The Hourglass Model: From Consumer's Behavior to Delivery

Diogo Mendes Correia
Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP)
Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT)
University of Aveiro
Aveiro, Portugal
diogo.correia@ua.pt

Leonor Teixeira
Institute of Electronics and Informatics Engineering of Aveiro (IEETA)
Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP)
Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT)
University of Aveiro
Aveiro, Portugal
lteixeira@ua.pt

João Lourenço Marques
Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP)
Department of Social, Political and Territorial Sciences (DCSPT)
University of Aveiro
Aveiro, Portugal
jjmarques@ua.pt

Abstract

Through an empirical study of 74 Portuguese e-commerce brands, from the fashion, cosmetics, supplements, jewelry, beverages, utilities, orthopedics, book, sports, technology, decoration, pet, printing, and flowers' sectors, it was noticed that consumers still do not have the possibility to personalize their products neither to request immediate deliveries or choose an exact delivery time.
Nowadays, the Industry is striving to allow consumers to buy the product they want, as they wish, and be delivered in the time and place they choose. The purchase personalization and the supply chain's arrangement to attend to the demand are expected to be increasingly based on predictive analytics. Prediction shall guide the definition of the supply chain. Moreover, the collaboration between stakeholders through an open marketplace is required to fulfill clients' needs and desires. Given the observed facts and empirical evidence, this paper highlights the importance of integrating manufacturing and delivery, supported by an Hourglass shared economy prediction-oriented supply chain model.

Keywords
Smart Manufacturing, Hourglass Model, Industry 4.0, Supply Chain, and Smart Cities.

1. Introduction
Information and Communication Technologies (ICTs) are increasingly present in our daily life. The line which separates the real from the virtual worlds is fading up. The new industrial revolution emerged to find the right balance between large-scale manufacturing and demand diversification with increase customization of a wide range of products under an unprecedented competitive and challenging market (Y. Wang et al. 2017).

Clients' requirements have increased in terms of personalization and complexity. The global competitive environment increases the market's volatility and trends, presenting enormous challenges for the Industry to follow it and deal with shorter product life cycles (Hofmann and Rüsch 2017).
The uncertainties with costs and available resources have accelerated the move to agile, high-performance, and sustainable manufacturing (Shin, Woo, and Rachuri 2014).
The manufacturing industry urges to integrate all the processes to meet consumer demands, market changes, and production uncertainties (Anand and Ward 2004; Lu and Ju 2017) within a short period without compromising product's quality (Paritala, Manchikatla, and Yarlagadda 2017).
Planning and scheduling can be fully integrated with operations with coordination and optimization models across the value chain (Kang et al. 2016). Moreover, a data-driven revolution will transform traditional manufacturing facilities smart enough to support real-time, accurate, and timely decision-making (Peter O'Donovan et al. 2015).
To evidentiate the existing inefficiency on the market and the fact that delivery is still arranged separately from manufacturing and order's management, a case study in the Portuguese context is highlighted in this paper.
Based on the Smart Manufacturing revision of literature and empirical evidence, this paper enunciates the importance of integrating manufacturing and delivery and proposes an Hourglass model to define the supply chain's new paradigm guidelines.

2. Smart Manufacturing Literature Review

Compared with prior industrial revolutions, Industry 4.0 or Smart Manufacturing's primary goal is not to replace the existing manufacturing assets but to ensure interoperability and interconnectivity among players using ICTs and standards (Trappey et al. 2017).
Manufacturing has passed through many advanced paradigms (Lean, Agile, Green, and Sustainable) with a typical lack of linkage of physical and virtual objects through a dynamic infrastructure network, lack of interoperability and data management, and analytics to perform in-depth analysis (Ren et al. 2019).
Over the past century, there was a shift from the Ford Assembly Line to the Toyota Production System, Flexible Manufacturing, Reconfigurable Manufacturing, Agent-Based Manufacturing, and now the Cloud Manufacturing (Putnik et al. 2013; Y. Tina Lee, Senthilkumaran Kumaraguru, Sanjay Jain, Stefanie Robinson and Helua, Qais Y. Hatim, Sudarsan Rachuri, David Dornfeld, Christopher J. Saldana 2017).
The Internet of Things (IoT) is gaining momentum and leading manufacturing to focus on integrating physical assets with cyberspace to form cyber-physical systems (CPS). These advancements enable collecting and processing data at all stages (J. Wang et al. 2018) through processes' virtualization (Bag et al. 2018).
Smart manufacturing emerged due to the disturbances in operation caused by the fact that there was no real-time analysis of the dynamic changes and real-time production performance. Therefore, an occurrence could affect and spread gradually throughout the entire value chain. With the new technologies, the manufacturing process can be monitored in real-time. The obtained data mined to perform continuously improved diagnosis and executions (Zhang et al. 2016).
Smart Manufacturing also aims to improve product quality, systems productivity, and sustainability while reducing production costs. The six pillars are manufacturing technology and processes, materials, data, predictive engineering, sustainability, resource sharing, and networking (Kusiak 2018).
The comprehensive definitions available underlie the use of advanced data analytics and ICT to improve operations over the supply network (shop floor, factory, supply chain, and life cycle). The three main objectives are plantwide optimization, sustainable production, and agile supply chains. Smart Manufacturing can generate the optimal value stream and new business models based on better predictive maintenance, robustness in product design, and adaptive logistics (Thoben, Wiesner, and Wuest 2017).
Traditionally, manufacturing was seen as just an in-line process or sequence where raw materials were turned into goods. It was challenging to monitor and predict manufacturing processes due to the lack of ICT supporting the supply chain. Business is becoming demand-dynamic with the need for real-time integrated computational, engagement, and involvement of the different stakeholders and workforce, and demand-driven supply chain processes (Davis et al. 2012). Traditional distribution and supply chains are not capable of dealing with the future development in production. It is needed to be highly flexible to provide robust customization of products and tailor the products for specific clients (Schlingensiepen et al. 2016).
Today manufacturing is seen as a set of practices that use ICT to govern operations, control production, and plan every step of the supply chain (Mittal et al. 2019).
Therefore, traditional techniques are no longer applicable. They were too time consuming and relied on the knowledge and experience of engineers for problem-solving. Because of consumer demand, production is becoming more

involved in tasks and constraints and operating performance uncertainty. There is a need for accurate prediction and processing methods capable of responding in a shorter time, controlling every detail of the operation to identify faults, defects, and abnormal occurrences (Y. Cheng et al. 2018).
As it happens with Smart Cities, the secret is once again on data. Advanced data analytics to improve system performance and decision-making are the ground basis of Smart Manufacturing (J. Wang et al. 2018). Nowadays, there is a need to handle vast amounts of data with high volume, velocity, and variety from multiple sources. Product quality inspection, fault diagnosis, and defect prognosis need Deep Learning advanced analytics to detect emerging problems early (Wen et al. 2018).
Equipment maintenance can represent a total of 30% of the operational cost. The constant machinery diagnosis for prevention is essential to promote machine uptime (P. O'Donovan et al. 2015).
Deep learning techniques play a vital role in the automation of learning, pattern identification, and decision making. Its benefits can be explained by reducing operational costs, facing consumer demand changes, increasing productivity, and reducing downtime. Cloud computing and big data analysis allow identifying the bottlenecks of manufacturing processes, realizing the causes, and finding solutions (Qi and Tao 2018).
Data analytics can have different levels: descriptive (to summarize what happens), diagnostic (to examine the problem's cause), predictive (prediction based on statistical models), and prescriptive (recommendation of action courses) (J. Wang et al. 2018). The mining of structured and semi-structured data from every source of the product's life cycle fuels the final applications (Tao et al. 2018).
Because the handling of high volumes of data urges the need for big data analytics (machine learning and predictive analytics), enabling timely and accurate insights to help decision making (Shin, Woo, and Rachuri 2014). New technologies such as robotics, hybrid processes, laser, and net-shape manufacturing will emerge and different forms and modes of transportation for the distribution channels and supply chain (Kusiak 2018).

3. Empirical Study

Industry moves towards a reality where it will be possible for the consumer to control all the decision phases in the supply chain process.
A case study was performed to get a more in-depth insight about the local Portuguese reality to evidence the existing gap. This research method examines complex phenomenon and intensively studies something with the goal of generalize it to a broader perspective (Gustafsson 2017).
This empirical study intended to analyze, in the Portuguese context, the brands' capacity to provide an end-to-end personalized service, from the definition of requirements to delivery to the client. Companies from the fashion, cosmetics, supplements, jewelry, beverages, utilities, orthopedics, book, sports, technology, decoration, pet, printing and flowers' sectors were considered. The search engine was Google. The results were obtained from the combination of the keywords "E-commerce"; "Companies" and "Portugal".
Data was taken from each entity's websites and analyzed later. Four different criteria were defined to standardize the comparison between the entities. Therefore, it was intended to study whether each entity allowed the client to:

C1: Change aspects of the product with personalized requirements – "Yes"/"No"
C2: Choose the exact time of delivery – "Yes"/"No"

The third and fourth criteria aimed to collect the sample's delivery data to understand how far the brands are from the ultimate personalization:

D1: Delivery time within the country – "Number of Days"
D2: The delivery is performed by a third-party service provider – "Yes"/"No"

From the initial 118 companies, only 74 were considered on the final sample due to insufficient available data. The results are detailed in Table 1.

Table 1. Case study

Company	Sector	C1	C2	D1	D2
1	Groceries	No	No	1 – 2	Yes
2	Groceries	No	No	1 – 3	Yes
3	Beverages	No	No	1 – 4	Yes
4	Supplements	No	No	1	Yes
5	Beverages	No	No	1 – 5	Yes
6	Pet	Yes	No	1 – 2	Yes
7	Pet	No	No*	0 – 5	No
8	Cosmetics	Yes	No	1 – 3	Yes
9	Cosmetics	No	No	1 – 2	Yes
10	Cosmetics	No	No	1 – 2	Yes
11	Orthopedics	No	No	2 – 4	Yes
12	Cosmetics	No	No	1 – 3	Yes
13	Cosmetics	No	No	1	Yes
14	Cosmetics	No	No	1 – 2	Yes
15	Ceramics	No	No	3 – 4	Yes
16	Utilities	No	No	2 – 5	Yes
17	Utilities	No	No	1 – 3	Yes
18	Technology	No	No	4 – 5	Yes
19	Technology	No	No	1 – 2	Yes
20	Technology	No	No	1 – 7	Yes
21	Sports	No	No	2 – 5	Yes
22	Printing	Yes	No	2 – 8	Yes
23	Gaming	No	No	1 – 3	Yes
24	Gaming	No	No	3 – 5	Yes
25	Books	No	No	1 – 2	Yes
26	Fashion	No	No	1 – 2	Yes
27	Sports	No	No	1 – 3	Yes
28	Fashion	No	No	1 – 4	Yes
29	Fashion	No	No	2 – 3	Yes
30	Fashion	No	No	1 – 3	Yes
31	Fashion	No	No	2 – 3	Yes
32	Fashion	No	No	3 – 5	Yes
33	Fashion	No	No	3 – 5	Yes
34	Fashion	No	No	1 – 5	Yes
35	Fashion	No	No	1 – 4	Yes
36	Fashion	No	No*	2 – 5	Yes
37	Fashion	No	No	2– 3	Yes
38	Fashion	No	No	3 – 7	Yes
39	Fashion	No	No	1 – 5	Yes
40	Fashion	No	No	1 – 5	Yes
41	Fashion	No	No	1 – 2	Yes
42	Fashion	No	No	1 – 2	Yes
43	Fashion	No	No	1 – 5	Yes
44	Fashion	No	No	3 – 5	Yes
45	Fashion	No	No	1 – 2	Yes
46	Fashion	No	No	2 – 3	Yes
47	Fashion	No	No	2 – 3	Yes
48	Fashion	No	No	1 – 5	Yes
49	Fashion	No	No	1 – 2	Yes
50	Jewelry	No	No	2 – 5	Yes
51	Jewelry	No	No	3 – 5	Yes
52	Fashion	Yes	No	30	Yes
53	Fashion	No	No	2 – 5	Yes
54	Fashion	No	No	1	Yes
55	Fashion	No	No	1 – 2	Yes
56	Fashion	No	No	1 – 5	Yes
57	Technology	No	No	1 – 5	Yes
58	Flowers	Yes	No*	1 – 2	No
59	Fashion	No	No	1 – 3	Yes
60	Fashion	No	No	2 – 3	Yes
61	Fashion	No	No	2 – 7	Yes
62	Fashion	No	No	3 – 7	Yes
63	Fashion	No	No	1 – 4	Yes
64	Fashion	No	No	2 – 4	Yes
65	Fashion	No	No	2 – 4	Yes
66	Fashion	No	No	4 – 5	Yes
67	Fashion	No	No	3 – 5	Yes
68	Mall	No	Yes	0 – 5	No
69	Cosmetics	No	No	2 – 5	Yes
70	Cosmetics	No	No	1 – 3	Yes
71	Fashion	No	No	2 – 5	Yes
72	Fashion	No	No	1 – 3	Yes
73	Fashion	No	No	2 – 4	Yes
74	Fashion	No	No	1 – 7	Yes

* It is allowed the choice of the day and time range period for delivery within a nearby confined small region.

Through the analysis of Table 1, it is possible to confirm the gap previously mentioned in this paper. There is still a general shortage in the possibility of the client purchasing a personalized product with the desired requirements and with a convenient delivery service. Only 5 of the 74 companies allow product's personalization. However, just 1 allows the choice of the exact time for the delivery, recurring to its delivery resources.

Company number 52 can be seen as an outlier of this sample. Personalizing its product only allows a delivery after 30 days. Companies 7 and 68 allow same-day delivery. However, they use their means to perform it. On the other hand, only company 68 allows the consumer to choose the exact delivery time.

Many companies that allow the delivery in one or two days require the purchase to be made by a specific time in the previous day and charge an extra fee.

Additionally, all companies safeguard immediate delivery with the existing stock. It would be necessary to integrate stock management and delivery to know it in real-time.

They also warn that after the delivery carrier's first attempt, the delivery will be left at the nearest pickup point.

4. The Hourglass Model

Industry 3.0, in the 1980s, was known as Mass Customization Production because of consumers' demand for a wider extensive variety of products.

Mass customization can be resumed in 3 ways: Make-to-stock, where the product is manufactured uniformly, and then the user-customized as he wants; Assemble-to-order, a combination of has been the modules produced with the client's request; Make-to-order, production only starts after the client's order.

However, mass customization presents limitations as: (1) the fact that the consumers do not participate in the design phase; (2) the potential combinations are usually made by designers and (3) the concept is not necessary to satisfy individual interests (Y. Wang et al. 2017).

The consumers' ongoing desire to participate in the design phase upgraded it to a personalized production model (Bortolini et al. 2017). The flexible manufacturing of mass customization products in small series (up to one sample) (Prause 2016) emerged to respond to the preferences of individual users (Hozdić 2015). Industry 4.0 and related technologies will enable personalization with shorter cycle-times and lower costs (Y. Wang et al. 2017). Fulfill consumer desires at a lower price will always be the ultimate goal (Karaköse and Yetiş 2017). Therefore, personalized products are increasing at the same time as personalized added value services.

The evolution of ICTs and the IoT and Cloud-Computing's growing role turns simple production into automated global value chains. It connects the different stakeholders (manufacturers, suppliers, and clients) (Safiullin, Krasnyuk, and Kapelyuk 2019), in a service-based model. Three dimensions are outlined in the Industry 4.0 paradigm: (1) cross-company horizontal integration throughout the value chain; (2) end-to-end engineering with intelligent cross-linking and digitalization from the raw material until the product's end of life; (3) vertical integration of the departments with associated value chain activities (Stock and Seliger 2016; Zhou, Liu, and Zhou 2016).

The future lies in digitization and automation, requiring minimal manual interventions (Monostori 2014).

The decentralization of operations will permit facing unforeseen changing conditions. The integration of the horizontal and vertical axes across stakeholders of the entire value chain at all organizational levels will achieve manufacturing efficiency (Erol et al. 2016). The product will control production (Nick, Pongrácz, and Radács 2018).

Industry 4.0 is characterized by the fusion of physical and virtual worlds (Kagermann, Wahlster, and Helbig 2013). This fusion is demonstrated in Figure 1, where the product's journey is showcased. The consumer's footprint will confirm the exact moment the product needs to be available, identifying if it is needed to manufacture or if there is a stock of it. When the client actually purchases the product, it is available to be delivered. Depending on the delivery requirements, it can be immediate or need the combination of multiple transport and storage assets.

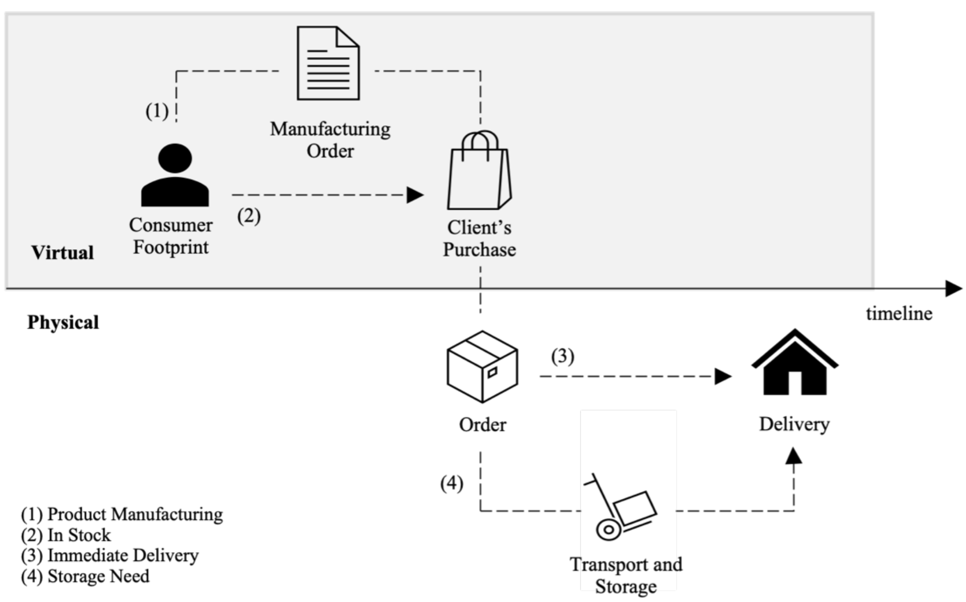

Figure 1. Product's Journey

The cyber layer is responsible for commanding machines at the physical layer according to the orders and their prediction. The Digital Twin is a virtual counterpart used to simulate real-time synchronizations of the field's sense-data (Negri, Fumagalli, and Macchi 2017). The creation of virtual models of the physical objects permits the simulation of their behavior to optimize the entire chain by continuously evaluating the scenarios considering the combinations of possible perturbations in the system. Instead of an in-line process, the digital technology turns it into a cyclical process where the product is conceptually designed and passes through simulation and feasibility assessment. Its quality is inspected at every stage, as inventory and marketing are also taken into account (Paritala, Manchikatla, and Yarlagadda 2017).

Cyber Physical Systems (CPS), constituted by sensors and actuators at the physical layer, will enhance algorithms' creation from processing the collected data at the cyber layer (Karaköse and Yetiş 2017). It aims to plan, configure, optimize and schedule production, manage inventory and simulate decisions, synchronizing manufacturing processes between the physical and the cyberspace (J. Cheng et al. 2018), covering production and logistics in the supply chain (Lu and Ju 2017). CPS will enable the creation of Smart Factories with decentralized and autonomous control and organization (Hofmann and Rüsch 2017). Although there is no consistent definition (Hozdić 2015), Smart Factories can be comprehended as self-behaving factories in a human-free production environment (Oztemel and Gursev 2020).

On the other hand, to meet the demand, computational resources and the internet providing responsiveness to manufacturing systems are needed. At this co-creation stage, with the adaptation of manufacturing to the individual requirements in real-time, 3D printing will mean a new manufacturing paradigm with a promising strategy in the one-of-a-kind products possible. 3D printers with personalized manufacturing technology can be distributed throughout different locations and households. These can potentially change the manufacturing and supply chain industry, reducing interurban freight transport and warehouse storage needs (Chen, Pan, and Ouyang 2014; Taniguchi, Thompson, and Yamada 2016).

The goal is to provide the most comfortable experience to consumers, allowing them to buy whatever they want and have it at the place and time they choose. Empirically, it is possible to notice that marketing and sales have been becoming increasingly target and niche-oriented to improve client acquisition costs throughout the years. For a long time, companies have followed consumer' journey and targeted them according to their shopping choices. Today, there are technologies as "Smartlook" (Smartlook 2020) that allow companies to monitor and understand the consumer's digital journey.

While traditionally, the manufacturing order was given only after the client's purchase. In the future, purchases are expected to be instantaneous since there is a prediction of the client's choice and purchase time.

With the collected historical data, the purchase personalization and the supply chain's arrangement to attend to the demand are expected to be increasingly based on predictive analytics. It is expected that each consumer be associated with a footprint based on historical information. The prediction will be the first step before the definition of the entire chain. It is therefore said that the manufacturing order is given even before the consumer makes the purchase. The lead and delivery times will be shorter because of the possibility of optimizing the supply chain and bringing manufacturing closer to the delivery location, possibly already within the last-mile.

Additionally, each return shall correspond to a new delivery. When the client makes a return request, the driver who picks up the product to be returned delivers the new one (Figure 2).

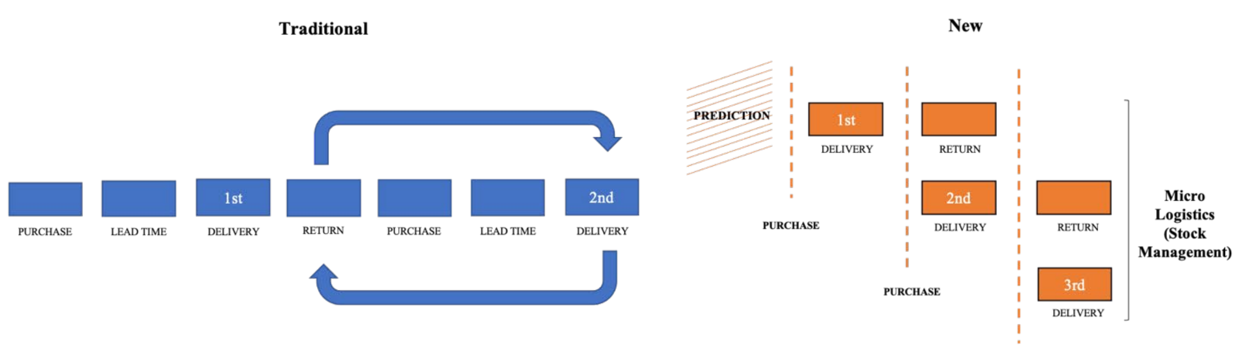

Figure 2. Traditional vs New

The differences between the traditional and the emergent model are described in Table 2.

Table 2. Comparison between the Traditional and the New models

	Traditional	New
Purchase	Limited to the existing items	Personalized, infinite solutions and combinations
Lead time	It depends on manufacturing agility	It depends mostly on prediction capacity and manufacturing location
Delivery	Rigid transportation and delivery options	At the chosen exact time and location
Return	Two steps additional delivery process	At the same time as the following delivery

This perspective moves from a reactive to a proactive approach. Moreover, the prediction is not just expected to be about the product's requirements but also about the delivery's convenience.
Pattern behaviors will be obtained, and companies will understand precisely what phase of their lives the consumers are, to target them with the right products and promotions.
Following the technological improvements, data will be the engine to perceive consumers' behaviors triggering the entire manufacturing process. The step where the client feels that he is buying something is a further step from the cyber layer's manufacturing order.
These premises are illustrated in Figure 3 as the shape of an Hourglass figure.

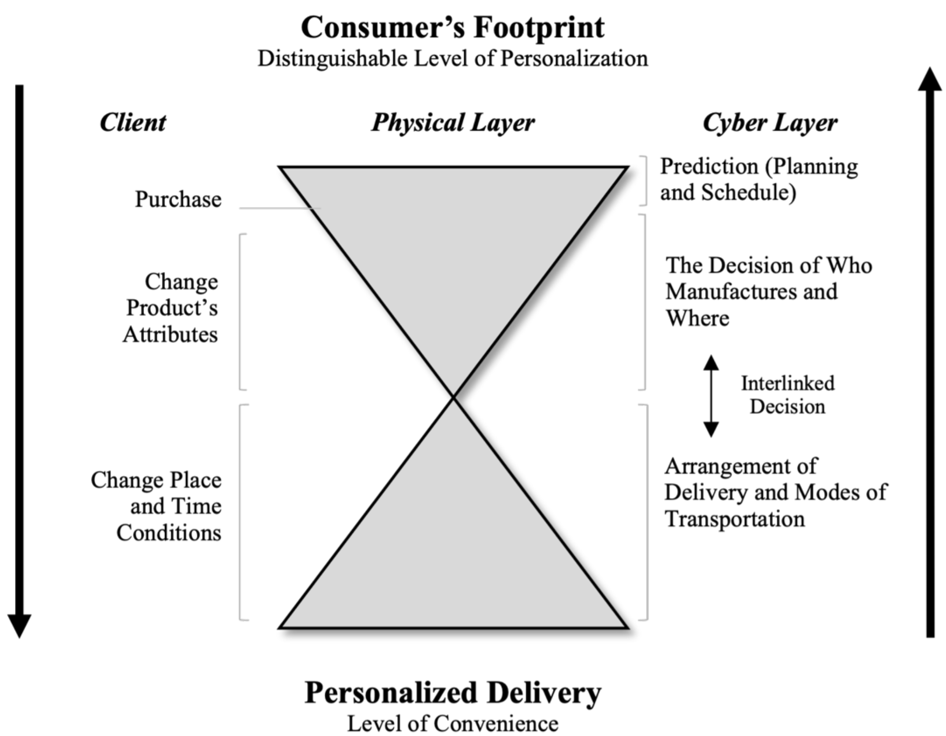

Figure 3. The Hourglass Model

Personalization can be found at the beginning and the end of the value chain. Each client's requirements will be different from each other, which will dictate the top of the chain. On the other hand, the ways of executing the individual delivery will dictate the bottom. In the middle is the transference of the goods from manufacturing to their transportation. The process is increasingly intended to be automated and standardized.

Delivery is expected to have an increasing preponderance in the entire process. The difficulty of making personalized deliveries, decreasing stock periods, and needs as possible makes the production timing increasingly aligned with the availability of resources to carry out transportation.
Manufacturing and logistics are linked. Moreover, the decision is at the same time top-down and bottom-up. Based on the purchase's prediction on the top, the supply chain is organized from the bottom. The fulfillment of the last-mile delivery step, a concept that emerged in the telecommunications industry to refer to the network's final leg (Xiao et al. 2017), will be the input to define the manufacturing timing.
The ultimate fulfillment of personalization will be made when the consumer has the chance to modify every aspect of the process in real-time. Because of that scenario, the capacity to adapt to the always-changing conditions is exceptionally complex. It is only possible due to the vertical integration between departments of the same company and horizontally, where physical assets and information details can be shared throughout the network (Figure 4).

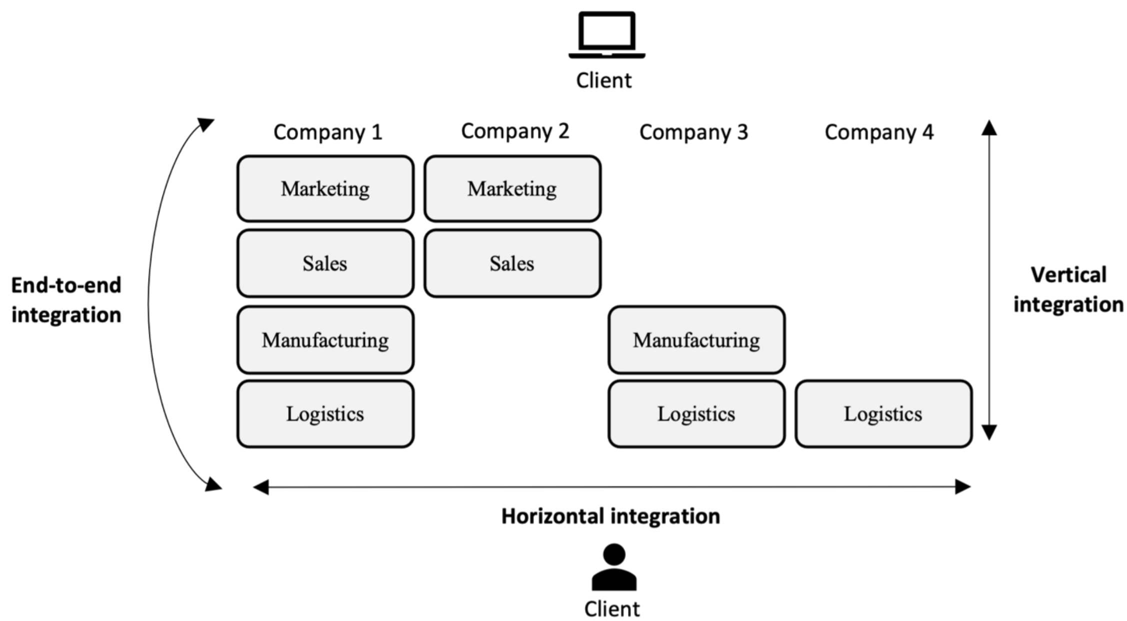

Figure 4. Industry 4.0 axes integration

The vertical integration allows better coordination among the different departments of the company. As previously mentioned, this coordination is expected to be made from logistics until the prediction of purchases based on data analytics.
Horizontal integration can be found at all stages. The knowledge about consumers can be shared, and the strategies to reach a specific target can be shared. Business models based on shared revenues will reinvent how the ecosystem interacts and how they are sold. The resource sharing in manufacturing and logistics will reduce operational costs and improve the competitiveness among the sectors.
With a resource share and flexible model, it is expected that proprietary operations may extinguish. Companies will focus on increasing the value of intangible aspects of their products and leave logistics or manufacturing to others. Alongside the evolution of Industry 4.0, shared business models are expected to grow, making the vertical and horizontal integration a diagonal integration.
The Industry is striving to a point where the process starts before the manufacturing order and may have the most diverse constraints. However, like when an Hourglass is turned upside down, the process keeps moving forward because there is no way to turn back as the client is waiting to the purchase delivery. People will increasingly want their purchases as soon as possible. Thus, the Hourglass way of thinking refers to the constant challenge of aligning the means for the necessary production and distribution, based on the sharing economy, to reach the goal of delivering as soon as it is possible.
After having the consumer's purchase time prevision, two options should be considered for manufacturing: 3D Printing and Smart Factory. The decision between the two options will be closely linked to the logistics component and the ability to satisfy the desired convenience level. According to manufacturing location, freight transportation may not

be necessary if production is made closer to the client. In this case, the delivery will focus mostly on the last-mile. Figure 5 shows several examples of each step.
The level of convenience can be summarized by the client's choice of the delivery option. That can range from the delivery at a desired place and time or the choice of a pickup point in the city to pick up the purchase.

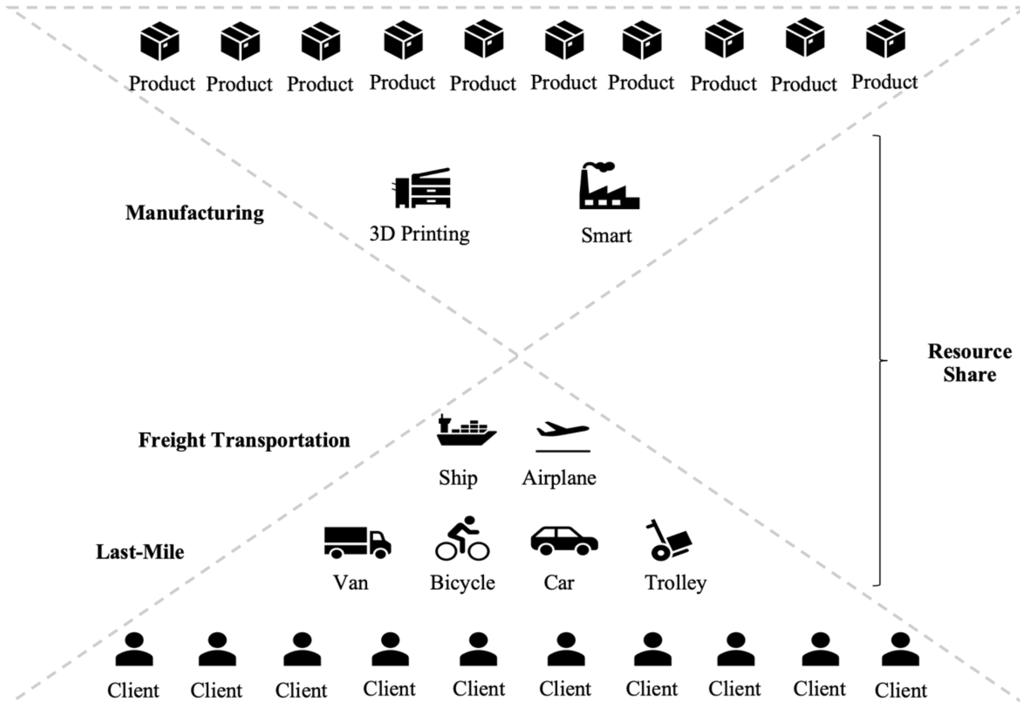

Figure 5. Physical Layer

5. Conclusion

From the study of 74 companies, it was possible to confirm that consumers still do not have the chance to purchase a personalized service in terms of product specifications and delivery convenience. The empirical study showed that only 5 of the 74 companies allow product's personalization. Only one allows the choice of the exact time for the delivery, using its delivery assets. Additionally, many companies that allow the delivery in 1 or 2 days require the purchase to be made by a specific time in the previous day and charge an extra amount.
Personalization is characterized by producing what the client wants (distinguishable level of product's personalization) and delivering it at the place and time he wants (level of convenience). The supply chain will increasingly be arranged from predictive analytics of the combination of consumers' behavior and the resources' availability to perform the delivery. The vertical, horizontal, and end-to-end integration will allow creating an open network where assets and resources are flexibly shared to provide more connection points throughout the globe to enhance the supply chain processes' interoperability. On the other hand, with a resource share and flexible model, it is expected that proprietary operations may extinguish. The decentralization of operations will permit facing unforeseen changing conditions.
Moreover, the Industry is striving to allow immediate deliveries. Real-time fulfillment will only be possible when manufacturing is transferred closed to the client, and the supply chain resumed to the last-mile. The distribution of 3D printers throughout different locations and households and the capacity to perform real-time deliveries, can potentially disrupt the Industry.
Nevertheless, there is a lack of standards definition for vertical and horizontal integration among the different departments of a company and between companies. One of the future biggest challenges will be to guarantee consumers' privacy and the freedom to buy what they want and not what companies force them to do. Additionally, it lacks a study of the role of the worker with the new paradigm. A future empirical study may support this paper's theoretical premises to validate how the last-mile can be fulfilled in practical terms.

Acknowledgement
This work was supported by Portuguese funds through the Institute of Electronics and Informatics Engineering of Aveiro (IEETA) and Foundation for Science and Technology, in the context of the project UIDB/00127/2020.

References
Anand, G., and P. T. Ward. 2004. "Fit, Flexibility and Performance in Manufacturing: Coping With Dynamic Environments." *Academy of Management Proceedings* 2004(1): 369–85.

Bag, Surajit, Arnesh Telukdarie, J. H.C. Pretorius, and Shivam Gupta. 2018. "Industry 4.0 and Supply Chain Sustainability: Framework and Future Research Directions." *Benchmarking*.

Bortolini, Marco et al. 2017. "Assembly System Design in the Industry 4.0 Era: A General Framework." *IFAC-PapersOnLine* 50(1): 5700–5705. https://doi.org/10.1016/j.ifacol.2017.08.1121.

Chen, Jing Elaine, Shan L. Pan, and Tao Hua Ouyang. 2014. "Routine Reconfiguration in Traditional Companies' e-Commerce Strategy Implementation: A Trajectory Perspective." *Information and Management* 51(2): 270–82. http://dx.doi.org/10.1016/j.im.2013.11.008.

Cheng, Jiangfeng, Weihai Chen, Fei Tao, and Chun Liang Lin. 2018. "Industrial IoT in 5G Environment towards Smart Manufacturing." *Journal of Industrial Information Integration* 10: 10–19.

Cheng, Ying et al. 2018. "Data and Knowledge Mining with Big Data towards Smart Production." *Journal of Industrial Information Integration* 9: 1–13. http://dx.doi.org/10.1016/j.jii.2017.08.001.

Davis, Jim et al. 2012. "Smart Manufacturing, Manufacturing Intelligence and Demand-Dynamic Performance." *Computers and Chemical Engineering* 47: 145–56. http://dx.doi.org/10.1016/j.compchemeng.2012.06.037.

Erol, Selim et al. 2016. "Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production." *Procedia CIRP* 54: 13–18. http://dx.doi.org/10.1016/j.procir.2016.03.162.

Gustafsson, Johanna. 2017. "Single Case Studies vs. Multiple Case Studies: A Comparative Study." *Academy of Business, Engineering and Science Halmstad University, Sweden*: 1–15. http://www.diva-portal.org/smash/record.jsf?pid=diva2:1064378%0Ahttp://www.diva-portal.org/smash/get/diva2:1064378/FULLTEXT01.pdf.

Hofmann, Erik, and Marco Rüsch. 2017. "Industry 4.0 and the Current Status as Well as Future Prospects on Logistics." *Computers in Industry* 89: 23–34. http://dx.doi.org/10.1016/j.compind.2017.04.002.

Hozdić, Elvis. 2015. "Smart Factory for Industry 4.0: A Review." *International Journal of Modern Manufacturing Technologies* 7(1): 28–35.

Kagermann, Henning, Wolfgang Wahlster, and Johannes Helbig. 2013. "Securing the Future of German Manufacturing Industry: Recommendations for Implementing the Strategic Initiative Industrie 4.0." *Final Report of the Industrie 4.0 Working Group* (April): 1–84.

Kang, Hyoung Seok et al. 2016. "Smart Manufacturing: Past Research, Present Findings, and Future Directions." *International Journal of Precision Engineering and Manufacturing - Green Technology* 3(1): 111–28.

Karaköse, Mehmet, and Hasan Yetiş. 2017. "A Cyberphysical System Based Mass-Customization Approach with Integration of Industry 4.0 and Smart City." *Wireless Communications and Mobile Computing*.

Kusiak, Andrew. 2018. "Smart Manufacturing." *International Journal of Production Research* 56(1–2): 508–17. https://doi.org/10.1080/00207543.2017.1351644.

Lu, Yan, and Feng Ju. 2017. "Smart Manufacturing Systems Based on Cyber-Physical Manufacturing Services (CPMS)." *IFAC-PapersOnLine* 50(1): 15883–89. https://doi.org/10.1016/j.ifacol.2017.08.2349.

Mittal, Sameer, Muztoba Ahmad Khan, David Romero, and Thorsten Wuest. 2019. "Smart Manufacturing: Characteristics, Technologies and Enabling Factors." *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 233(5): 1342–61.

Monostori, László. 2014. "Cyber-Physical Production Systems: Roots, Expectations and R&D Challenges." *Procedia CIRP* 17: 9–13. http://dx.doi.org/10.1016/j.procir.2014.03.115.

Negri, Elisa, Luca Fumagalli, and Marco Macchi. 2017. "A Review of the Roles of Digital Twin in CPS-Based Production Systems." *Procedia Manufacturing* 11(June): 939–48. http://dx.doi.org/10.1016/j.promfg.2017.07.198.

Nick, Gábor, Ferenc Pongrácz, and Edit Radács. 2018. "Interpretation of Disruptive Innovation in the Era of Smart Cities of the Fourth Industrial Revolution." *Deturope* 10(1): 53–70.

O'Donovan, P., K. Leahy, K. Bruton, and D. T.J. O'Sullivan. 2015. "An Industrial Big Data Pipeline for Data-Driven Analytics Maintenance Applications in Large-Scale Smart Manufacturing Facilities." *Journal of Big Data* 2(1): 1–26.

O'Donovan, Peter, Kevin Leahy, Ken Bruton, and Dominic T.J. O'Sullivan. 2015. "Big Data in Manufacturing: A

Systematic Mapping Study." *Journal of Big Data* 2(1). http://dx.doi.org/10.1186/s40537-015-0028-x.
Oztemel, Ercan, and Samet Gursev. 2020. "Literature Review of Industry 4.0 and Related Technologies." *Journal of Intelligent Manufacturing* 31(1): 127–82. https://doi.org/10.1007/s10845-018-1433-8.
Paritala, Phani Kumari, Shalini Manchikatla, and Prasad K.D.V. Yarlagadda. 2017. "Digital Manufacturing-Applications Past, Current, and Future Trends." *Procedia Engineering* 174: 982–91. http://dx.doi.org/10.1016/j.proeng.2017.01.250.
Prause, Gunnar. 2016. "Sustainable Business Models and Structures for Industry 4.0." *Journal of Security and Sustainable Issues* 2(December 2015).
Putnik, G. et al. 2013. "Scalability in Manufacturing Systems Design and Operation: State-of-the-Art and Future Developments Roadmap." *CIRP Annals - Manufacturing Technology* 62(2): 751–74. http://dx.doi.org/10.1016/j.cirp.2013.05.002.
Qi, Qinglin, and Fei Tao. 2018. "Digital Twin and Big Data Towards Smart Manufacturing and Industry 4.0: 360 Degree Comparison." *IEEE Access* 6: 3585–93.
Ren, Shan et al. 2019. "A Comprehensive Review of Big Data Analytics throughout Product Lifecycle to Support Sustainable Smart Manufacturing: A Framework, Challenges and Future Research Directions." *Journal of Cleaner Production* 210: 1343–65.
Safiullin, Anton, Lyudmila Krasnyuk, and Zoya Kapelyuk. 2019. "Integration of Industry 4.0 Technologies for 'Smart Cities' Development." *IOP Conference Series: Materials Science and Engineering* 497(1): 0–8.
Schlingensiepen, Jörn, Florin Nemtanu, Rashid Mehmood, and Lee McCluskey. 2016. 32 Studies in Systems, Decision and Control *Autonomic Transport Management Systems—Enabler for Smart Cities, Personalized Medicine, Participation and Industry Grid/Industry 4.0*.
Shin, Seung Jun, Jungyub Woo, and Sudarsan Rachuri. 2014. "Predictive Analytics Model for Power Consumption in Manufacturing." *Procedia CIRP* 15: 153–58. http://dx.doi.org/10.1016/j.procir.2014.06.036.
Smartlook. 2020. "Smartlook." https://www.smartlook.com/ (November 1, 2020).
Stock, T., and G. Seliger. 2016. "Opportunities of Sustainable Manufacturing in Industry 4.0." *Procedia CIRP* 40(Icc): 536–41.
Taniguchi, Eiichi, Russell G. Thompson, and Tadashi Yamada. 2016. "New Opportunities and Challenges for City Logistics." *Transportation Research Procedia* 12(June 2015): 5–13.
Tao, Fei, Qinglin Qi, Ang Liu, and Andrew Kusiak. 2018. "Data-Driven Smart Manufacturing." *Journal of Manufacturing Systems* 48: 157–69. http://dx.doi.org/10.1016/j.jmsy.2018.01.006.
Thoben, Klaus Dieter, Stefan Alexander Wiesner, and Thorsten Wuest. 2017. "'Industrie 4.0' and Smart Manufacturing-a Review of Research Issues and Application Examples." *International Journal of Automation Technology* 11(1): 4–16.
Trappey, Amy J.C. et al. 2017. "IoT Patent Roadmap for Smart Logistic Service Provision in the Context of Industry 4.0." *Journal of the Chinese Institute of Engineers, Transactions of the Chinese Institute of Engineers,Series A* 40(7): 593–602. http://doi.org/10.1080/02533839.2017.1362325.
Wang, Jinjiang et al. 2018. "Deep Learning for Smart Manufacturing: Methods and Applications." *Journal of Manufacturing Systems* 48: 144–56. http://dx.doi.org/10.1016/j.jmsy.2018.01.003.
Wang, Yi, Hai Shu Ma, Jing Hui Yang, and Ke Sheng Wang. 2017. "Industry 4.0: A Way from Mass Customization to Mass Personalization Production." *Advances in Manufacturing* 5(4): 311–20. https://doi.org/10.1007/s40436-017-0204-7.
Wen, Long, Xinyu Li, Liang Gao, and Yuyan Zhang. 2018. "A New Convolutional Neural Network-Based Data-Driven Fault Diagnosis Method." *IEEE Transactions on Industrial Electronics* 65(7): 5990–98.
Xiao, Zuopeng, James J. Wang, James Lenzer, and Yonghai Sun. 2017. "Understanding the Diversity of Final Delivery Solutions for Online Retailing: A Case of Shenzhen, China." *Transportation Research Procedia* 25: 985–98. http://dx.doi.org/10.1016/j.trpro.2017.05.473.
Y. Tina Lee, Senthilkumaran Kumaraguru, Sanjay Jain, Stefanie Robinson, Moneer, and And Soundar Kumara Helua, Qais Y. Hatim, Sudarsan Rachuri, David Dornfeld, Christopher J. Saldana. 2017. "A Classification Scheme for Smart Manufacturing Systems' Performance Metrics." 1(1): 52–74.
Zhang, Yingfeng, Wenbo Wang, Naiqi Wu, and Cheng Qian. 2016. "IoT-Enabled Real-Time Production Performance Analysis and Exception Diagnosis Model." *IEEE Transactions on Automation Science and Engineering* 13(3): 1318–32.
Zhou, Keliang, Taigang Liu, and Lifeng Zhou. 2016. "Industry 4.0: Towards Future Industrial Opportunities and Challenges." In *12th International Conference on Fuzzy Systems and Knowledge Discovery, FSKD*, , 2147–52.

Biographies

Diogo Mendes Correia is a PhD Candidate in the University of Aveiro. He holds a master's degree in engineering and Industrial Management. His research and scientific publications cover the areas of Smart Cities and Industry 4.0. He worked as Smart Cities Manager in a technological company, creating international consortia for the development of new products and spinoffs. In the meantime, he is an experienced entrepreneur and has created three companies always with top management responsibilities. Currently, he is mostly dedicated as Chief Operating Officer in LUGGit. Based on his knowledge in the areas of supply chain management and logistics, Diogo is responsible for LUGGit's operation. Presently, he is also a member of the research unit on Governance, Competitiveness and Public Policy (GOVCOPP) and the consortia director in the R&D project of LUGGit with the University of Aveiro named "SCALUM - Scalable, efficient and abstract luggage mobility infrastructure".

Leonor Teixeira graduated in Industrial Engineering and Management, received a MSc. degree in Information Management, and a PhD in Industrial Management, from the University of Aveiro, Portugal. She is currently an Associate Professor of the Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT) at the University of Aveiro. She is also a researcher (Integrated Member) at the Institute of Electronics and Telematics Engineering (IEETA) and collaborator at Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP) of University of Aveiro. Her current research interests include Industrial Management in general, and in Information Systems applied to Industry in particular. She has over 200 publications in peer-reviewed journals, book chapters and proceedings, and has several communications at international scientific conferences, some of which as invited speaker. She serves as a member of Program Board and Organizing Committees for several Scientific Committees of International Conferences and has collaborated as reviewer with several journals. She is associated member of IIIS, IEEE Society and APSI/PTAIS.

João Lourenço Marques is assistant professor at the Department of Social, Political and Territorial Sciences of the University of Aveiro, lecturing courses in the areas of Urban and Regional Planning (quantitative methods and techniques to support decision making). He received his PhD degree in Social Sciences from the University of Aveiro (European PhD) by the same university. Currently he is integrated member of the Research Unit in Governance, Competitiveness and Public Policies, coordinating the Research Group of Systems for Decision Support. He has been conducting and coordinating several research and projects in the fields of strategic spatial planning, decision support systems, spatial competitiveness analysis, demographic dynamics and forecast, econometric and economic models for regional development.