakota R., Whinston A.B., 1997, Electronic Commerce: a Manager's Guide, Addison-Wesley, Reading, MA.

[17] Skjoett-Larsen T., 2000, European logistics beyond 2000, International Journal of Physical Distribution & Logistics Management, 30(5) 377-387.

[18] Soliman F., Youssef M., 2001, The impact of some recent developments in e-business in the management of next generation manufacturing, International Journal of Operations & Production Management, 21(5; 6) 538-564.

[19] Zugelder M.T., Flaherty T.B., Johnson J.P., 2000, Legal issues associated with international internet marketing, International Marketing Review, 17(3) 253-271.

[20] Gunasekaran A., Marri H.B., McGaughey R.E., Nebhwani M.D., 2002, E-commerce and its impact on Operations management, International Journal of Production Economics, 75 185-197.

[21] Boll S., Gruner A., Haaf A., Klas W., 1999, EMP – A database-driven electronic market place for business-to-business commerce on the internet, Distributed and Parallel Database, 7(2) 149-177.
[22] Wang F., Head M., Archer N., 2000, A relationship-building model for the web retail marketplace, Internet Research, 10(5) 374-384.
[23] Kathman K., 2002, Brand identity development in the new economy, Design Issue, 18(1), 25-35.
[24] Sarkis J., Meade L.M., Talluri S., 2004, E-logistics and the natural environment, Supply Chain Management: an International Journal, 9(4), 303-312.
[25] Korzeniowski A., Jasiczak J., 2005, Accomplishment of selected package functions in e-commerce, LogForum,, 1, 1-7.
[26] Regattieri A., Santarelli G., Gamberi M., Gamberini R., 2014, The use of RFID technology in packaging systems. An experimental research on traceability. Packaging Technology & Science, 27, 591–608.
[27] Regattieri A., Santarelli G., Olsson A., 2012, The customers' perception of primary packaging: a comparison between Italian and Swedish situation, Proceedings of 18th IAPRI World Packaging Conference, San Luis Obispo, California, USA.
[28] Regattieri A., Santarelli G., Accorsi R., Mora C., Pareschi A., 2012, A mathematical model for packaging cost evaluation along the supply chain, Proceedings of XVII Summer School Francesco Turco, Venice, Italy.
[29] Ferrari E., Pareschi A., Persona A., Regattieri A. 2002. TPM: situation and procedure for a soft introduction in Italian factories. TQM magazine, 14(6), 350-358.