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# A model to describe logistics service architecture based on product architecture

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**Abstract**

The growth in e-commerce has led to increased demand for logistics services. This puts a pressure on third-party logistics (3PL) providers who struggle with increasing operating costs and heightened competition. These providers could potentially exploit the advantages of modularisation, but few studies address the design of modular logistics services. This study explores modular design of logistics services and proposes a model to describe logistics service architecture based on product architecture. A case study shows that warehousing services can be described in three domains.

*Keywords: logistics service architecture, product architecture, modularisation, warehouse, third-party logistics (3PL)*

## 1. Introduction

The demand for logistics services has increased significantly over the last decades with the growth of e-commerce (Ngah *et al.*, 2023; Vlachos and Polichronidou, 2023). More consumers shop online and, especially, the COVID-19 pandemic demonstrated our increasing dependency on online shopping (Charm *et al.*, 2020; Ngah *et al.*, 2023). Today, consumers are demanding efficient and more complex logistics services when they are online shopping (Bartman *et al.*, 2022; Ngah *et al.*, 2023). Consumers are purchasing a wider variety of products online and expect faster delivery times (Bartman *et al.*, 2022). The e-commerce industry is expected to continue growing over the next couple of years with almost a quarter of all global sales being made online in 2025 ("What is e-commerce?", 2023). This development puts a pressure on third-party logistics (3PL) providers to meet the increasing demand (Bartman *et al.*, 2022).

The logistics industry is becoming increasingly more competitive within e-commerce (Bartman *et al.*, 2022). Online retailers are willing to switch providers to improve business success. Most logistics service providers offer similar services, thus 3PL providers need to ensure customer satisfaction to retain customers (Ngah *et al.*, 2023). Additionally, operating costs are increasing in the logistics industry (Bartman *et al.*, 2022) and 3PL providers need to continuously improve performance to gain a competitive advantage (Baruffaldi *et al.*, 2020). Undoubtedly, 3PL providers need to adapt their business models to the fast-changing pace of e-commerce. This requires new strategies and improved warehouse operations (Bartman *et al.*, 2022; Custodio and Machado, 2020).

Design is a key aspect of competitiveness in business (D'Ippolito, 2014). 3PL providers need to continually develop logistics services to remain competitive (Barker *et al.*, 2021). Bartman *et al.* (2022) argue that 3PL providers should develop configurable, standard services for e-commerce customers to enable customisation to the customers' requirements while maintaining profitable warehouse operations. Several authors agree that the use of modular designs can contribute to competitiveness in



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the service and logistics industry (Løkkegaard *et al.*, 2016; Pekkarinen and Ulkuniemi, 2008; Voss and Hsuan, 2009). Although design and development of logistics services is an important factor for competitiveness, few studies investigate the design of modular logistics services.

The aim of this study is to propose a model to describe logistics service architecture. This model describes the different aspects of logistics services. The purpose of this model is to support the design and development of modular logistics services. The model is based on selected literature within product architecture and modular design of logistics services. The model is applied in a case study to describe a logistics service architecture. The case company is a 3PL provider of warehousing services to e-commerce businesses. Finally, applicability of the model and limitations of the study are discussed.

## 2. Literature review

The first section introduces 3PL providers to understand some of the challenges in the logistics industry. The second section describes product architecture and different approaches for developing and modelling these. The last section investigates modular design of logistics services.

### 2.1. Third-party logistics (3PL) providers

3PL providers manage logistics activities on behalf of shippers or suppliers. This includes the management and execution of transportation or warehousing. Customers of 3PL outsource their logistics activities to 3PL providers. The 3PL providers act as a middleman between the two parties, the shippers and suppliers and the customers, and facilitate and manage logistics activities between the two parties (Hertz and Alfredsson, 2003). Outsourcing of logistics activities can enable businesses and online retailers to save costs and improve responsiveness, while they can focus on their core competencies (Zacharia *et al.*, 2011).

One of the main challenges for 3PL providers is the balance between customisation to the individual customer and organisation between several customers (Hertz and Alfredsson, 2003). 3PL providers offer a set of basic services along with a variety of additional services. Basic services include the activities related to transporting goods or receiving, storing, and shipping items from warehouses (Abdul Rahman *et al.*, 2021; Soinio *et al.*, 2012), whereas additional services, or value-added services (VAS), are customer-specific (Bowersox *et al.*, 2002; Soinio *et al.*, 2012). The delivery of additional services may strengthen the relationship between 3PL providers and customers (van Hoek, 2000; Jum'a and Basheer, 2023). However, tailored solutions are costly and could hinder competitiveness (Ponsignon *et al.*, 2021).

E-commerce has led to several new challenges in the 3PL industry. Online retailers have many unique items and large order volumes which require labour-intensive handling in warehouses (Azadeh *et al.*, 2019). These processes are increasingly automated with robotic handling systems (Azadeh *et al.*, 2019), but 3PL providers still need to be flexible to satisfy customers' needs (Jum'a and Basheer, 2023). Online retailers exhibit a tendency to switch 3PL providers. In fact, it is more costly to take new customers in than retaining existing. Therefore, 3PL providers need to ensure customers are satisfied (Ngah *et al.*, 2023).

### 2.2. Development of product architectures

A product architecture can be described as *"the scheme by which the function of the product is allocated to physical components"* (Ulrich, 1995, p. 420). The function is what the product does which is separate from the physical characteristics (Ulrich, 1995). Ulrich (1995) defines product architecture as the arrangement and mapping of functional elements to physical components and the specification of interfaces between physical components. Product architecture and the concept of modularity are closely related (Fixson, 2005; Voss and Hsuan, 2009). Voss and Hsuan (2009) describe modularity as *"the scheme by which interfaces shared among components in a given product architecture are standardized and specified to allow for greater reusability and commonality (or sharing) of components among product families"* (Voss and Hsuan, 2009, p. 543).

The design and development of product architectures has been studied extensively (Harlou, 2006; Hvam *et al.*, 2008). Meyer and Lehnard (1997) develop the Power Tower to build a common product



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platform. A product platform is the design of product families from common components, modules, or parts. The Power Tower is a conceptual framework that describes the three essential elements for managing the evolution of a product family. The first element is the market applications which is described through a matrix of market segments (Meyer and Lehnard, 1997). The second element is the product platforms which are the *"set of subsystems and interfaces that form a common structure"* (Meyer and Lehnard, 1997, p. 39). According to Meyer and Lehnard (1997), this combination, or structure, defines the architecture of products. The final element is the common technical and organisational building blocks of the product platform. Derivative products can be developed and produced from the same product platform to address the needs of different market segments (Meyer and Lehnard, 1997).

Several studies base product modelling on the Domain Theory and develop methods for modularisation (Andreasen *et al.*, 2014; Harlou, 2006; Hvam *et al.*, 2008). The Domain Theory aims to understand artefacts through analysis and synthesis (Andreasen *et al.*, 2014). The theory consists of three domains that lead to three system models: (1) the activity view explains the product's use or application, (2) the organ view explains the product's function, and (3) the part view explains the product's components (Andreasen *et al.*, 2014). Andreasen *et al.* (2014) state that ideas and concepts in the three views can promote product development, e.g. when designing a new product, in incremental design, and in platform-based design. Harlou (2006) develops the Product Family Master Plan (PFMP), a tool for modelling the variety of product families, based on the Domain Theory. The PFMP consists of three views that correspond to the three domains: (1) the customer view describes features and characteristics in the customer's interest, (2) the engineering view describes the organ structure of the product family and the variety of organs, and (3) the part view describes the physical components. The product family in the engineering view shows variety to the market in the customer view and commonality to the production system in the part view (Harlou, 2006). The PFMP and its terminology have been applied in numerous companies to develop product architectures (Mortensen *et al.*, 2012) and to model product families to be incorporated in configuration systems (Campo Gay and Hvam, 2023; Hvam *et al.*, 2008, 2019).

The general idea of the described approaches within product architectures and product platforms is to align the market, the product's function, and the production of the product.

## 2.3. Modular design of logistics services

Modular design is a design approach that divides products into modules that can be interchanged and combined to create product families. One of the benefits of modular design is the creation of variety while minimising costs (Andreasen *et al.*, 2015; Ulrich, 1994). Modular design has been used extensively in products (Hvam *et al.*, 2008). Several authors argue that modular design could be advantageous for logistics service providers (Bask *et al.*, 2011; Pekkarinen and Ulkuniemi, 2008; Ponsignon *et al.*, 2021; Rajahonka, 2013). Bask *et al.* (2011) and Ponsignon *et al.* (2021) both conclude that a modular approach can be applied to logistics services to achieve customisation and flexibility as well as economies of scale. Bask *et al.* (2010) states that e-commerce offers new opportunities for logistics service providers to bundle services and provide VAS modules, e.g. transportation along with gift-wrapping or installation of appliances. Research within modular design of logistics services is limited as well as research in the field of service modularity (Brax *et al.*, 2017; Iman, 2016; Pekkarinen and Ulkuniemi, 2008; Ponsignon *et al.*, 2021).

Service modularity resembles process modularity (Bask *et al.*, 2011). Bask *et al.* (2011) define service process modularity as *"the service production processes for creating the service offerings and modularity as the application of reusable process steps which can be combined in different ways"* (Bask *et al.*, 2011, p. 390) to meet customer requirements by providing flexibility and customisation. The study focuses on modularity among Finnish logistics service providers. These providers use repetitive and routine standard processes that can be divided into sub-processes or process modules. The studied providers can achieve economies of scale by using standard process modules (Bask *et al.*, 2011).

Pekkarinen and Ulkuniemi (2008) propose a modular service platform based on theory from product platforms and modifies the model after applying it to logistics services. The conceptual platform consists of three dimensions of modularity with interfaces between the dimensions: (1) modular services, (2)



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modular processes, and (3) modular organisation. Each dimension consists of multiple service modules which can be service elements or processes. A service element offers one service characteristic and is the equivalent of a "product component" and a process module is a standardised process step. Different service offerings can be derived from the modular service platform to target different market segments (Pekkarinen and Ulkuniemi, 2008). Pekkarinen and Ulkuniemi (2008) choose the logistics industry in their case study because physical and service elements are central in these services. The empirically grounded platform is expanded with: A tailoring module that represents the organisation and processes to produce a tailored service, i.e. a service with unique features and non-standardised interfaces; a fourth dimension of modularity, customer interface, consisting of organisational or process modules to effectively manage the customer interface in service co-creation; and the customer's goals and concerns. The study finds that logistics service providers, as well as customers, can have difficulties understanding the customers' needs or segment. Therefore, it is necessary to understand the customers' goals and concerns to identify a suitable service offering. Lin and Pekkarinen (2011) extend on the modular service platform by Pekkarinen and Ulkuniemi (2008) and propose a platform categorised in three layers, service, process, and activity layer, with an organisational dimension connected to each layer. The study finds that customised logistics services can be designed and delivered cost-effectively and flexibly by using the modular logistics service platform (Lin and Pekkarinen, 2011).

Similarly to the approaches within product architecture, these models emphasise an understanding of the market and the customers' needs when designing modular logistics services. Other studies investigate modularity in the logistics industry (Ponsignon *et al.*, 2021; Rajahonka, 2013), but few studies describe modular design of logistics services. The aim of this study is to contribute to a better understanding of how modular logistics services can be designed.

## 3. A model to describe logistics service architecture

The proposed model to describe logistics service architecture is based on the PFMP by Harlou (2006), as the tool and its terminology have shown to be useful for describing and visualising product architectures and for standardising components in product families (Hvam *et al.*, 2008; Mortensen *et al.*, 2012). The model consists of three views: (1) client view, (2) service view, and (3) resource view. The three views correspond to the customer, engineering, and part view in the PFMP.

The client view describes the logistics services from the client's point of view. This view contains features and characteristics in the client's interest and should outline the client's needs. The customer view is renamed "client view" to differentiate between product and service architecture and to emphasise the client's, business', role in service co-creation.

The service view describes the structure and variety of logistics services. These are the service production processes that create the service offerings (Bask *et al.*, 2011). These processes either relate to physical operations or information processing as in the dimension, modular processes, defined by Pekkarinen and Ulkuniemi (2008).

The resource view describes the physical structure and the resources for producing service offerings. This view is the physical entity of the services. Wong and Karia (2010) study 15 logistics service providers and identify five different types of logistics resources: (1) physical, (2) human, (3) information, (4) knowledge, and (5) relational resources. Information, knowledge, and relational resources are intangible and more difficult to operationalise. Physical and human resources are not functional by themselves but need the other resources to be useful (Wong and Karia, 2010). Four types of resources are defined in this model:

1. **Equipment**. Equipment is physical resources for service production.
2. **People**. People are the employees, with different capabilities, who perform the services.
3. **Information technology (IT)**. IT are the systems that control and support the logistics services and exchange information with the client.
4. **Consumables**. Consumables are commodities provided by the logistics company or the client.

The three views are outlined in Figure 1. Similarly to the PFMP, the service view shows variety to the market in the client view and commonality to the service production in the resource view.



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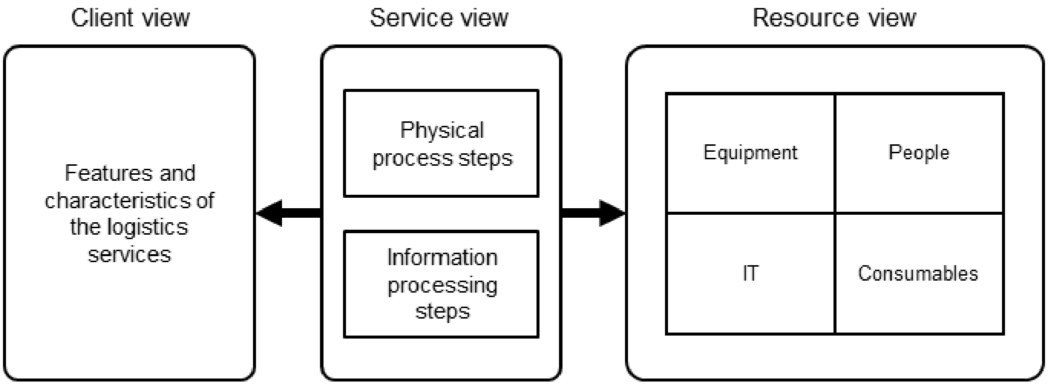


**Figure 1. Proposed model to describe logistics service architecture (inspired by Harlou (2006))**

## 4. Research method

This study adopts a case study strategy to investigate logistics service architecture in real life. The case study method is undertaken because it allows for the study of a phenomenon in its natural setting and a fuller understanding of the nature and complexity of the phenomenon (Voss *et al.*, 2002). This study focuses on the 3PL industry as it is challenged by the growth of e-commerce and studies argue that modular design could benefit this industry (Bask *et al.*, 2011; Lin and Pekkarinen, 2011).

The case study includes a single case company to allow for an in-depth analysis of logistics service architecture. The case company is a 3PL provider of both transportation and warehousing services. The company is facing similar challenges as described in the literature. The model is applied to warehousing services in Danish warehouses.

Data is collected from several sources. We conducted in-depth interviews with managers from sales, project, and contract management. These managers engage in selling and developing warehousing services for different customer segments in the Danish warehouses. We observed several warehouse operations across the Danish warehouses and interviewed warehouse workers and operational managers on the sites to understand the different service offerings and to map warehouse processes. The final data source is various documentation of warehousing services. This includes internal and external documentation, e.g. sales offers, standard operating procedures, and contracts. The model has been applied across different customer segments, but we choose to focus on the e-commerce segment in the following case study.

## 5. Application in a 3PL company

The 3PL company is a world-leading provider of logistics services. The company operates more than 400 warehouses globally with a small number of warehouses located in Denmark. The company faces several challenges in the e-commerce industry. The demand for logistics services is increasing and the company needs to scale warehouse operations. Other 3PL providers offer similar services to online retailers, and the company must offer competitive prices and excellent services to be competitive. However, operating costs are increasing, and the company needs to optimise warehouse operations. The company has started several initiatives within the e-commerce segment. The following sections describe the results from applying the proposed model to warehousing services. The results have been summarised and simplified due to confidentiality.

### 5.1. Client view

The client view describes the business and its needs to understand which warehousing services to offer. This view was defined from documentation in the sales process, i.e. sales offers and standard operating procedures, and through interviews with a sales manager, project manager, and operational manager with responsibility of several e-commerce clients.

This view includes general information such as the client's industry, preferred warehouse location, and international standards. More detailed information includes a thorough description of the client's goods,



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order volumes and warehouse space, shipping information, and IT integrations. Clients within the e-commerce segment sell goods directly to consumers. A business-to-consumer (B2C) process changes the requirements for logistics services in terms of packaging and shipping. Furthermore, these clients typically want VAS such as gift-wrapping, return labels, or returns handling. These are additional needs that should be uncovered in the client view.

## 5.2. Service view

The service view describes the activities associated with handling the client's goods in the warehouse. This view was defined through observation of warehouse operations and interviews with a project manager and several warehouse workers and operational managers on the sites.

These activities are split into three overall categories: (1) inbound, (2) outbound, and (3) extra services. Inbound is the process of receiving and placing items into the warehouse and outbound is the process of picking and shipping items from storage. Some of the identified processes are VAS. The process "Sorting items" is a VAS while elements of "Packing" are VAS, e.g. gift-wrapping (see Figure 2). Extra services are processes that take place outside the inbound and outbound process, e.g. stock count or cancellation of orders. These are mostly VAS. The actual storage of goods is not a process but rather a resource tied to the sub-process "Putaway to storage". Processes that had different names but served identical purposes between clients were standardised into one process and given a common name. The purpose of this standardisation is to avoid unnecessary complexity and to enhance the reusability of services between different clients.

Most processes consist of both physical process steps and information processing steps. Information processing plays a big role in warehousing services as information is constantly exchanged between the client and the company. Messages inform the company of new orders and initiate processes in the warehouse. Likewise, the client receives information on stock levels and order statuses.

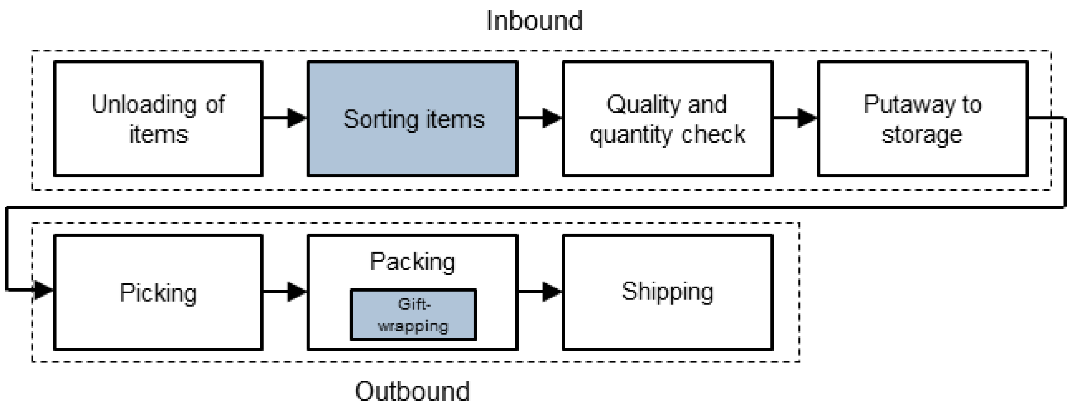


**Figure 2. Simplified model of the inbound and outbound process; blue processes are examples of VAS**

## 5.3. Resource view

The resource view describes tangible and intangible resources for service production. These resources are derived from the identified processes in the service view and from documentation in the sales process. This documentation specifies the different types of resources in the company and how these are priced.

The identified resources are divided into five categories. The resource, equipment, is split into two types of resources: Facilities and equipment. Facilities are the storage solutions provided to the client, e.g. racks or pallet locations. These facilities differ from warehouse locations; therefore, some services cannot be offered in some warehouses. Equipment is resources used to perform services, e.g. forklifts or scanners. Unlike facilities, these do not depend on the warehouse location and can be acquired if necessary. Similar resources between clients were categorised together to simplify offerings, e.g. "labels" is one category of consumables with two types of labels.



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Table 1 provides some examples of the identified resources.

Table 1. Examples of the five types of resources

| Facilities | Equipment | People | IT | Consumables |
|---|---|---|---|---|
| Racks, pallet locations, automation solutions in different warehouses. | Forklifts, scanners, printers, trolleys. | Warehouse workers: Either employed by the company or subcontracted. These have different capabilities, e.g. license to operate forklifts. | Warehouse management systems | Boxes, envelopes, gift wrapping, labels: Either provided by the client or the company. |

## 5.4. Logistics service architecture for warehousing services

The three views are consolidated into one model that describes the logistics service architecture for warehousing services (see Figure 3). The model was presented to a sales manager, project manager, and operational manager, with responsibility of several e-commerce clients, and revised with their corrections. The final model has been presented to the same employees along with the sales manager and project manager with an overall responsibility of the Danish warehouses. The model provides an overview and classifications of warehousing services and common names across the service offering. Several employees agreed that the model could support the sales and after-sales processes. The model could be used to determine different clients' needs and the suitable service offering from common processes and resources. The model could also be a communication tool to explain warehousing services to clients and to avoid misunderstandings between the company and the client. Likewise, the model could increase the understanding of the organisation's capabilities to avoid situations where the company fails to deliver what it has promised the client.

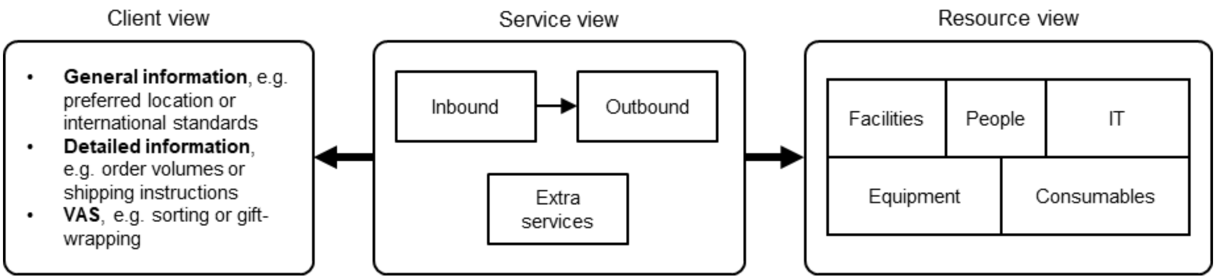


Figure 3. Model of logistics service architecture for warehousing services in the case company

# 6. Discussion & conclusion

The rise in online shopping over the last decades has offered new opportunities for 3PL providers. These companies manage logistics activities for online retailers and provide services that replicate the traditional shopping experience to consumers, such as gift-wrapping. Although this market is growing, competition within the logistics industry is at a high. 3PL providers need to meet the increasing demand while reducing costs to stay competitive. Several studies argue that modular design of logistics services could overcome these challenges and contribute to a competitive advantage. Few studies address modularisation of logistics services, as well as services in general. There is a gap and a lack of knowledge of modular design of logistics services in the literature.

This study contributes to the field of modularisation by proposing a model that lays the foundation for a logistics service architecture to describe the relation between function and physical structure. The model is based on the PFMP by Harlou (2006) which is adapted to logistics services. It describes the variety of logistics services and the commonality between these services. The model consists of three views: (1) client view, (2) service view, and (3) resource view. The model was applied to a 3PL provider to describe a logistics service architecture for warehousing services. The case study shows that warehousing services can be described in three domains. The service view describes how the company organises resources to create value for clients. The model provides an overview of warehousing services



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which could support discussions with future clients as well as internal collaboration. It describes common elements of warehousing services that are shared between different clients.

The case study focused on the e-commerce segment which was easily defined from a B2C perspective. The model was also applied to other customer segments, and this showed that some clients were difficult to define. Therefore, it was challenging to understand the clients' needs and to identify services that satisfy these needs. This issue was described by Pekkarinen and Ulkuniemi (2008), who argue that it is also necessary to understand the customer's goals and concerns to offer valuable services. These elements could be incorporated into the model. The model could also be supported by a customer segmentation like in some applications of the PFMP (Mortensen *et al.*, 2012). These segmentations could be based on historical data of existing and past clients to understand past service offerings.

This study is not exhaustive and has several limitations. The case study has a single case which allows for in-depth analysis, but limits generalisability of the model and the conclusions drawn from the study. The model is likely to apply to other logistics companies that offer warehousing services. However, it cannot be generalised to other logistics services. The proposed model should be analysed in more cases and with other logistics services to validate the model. The model only focuses on the logistics services directly related to transportation or warehousing. One could argue that other processes, such as implementation of new clients into warehouses, are part of the service production processes. This was evident from the case study which showed that the company provides a variety of services that are not dependent on order volumes. These services should be addressed in future studies.

The objective of this study was not to define logistics service modules or interfaces. Both Ponsignon *et al*. (2021) and Rajahonka (2013) emphasise the importance of well-defined and well-designed interfaces in logistics services. The model provides a basis for understanding the architecture of logistics services and how to design logistics services from a variety and commonality perspective. Future studies should focus on defining service modules and interfaces and on designing new service offerings using the model.

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## References

Abdul Rahman, N.S.F., Karim, N.H., Md Hanafiah, R., Abdul Hamid, S. and Mohammed, A. (2021), “Decision analysis of warehouse productivity performance indicators to enhance logistics operational efficiency”, International Journal of Productivity and Performance Management, Emerald Group Holdings Ltd., https://dx.doi.org/10.1108/IJPPM-06-2021-0373.

Andreasen, M.M., Hansen, C.T. and Cash, P. (2015), Conceptual Design: Interpretations, Mindset and Models, Springer, https://dx.doi.org/10.1007/978-3-319-19839-2.

Andreasen, M.M., Howard, T.J. and Bruun, H.P.L. (2014), “Domain Theory, Its Models and Concepts”, in Blessing, L.T.M. and Chakrabarti, A. (Eds.), An Anthology of Theories and Models of Design, Springer, London, pp. v–455, https://dx.doi.org/10.1007/978-1-4471-6338-1.

Azadeh, K., De Koster, R. and Roy, D. (2019), “Robotized and automated warehouse systems: Review and recent developments”, Transportation Science, INFORMS Inst.for Operations Res.and the Management Sciences, Vol. 53 No. 4, pp. 917–945, https://dx.doi.org/10.1287/trsc.2018.0873.

Barker, J.M., Gibson, A.R., Hofer, A.R., Hofer, C., Moussaoui, I. and Scott, M.A. (2021), “A competitive dynamics perspective on the diversification of third-party logistics providers’ service portfolios”, Transportation Research Part E: Logistics and Transportation Review, Elsevier Ltd, Vol. 146, https://dx.doi.org/10.1016/j.tre.2020.102219.

Bartman, T., Dragendorf, J., McConnell, S., Murnane, J. and Pan, I. (2022), “The promise and challenge of multi-client fulfillment for e-commerce”, McKinsey & Company, 5 July, available at: https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/the-promise-and-challenge-of-multi-client-fulfillment-for-e-commerce (accessed 15 November 2023).

Baruffaldi, G., Accorsi, R., Manzini, R. and Ferrari, E. (2020), “Warehousing process performance improvement: a tailored framework for 3PL”, Business Process Management Journal, Emerald Group Holdings Ltd., Vol. 26 No. 6, pp. 1619–1641, https://dx.doi.org/10.1108/BPMJ-03-2019-0120.



https://doi.org/10.1017/pds.2024.82 Published online by Cambridge University Press

Bask, A., Lipponen, M., Rajahonka, M. and Tinnilä, M. (2011), "Modularity in logistics services: a business model and process view", Int. J. Services and Operations Management, Vol. 10 No. 4, pp. 379–399, https://dx.doi.org/10.1504/IJSOM.2011.043463.

Bowersox, D.J., Closs, D.J. and Cooper, M.B. (2002), Supply Chain Logistics Management, International., McGraw-Hill/Irwin, New York.

Brax, S.A., Bask, A., Hsuan, J. and Voss, C. (2017), "Service modularity and architecture – an overview and research agenda", International Journal of Operations and Production Management, Emerald Group Publishing Ltd., Vol. 37 No. 6, pp. 686–702, https://dx.doi.org/10.1108/IJOPM-03-2017-0191.

Campo Gay, I. and Hvam, L. (2023), "Product Variant Master in the Construction Industry", Proceedings of the 25th International Workshop on Configuration (ConfWS 2023), Vol. 3509, CEUR-WS, Malaga, pp. 118–125.

Charm, T., Coggins, B., Robinson, K. and Wilkie, J. (2020), "The great consumer shift: Ten charts that show how US shopping behavior is changing", McKinsey & Company, August, available at: https://www.mckinsey.com/capabilities/growth-marketing-and-sales/our-insights/the-great-consumer-shift-ten-charts-that-show-how-us-shopping-behavior-is-changing (accessed 15 November 2023).

Custodio, L. and Machado, R. (2020), "Flexible automated warehouse: a literature review and an innovative framework", International Journal of Advanced Manufacturing Technology, Springer, Vol. 106 No. 1–2, pp. 533–558, https://dx.doi.org/10.1007/s00170-019-04588-z.

D'Ippolito, B. (2014), "The importance of design for firmscompetitiveness: A review of the literature", Technovation, Elsevier Ltd, Vol. 34 No. 11, pp. 716–730, https://dx.doi.org/10.1016/j.technovation.2014.01.007.

Fixson, S.K. (2005), "Product architecture assessment: A tool to link product, process, and supply chain design decisions", Journal of Operations Management, Vol. 23 No. 3–4, pp. 345–369, https://dx.doi.org/10.1016/j.jom.2004.08.006.

Harlou, U. (2006), Developing Product Families Based on Architectures: Contribution to a Theory of Product Families, Technical University of Denmark, Kongens Lyngby, June.

Hertz, S. and Alfredsson, M. (2003), "Strategic development of third party logistics providers", Industrial Marketing Management, Vol. 32, pp. 139–149, https://dx.doi.org/10.1016/S0019-8501(02)00228-6.

van Hoek, R.I. (2000), "Role of third party logistic services in customization through postponement", International Journal of Service Industry Management, # MCB University Press, Vol. 11 No. 4, pp. 956–4233, https://dx.doi.org/10.1108/09564230010355395.

Hvam, L., Kristjansdottir, K., Shafiee, S., Mortensen, N.H. and Herbert-Hansen, Z.N.L. (2019), "The impact of applying product-modelling techniques in configurator projects", International Journal of Production Research, Taylor and Francis Ltd., Vol. 57 No. 14, pp. 4435–4450, https://dx.doi.org/10.1080/00207543.2018.1436783.

Hvam, L., Mortensen, N.H. and Riis, J. (2008), Product Customization, Springer, Berlin, https://dx.doi.org/10.1007/978-3-540-71449-1.

Iman, N. (2016), "Modularity matters: a critical review and synthesis of service modularity", International Journal of Quality and Service Sciences, Emerald Group Publishing Ltd., Vol. 8 No. 1, pp. 38–52, https://dx.doi.org/10.1108/IJQSS-05-2015-0046.

Jum'a, L. and Basheer, M.E. (2023), "Analysis of Warehouse Value-Added Services Using Pareto as a Quality Tool: A Case Study of Third-Party Logistics Service Provider", Administrative Sciences, MDPI, Vol. 13 No. 2, pp. 1–23, https://dx.doi.org/10.3390/admsci13020051.

Lin, Y. and Pekkarinen, S. (2011), "QFD-based modular logistics service design", Journal of Business and Industrial Marketing, Vol. 26 No. 5, pp. 344–356, https://dx.doi.org/10.1108/08858621111144406.

Løkkegaard, M., Mortensen, N.H. and McAloone, T.C. (2016), "Towards a framework for modular service design synthesis", Research in Engineering Design, Springer London, Vol. 27 No. 3, pp. 237–249, https://dx.doi.org/10.1007/s00163-016-0215-6.

Meyer, M.H. and Lehnard, A.P. (1997), The Power of Product Platforms: Building Value and Cost Leadership, The Free Press.

Mortensen, N.H., Boelskifte, P., Holmskov, L., Gamillscheg, B., Bruun, H.P.L., Hansen, C.L., Cleemann, K.K., et al. (2012), Radikal Forenkling via Design, Vol. 1, DTU Mekanik, Kongens Lyngby.

Ngah, A.H., Thurasamy, R. and Han, H. (2023), "If you don't care, I will switch: online retailers' behaviour on third-party logistics services", International Journal of Physical Distribution and Logistics Management, Emerald Publishing, Vol. 53, https://dx.doi.org/10.1108/IJPDLM-04-2022-0124.

Pekkarinen, S. and Ulkuniemi, P. (2008), "Modularity in developing business services by platform approach", The International Journal of Logistics Management, Vol. 19 No. 1, pp. 84–103, https://dx.doi.org/10.1108/09574090810872613.

Ponsignon, F., Davies, P., Smart, A. and Maull, R. (2021), "An in-depth case study of a modular service delivery system in a logistics context", International Journal of Logistics Management, Emerald Group Holdings Ltd., Vol. 32 No. 3, pp. 872–897, https://dx.doi.org/10.1108/IJLM-07-2020-0295.



https://doi.org/10.1017/pds.2024.82 Published online by Cambridge University Press

Rajahonka, M. (2013), “Views of logistics service providers on modularity in logistics services”, International Journal of Logistics Research and Applications, Taylor and Francis Ltd., Vol. 16 No. 1, pp. 34–50, https://dx.doi.org/10.1080/13675567.2013.767325.
Soinio, J., Tanskanen, K. and Finne, M. (2012), “How logistics-service providers can develop value-added services for SMEs: A dyadic perspective”, International Journal of Logistics Management, Vol. 23 No. 1, pp. 31–49, https://dx.doi.org/10.1108/09574091211226911.
Ulrich, K. (1994), “Fundamentals of product modularity”, in Dasu, S. and Eastman, C. (Eds.), Management of Design, 1994th ed., Springer, Netherlands, pp. 219–231, https://dx.doi.org/10.1007/978-94-011-1390-8_12.
Ulrich, K. (1995), “The role of product architecture in the manufacturing firm”, Research Policy, Vol. 24 No. 419–440, pp. 419–440, https://dx.doi.org/10.1016/0048-7333(94)00775-3.
Vlachos, I. and Polichronidou, V. (2023), “Multi-demand supply chain triads and the role of Third-Party Logistics Providers”, International Journal of Logistics Management, Emerald Publishing, pp. 1–22, https://dx.doi.org/10.1108/IJLM-04-2022-0161.
Voss, C., Tsikriktsis, N. and Frohlich, M. (2002), “Case research in operations management”, International Journal of Operations and Production Management, Vol. 22 No. 2, pp. 195–219, https://dx.doi.org/10.1108/01443570210414329.
Voss, C.A. and Hsuan, J. (2009), “Service architecture and modularity”, Decision Sciences, Vol. 40 No. 3, pp. 541–569, https://dx.doi.org/10.1111/j.1540-5915.2009.00241.x.
“What is e-commerce?” (2023), McKinsey & Company, 29 June, available at: https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-e-commerce (accessed 15 November 2023).
Wong, C.Y. and Karia, N. (2010), “Explaining the competitive advantage of logistics service providers: A resource-based view approach”, International Journal of Production Economics, Vol. 128 No. 1, pp. 51–67, https://dx.doi.org/10.1016/j.ijpe.2009.08.026.
Zacharia, Z.G., Sanders, N.R. and Nix, N.W. (2011), “The emerging role of the third-party logistics provider (3PL) as an orchestrator”, Journal of Business Logistics, Vol. 32 No. 1, pp. 40–54, https://dx.doi.org/10.1111/j.2158-1592.2011.01004.x.



https://doi.org/10.1017/pds.2024.82 Published online by Cambridge University Press