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TOWARDS A DEFINITION OF 'LOGISTICS SERVICE INTERFACES': LITERATURE SYNTHESIS AND A CASE STUDY

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Abstract: *Scholars have shown an increasing interest in service modularity over the last decades with several studies agreeing that modularity could contribute to competitive advantages in service-based companies. A few studies investigate if service modularity can produce competitive advantages in the intense competition between logistics service providers (LSP). While interfaces are critical elements in successful modular product architectures and product customization, they are rarely addressed in logistics service research. To lay out a basis for future research on the topic, this study develops a definition of logistics service interfaces (LSIs). To do so, the study reviews existing research on service modularity, which is synthesized into a definition of LSIs. A case study of a world-leading LSP is conducted to illustrate the usefulness of the provided definition. Finally, the definition is discussed along with considerations for future research.*

Key Words: ***Interfaces, service modularity, logistics, logistics service providers (LSP), definition***

1. INTRODUCTION

Interfaces are critical elements in successful, modular product architectures. Modularity typically describes the degree to which a product or system can be divided into parts or modules (Schilling, 2000, p. 312) with physical interfaces that connect product components and form product architectures (Ulrich, 1995). The interest in service modularity has increased over the last decades (de Mattos *et al.*, 2021). Such studies generally agree that service modularity could benefit service-oriented companies, especially logistics service providers (LSPs) that operate in highly competitive markets. As with product modularity, interfaces are important in service modularity and customization (De Blok *et al.*, 2014). Although there is some literature on service modularity, few studies focus on service interfaces and provide examples (de Mattos *et al.*, 2021; Ponsignon *et al.*, 2021). In this context, the literature provides little explanation and empirical examples in the context of logistics services. Therefore, this study seeks to define logistics service interfaces (LSIs) and illustrate their usefulness through a case study of a world-leading logistics provider.

The following section reviews existing studies on interfaces in service modularity and modularity in logistics services, on which basis an overall conceptualization of LSIs is developed. This is followed by describing the research method and a case study of a world-leading provider of warehouse services. Finally, the definition of LSIs is further elaborated, and the findings and limitations of the study are discussed.

2. LITERATURE

2.1. Service module interfaces

de Mattos *et al.* (2021) reviewed service modularity literature and defined service modularity as a strategy for designing services by combining standardized service modules to allow for configuration and customization of services. They argue that service modules are sets of elements or components, e.g., characteristics, products, or subprocesses of a service. Service elements or components are the smallest units a service can be divided into, e.g., processes, operations, people, objects, and/or resources (de Mattos *et al.*, 2021). Service modularity closely relates to service production due to the nature of services. Thus, service modularity is often defined similarly to process modularity (Iman, 2016). de Mattos *et al.* (2021) found that the most adopted definition of service interfaces is by Voss & Hsuan (2009). Voss & Hsuan (2009) described service interfaces as linkages between nodes, i.e., either modules or service components, and can include people, information, and rules governing the flow of information.

Bask *et al.* (2010) emphasized that service interfaces often are more "soft" or human than product interfaces because of the nature of services. The customer takes an active role in the service process and services are simultaneously produced and consumed. Thus, the service product can be defined as the service process (Voss & Hsuan, 2009). Bask *et al.* (2010) posited that for this reason, service modularity is more complex than product modularity. De Blok *et al.* (2014) summarized the literature on interfaces in service modularity to create a typology of interfaces in modular services. Through a case study in modular health care provision, the study found that interfaces could be distinguished on two levels: (1) component, i.e., interfaces between interacting components, and (2) service package, i.e., interfaces between service providers in the care package. The typology has two dimensions: (1) interface entities, i.e., the two levels of interfaces, and (2) interface aims (variety and coherence). This resulted in four interface categories that specify how the interface entities create variety and coherence. De Blok *et al.* (2014, p. 186) adapt the following definition of interfaces in modular services: *"the set of rules and guidelines governing the flexible arrangement, interconnections, and interdependence of service components and service providers."* Although this study is the most comprehensive focusing on interfaces in service modularity and providing examples from multiple organizations, it is limited in terms of generalizability as the case study only included home health care services for elderly. This is different in the sense that there are no physical resources in the service, whereas logistics services have both physical and service elements (Pekkarinen & Ulkuniemi, 2008).

2.2. Modularity in logistics services

A few studies have explored modularity in logistics services (Bask *et al.*, 2011; Pekkarinen & Ulkuniemi, 2008; Ponsignon *et al.*, 2021). Pekkarinen & Ulkuniemi (2008) developed a modular service platform based on a case study in logistics services. This platform consists of four dimensions of modularity: service, process, organizational, and customer interface. Each dimension consists of modules with interfaces between the modules as well as interfaces between the dimensions. A service module consists of one or several service elements with one service characteristic. The service production process consists of process modules that either relate to physical or information processing. Organizational modules are functional units that describe the organization's ability to flexibly use its own and other firm's resources. Finally, customer interfaces consist of process and organizational modules to effectively manage the customer interface. Pekkarinen & Ulkuniemi (2008) provide an example of interfaces between IT processes, i.e., different information channels such as paper, phone, EDI, etc. Finally, they conclude that the most difficult challenge in the development of the modular platform is coordination.

Lin & Pekkarinen (2011) expanded on Pekkarinen & Ulkuniemi (2008) modular service platform approach with a fifth dimension, activity, and developed a framework based on quality function deployment to design modular logistics services. This framework can be used to design modules and simultaneously be redesigned while considering the interfaces. The study did not go further into describing the interfaces but stated that future research should focus on interfaces at different levels, especially to use the modular platform with different customer segments. Bask *et al.* (2011) investigated modularity in business models and processes in logistics services and interviewed 24 LSPs, which used repetitive and routine standard processes that could be divided into subprocesses or process modules. They found that more formalized interfaces and IT systems, as well as the development and reorganization of partner networks, were prerequisites for modularity in logistics services.

Ponsignon *et al.* (2021) investigated the design of a service delivery system for modular logistics services and found that this consisted of three types of processes: (1) core processes (platform), (2) dedicated modular processes, and (3) optional modular processes. Interfaces manage interdependencies between the platform and the dedicated modular processes and assure that the platform is not exposed to undesired customer input variability by defining rules that describe if customer inputs, supplied material inputs, and information inputs, can be accommodated by the platform. The study emphasized the importance of well-designed interfaces.

3. CONCEPTUAL DEFINITION OF LOGISTICS SERVICE INTERFACES

Figure 1 shows a conceptual definition of LSIs based on the service modularity literature reviewed in the previous section. As illustrated, LSIs link service elements and the service modules. Service elements involve, for example, people, machines, information technology, and storage facilities. Service modules consist of service elements and are associated with service production processes. Therefore, in this perspective, service modules are understood as processes and LSIs refer to the relationships between service elements within a service module, as well as the relationships between service modules. In other words, an LSI refers to the compatibility of service elements or service modules.

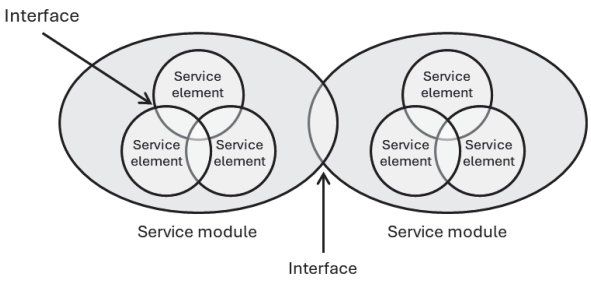

Fig. 1. *Conceptual definition of logistics service interfaces*

4. RESEARCH METHOD

This study employed a single-case study approach to investigate LSIs in the logistics industry and to empirically ground the definition of interfaces in logistics services. This approach was chosen as it allows for the study of a phenomenon in a real setting and for a comprehensive understanding of the complete

phenomenon. The single-case study allowed for an in-depth analysis (Voss *et al.*, 2016).

The case study was conducted in a world-leading LSP, also referred to as *the company*, that offers transportation and warehouse services. This case study focuses on warehouse services, i.e., activities related to storage, receiving, picking, and shipping of goods (Abdul Rahman *et al.*, 2021). The case study is based on observations by the researchers in the case company. The researchers have analyzed seven Danish warehouses and around 16 clients from different industries. This case study describes three observed warehouse processes to illustrate interfaces in logistics services.

5. CASE STUDY RESULTS

Warehouse operations can be divided into two overall processes: (1) inbound and (2) outbound. Both processes consist of several sub-processes that are common for most clients. *Inbound* entails unloading, goods receipt, receiving, movement to put-away, and put-away to storage. O*utbound* includes picking from storage, packing, labeling, and loading trucks. Several additional services and processes are available to clients in addition to these processes, e.g., sorting, repacking, and gift-wrapping. These processes constitute the service production processes and are therefore defined as service modules.

The three observed processes include unloading products (goods), sorting, and goods receipt (see Fig. 2). The truck driver received a notification of the designated warehouse dock for unloading. This was communicated to the truck driver through the transportation management system (TMS). The products arrived at the warehouse on mixed pallets in a truck and were unloaded with a forklift operated by a forklift driver. The process of sorting immediately followed as the products were on mixed pallets, i.e., stock-keeping units (SKUs) were mixed. The products were sorted and reallocated to pallets containing the same type of products. The products were sorted by warehouse employees onto new pallets containing one SKU. Subsequently, the goods receipt was completed. This process involved quality and quantity checks by warehouse employees. Damaged goods were documented with pictures. The barcode of each product was scanned to ensure the received products match the information on the delivery note. Finally, the products were registered on an item level in the warehouse management system (WMS).

Evidently, there are interfaces between the service elements. For example, there is an interface between the truck and the warehouse dock, allowing the truck to connect to the warehouse and unload. There is also an interface between the product on pallets and the forklift that allows the pallets to be lifted. Furthermore, the size of the product determines how it can be unloaded, and who can do this, i.e., only warehouse employees with a license to operate forklifts. On the other hand, there is not an interface between loose boxes and forklifts, because loose boxes cannot be moved by forklifts. Likewise, information exchanged between the TMS or WMS and the customer's system is normally sent via electronic data interchange (EDI) or application programming interface (API). The barcodes on the products are interfaces between the products and the WMS, allowing the company to identify products in the WMS.

In relation to interfaces between service modules, the second process, 'sorting', shows that the interfaces between the service modules dictate if two service processes can be combined. In this case, the products must be sorted before they can be stored, implying that the process of unloading and producing a goods receipt cannot be connected if products are mixed. Products are stored according to SKU numbers. Thus, mixed products must be sorted in types of SKUs to complete the remaining inbound sub-processes. This shows that the output from one service process must be compatible with the input for another service process. Another interface between service processes concerns employee and warehouse facility availability in the sense that two service modules can only be combined if both can be carried out, which depends on whether required employees and warehouse facilities are available.

6. DISCUSSION AND CONCLUSION

This study investigated interfaces in the logistics industry to propose a definition of LSIs. Existing research includes several studies that investigate modularity in logistics services, but these rarely address service interfaces although they are important in service modularity and customization. To add to this knowledge, a conceptual definition of LSIs was formulated based on the literature. In this definition, interfaces in logistics services are defined as linkages between service modules (service production processes) and service elements (people, objects, and equipment). The usefulness of the definition was illustrated by a case study of a world-

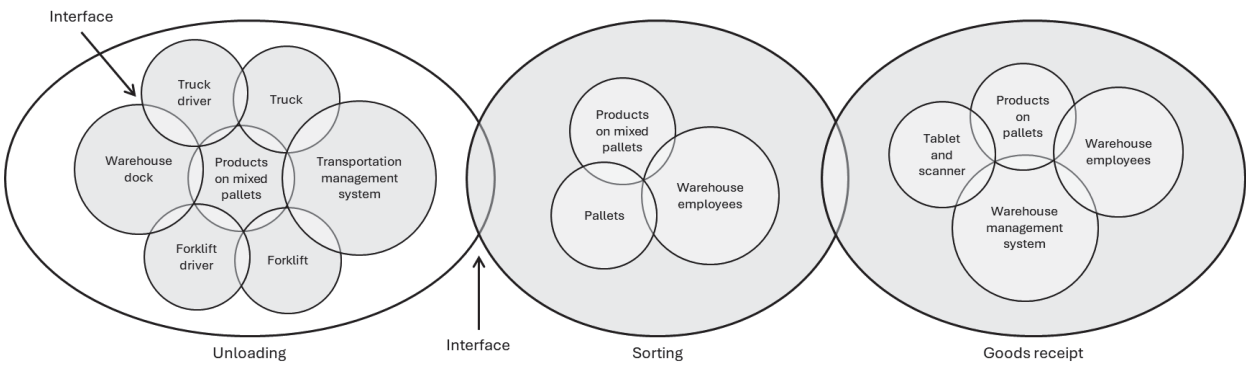

Fig. 2. *Warehouse processes*

leading provider of logistics services. Specifically, the study showed that the definition allowed for describing interfaces between service elements and service modules.

The study showed that interfaces between service elements could be both physical and information oriented. Physical interfaces include, for example, the compatibility of pallets and forklifts, as well as trucks and warehouse docks. Information-oriented interfaces include, for example, EDI or API and barcodes on products that are compatible with the WMS. Next, observed interfaces between service modules included product types, employee availability, and warehouse facilities. Thus, interfaces between service elements relate more to resources and how these are connected, while service module interfaces concern the alignment between input and output of processes and the availability of resources. The study showed that the product, which includes SKU(s), packaging, labeling, etc., must be aligned with two processes. If the product output from one process is not compatible with the following, the two processes cannot be combined. Therefore, the products also determine the structure of the processes. This interface, for example, ensures that the process of outbound cannot precede the process of inbound.

Although the definition provided by the present study was only investigated in the context of warehouse services, it has such a general nature that it appears to also be applicable to other logistics services. Nevertheless, future studies should investigate interfaces in other logistics services such as transportation. Overall, the present study demonstrates the complexity of conceptualizing logistics services and their interfaces. However, to accommodate the increasing digitalization and demands for increased efficiency, there is a need for LSPs to be able to define their services and the interfaces between them. As current literature provides very little guidance on this matter, it is the hope of the authors that this paper will stimulate further such research.

7. REFERENCES

Abdul Rahman, N.S.F., Karim, N.H., Md Hanafiah, R., Abdul Hamid, S. & 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. 72 (4), 962-985. Available from: doi: 10.1108/IJPPM-06-2021-0373

Bask, A., Lipponen, M., Rajahonka, M. & Tinnilä, M. (2010) The concept of modularity: Diffusion from manufacturing to service production. *Journal of Manufacturing Technology Management*. 21 (3), 355-375. Available from: doi: 10.1108/17410381011024331

Bask, A., Lipponen, M., Rajahonka, M. & Tinnilä, M. (2011) Modularity in logistics services: A business model and process view. *International Journal of Services and Operations Management*. 10 (4), 379-399. Available from: doi: 10.1504/IJSOM.2011.043463

De Blok, C., Meijboom, B., Luijkx, K., Schols, J. & Schroeder, R. (2014) Interfaces in service modularity: A typology developed in modular health care provision. *Journal of Operations Management*. 32 (4), 175-189. Available from: doi: 10.1016/j.jom.2014.03.001

Iman, N. (2016) Modularity matters: a critical review and synthesis of service modularity. *International Journal of Quality and Service Sciences*. Emerald Group Publishing Ltd. 8 (1), 38-52. Available from: doi: 10.1108/IJQSS-05-2015-0046

Lin, Y. & Pekkarinen, S. (2011) QFD-based modular logistics service design. *Journal of Business and Industrial Marketing*. 26 (5), 344-356. Available from: doi: 10.1108/08858621111144406

de Mattos, C.S., Fettermann, D.C. & Cauchick-Miguel, P.A. (2021) Service modularity: literature overview of concepts, effects, enablers, and methods. *Service Industries Journal*. Taylor & Francis. 41 (15-16), 1007-1028. Available from: doi: 10.1080/02642069.2019.1572117

Pekkarinen, S. & Ulkuniemi, P. (2008) Modularity in developing business services by platform approach. *The International Journal of Logistics Management*. 19 (1), 84-103. Available from: doi: 10.1108/09574090810872613

Ponsignon, F., Davies, P., Smart, A. & 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. 32 (3), 872-897. Available from: doi: 10.1108/IJLM-07-2020-0295

Schilling, M.A. (2000) Toward a general modular systems theory and its application to interfirm product modularity. *Academy of Management Review*. 25(2), 312-334.

Ulrich, K. (1995) The role of product architecture in the manufacturing firm. *Research Policy*. 24, 419-440.

Voss, C., Johnson, M.H. & Godsell, J. (2016) Case research. In: Karlsson, C. (eds.) *Research Methods for Operations Management*. Second. Routledge, Oxfordshire, pp. 165-197.

Voss, C.A. & Hsuan, J. (2009) Service architecture and modularity. *Decision Sciences*. 40 (3), 541-569. Available from: doi: 10.1111/j.1540-5915.2009.00241.x

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