




Article

Design Product-Service Systems by Using a Hybrid Approach: The Fashion Renting Business Model

Virginia Fani ^{1,*}, Fabiana Pirola ², Bianca Bindi ¹, Romeo Bandinelli ¹ and Giuditta Pezzotta ²

¹ Department of Industrial Engineering, University of Florence, Viale Morgagni, 40/44, 50134 Florence, FI, Italy; bianca.bindi@unifi.it (B.B.); romeo.bandinelli@unifi.it (R.B.)

² Department of Management, Information and Production Engineering, University of Bergamo, Viale Marconi, 5, 24044 Dalmine, BG, Italy; fabiana.pirola@unibg.it (F.P.); giuditta.pezzotta@unibg.it (G.P.)

* Correspondence: virginia.fani@unifi.it

Abstract: As is known, sustainability issues represent one of the main challenges companies have to face. Among all, the fashion industry is considered one of the most impactful, both in terms of resource utilization and pollution. Fashion renting is a recent business model for companies to reduce their environmental footprint, following a circular economy approach. The study aims to develop and discuss the proposed hybrid approach to effectively support fashion companies in designing new business models, taking into account both the customer and the company perspective. On the one hand, agent-based modeling (ABM) allow us to represent customers' behaviour and interaction. On the other hand, discrete event simulation (DES) paradigm is used to model fashion renting processes. Because customers' attitude to that service reflects its successful implementation, motivators and barriers have been investigated to be included in the model. The practical implication is defining a model to support fashion companies in designing rental business models before implementing them. From a theoretical point of view, it overcomes the literature gap about the definition of a unique model for fashion renting, including processes, customers and interactions between agents. Follow-up research will include the presentation of simulation results.

Keywords: product service systems; circular economy; fashion; renting; agent-based modeling; discrete event simulation; decision making



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1. Introduction

Nowadays, sustainability represents one of the main challenges companies face, as confirmed by the increased attention paid by public opinion. The fashion industry represents one of the main sectors in terms of turnover and employment [1] and its environmental impact [2,3]. Fashion renting is a recent business model where customers will not buy an item but use it for a specific rental period. Rental extends the product lifecycle facing the trend, typical of the fashion industry, where people grow bored of something or simply follow an impulse purchase to “newness”. Indeed, a specific item will not be used only once and then dismissed, but it will be used even once by a person but rented several times by different people. In this perspective, the transformation of the business model from selling tangible products to new models based on the renting paradigm developed to emphasize the function of the product (i.e., *attention to fashion*) and the efficiency in its use (i.e., *to be sustainable*) promotes an increase in the value perceived by customers and reduces the impact of products on the environment. This concept, known as Product-Service System (PSS), represents a clear business model that companies can adopt to support their transition toward the circular economy.

According to this, fashion renting also belongs to the circular economy paradigm following the “reuse” purpose, moving away from the linear economy that considers only the “buy-use-dismiss” flow. From an overall perspective, fewer clothes or accessories have

to be produced, reducing the carbon, water, and waste footprint related to production processes. Embracing this circular economy paradigm while ensuring trendy items to customers, fashion renting reduces the fashion footprint and simultaneously guarantees the customers' status, as well as other new business models facing similar drivers and barriers such as the second-hand market [4].

Lang [5] confirmed that fashion renting increases its value, with North America covering 40% of the global market. Embracing the circular economy paradigm while ensuring trendy items to customers, fashion renting reduces the fashion footprint and simultaneously guarantees the customers' status.

Even if it is widespread in the USA market, the fashion renting phenomenon still represents an emerging business model in other countries, making fashion companies aware of the impacts of its implementation in terms of changes in their delivery processes. According to this, companies embracing this transition should be supported by tools able to design and assess the new delivery processes and the impact on the supply chain configurations before implementing them in a real context. In this perspective, the adoption of methodologies developed to design PSS could be adopted. Moreover, several contributions in the literature confirm that simulation could also be a possible solution, even in low-tech industries such as the fashion one [6–10]. To consider all the facets that characterize a PSS as fashion renting, the literature on PSS design underlines how it is necessary to use tools capable of analysing both the customer and the company aspects. In this perspective, a hybrid approach should be followed, combining both processes and customers' behaviour modeling through Discrete Event Simulation (DES) and Agent-Based Modeling (ABM), respectively. Hybrid modeling methodology has been used in the literature for integrating customers' behaviours to improve service operation management [11], but the only contribution related to the fashion renting business model does not analyse influences and interactions between customers [6].

Therefore, the paper aims to show how hybrid modeling can be used to effectively support fashion companies in designing new business models, such as fashion renting, before implementing them in a real context. In particular, the paper presents a hybrid model, based on the DES and ABM paradigms, developed using the software AnyLogic to examine the customers' potential behaviours along the downstream Fashion Supply Chain (FSC). The model is built upon a deep analysis of the main drivers and barriers to rental service, the influence of customer-to-customer interactions and the fashion business process.

Starting from this point, the paper is structured as follows: in Section 2, drivers and barriers to the fashion renting have been analysed to identify the parameters and emotional states to include in the developed model; Section 3 deals with the methods to design and simulate a PSS; Section 4 describes the hybrid model definition and development with AnyLogic®; in Section 5, a discussion on the adoption of a hybrid approach to fashion renting modeling is reported; Section 6 highlights some remarks and a conclusion.

2. Drivers and Barriers to Fashion Renting

Fashion renting is a business model that allows people to rent clothes, shoes, bags, and other accessories, whether high fashion or not, at an affordable price.

In the literature, several papers deal with the attitude towards the adoption of this business model, as well as with the barriers to fashion renting. In Table 1, the evidence from the literature contributions filtered by the last ten years are reported, classified according to the identified drivers and barriers, and listed from the most to the least cited.

Table 1. Drivers and barriers to fashion renting.

Driver/Barrier	Description	Reference	
Driver	Experience	Renting is an enjoyable experience	[5,12–19]
	Attention to fashion	Renting always allows fashionable items	[2,9,11–16]
	Sustainability	Renting is a sustainable business model	[5,12–19]
	Price	Renting makes luxury items affordable	[5,12,13,16,17,19]
	Attitude to rent	Renting is an accepted cross-industry attitude	[5,12,14,18,19]
Barrier	Psychological risk	Renting does not match customers' personal image	[5,12,15–17,19]
	Hygiene	Renting does not guarantee the item cleaning	[5,12,15,16,20]
	Performance risk	Renting does not always allow to try on items	[5,12,13,15]
	Financial risk	Renting is a waste of money for short-time ownership	[5,16–18]
	Item damage	Renting has hidden costs for damaged items	[16]

Starting from the drivers, *experience* emerges as the most important factor that leads customers to rent a garment rather than buy it. In Lang [5] and Becker-Leifhold [14], the fashion renting experience has been linked to the customers' perceived enjoyment to share items with others, while Lang et al. [15] add that renting enables customers to be focused on enjoying the usage of products without a heavy ownership burden. Experiential aspects are analysed in the literature even by Armstrong et al. [12], highlighting that fashion renting scenarios were perceived to provide more similar emotional experiences than shopping with less material consumption. Moreover, Lang et al. [13] and Mukendi and Henninger [16] state that experiential value also refers to the perceived value of trying on an outfit: customers undecided about a garment fitting may consider trying it on during the rental period, thus avoiding error in purchasing. McNeill and Venter [17] affirm that renting represents self-expression of individuality, giving more comprehensive chances to experiment with fashion items. It has been confirmed even by Mukendi and Henninger [16], who state that rental offers customers the opportunity to trial a more comprehensive range of styles and trends, allowing people to keep their social status. Becker-Leifhold [14] highlights that customers could positively evaluate their rental experience even in terms of ease of accessing the service. Even if the customers' personal experience during the service represents one of the main drivers, Lee and Huang [18] and Becker-Leifhold [14] also focus on others' experiences: for instance, customers are naturally influenced by external feedback, such as reviews and Word Of Mouth (WOM), especially from close friends or family. Lee and Chow [19] add that others' experiences highly influence customers' intentions to rent fashion items, especially for individuals who have never tried renting before. According to this, Lee and Huang [18] suggest that fashion rental companies carry out marketing strategies to encourage customers to share their experiences.

Another factor that positively affects fashion renting is the *attention to fashion*, which is treated in most revised scientific articles. As confirmed by Armstrong et al. [12] and Mukendi and Henninger [16], by renting clothes, customers can have an always-trendy wardrobe and continually change their look without purchasing fashion items only needed for a short time. Lee and Chow [19] state that economic advantages refer to affordable access to desirable fashion items and avoid risks and responsibilities associated with ownership. Lee and Huang [18] confirm that consumers sensitive to fashion trends perceive more advantages related to rental services, conferring customers a status symbol [14]. Even Lang [5] and Lang et al. [15] confirm that fashion renting is often perceived as an opportunity to access more options and new-to-the-user fashionable items. As McNeill and Venter [14] highlighted, this attitude seems to be more evident in millennials and females, who perceive remaining fashionable as a great motivator.

Sustainability is the third most important reason for consumers to rent. As Lee and Chow [19] stated, rented fashion items have perceived ecological benefits in reducing pollution and saving natural resources. Even Armstrong et al. [12] and Mukendi and Henninger [16] highlight that environmental benefits primarily contribute to a positive perception, for instance, in terms of extending use time and reusing, decreasing the need for early disposal and reducing material consumption. Lang et al. [15] and Lee and Huang [18]

add that attitude toward sustainable paradigms, like Collaborative Fashion Consumption (CFC), is positively associated with the intention of fashion renting. McNeill and Venter [17] even confirm that rental models solve the “wear once” phenomenon.

The same number of contributions could be found in the literature for *price* as a motivator, representing an important reason to rent, especially for millennials and zoomers due to their low economic resources. The economy has been stated as one of the main motivators for rental, even by Lang [5], making luxury items accessible to a broader range of customers without paying the full price. Both Lang et al. [15] and Lang et al. [13] confirm this result, while Armstrong et al. [12] add that the perceived clear economic benefits refer to reduce the overall clothing purchases. McNeill and Venter [17] state that limited finances are one of the more significant motivators, even more than sustainability issues. Mukendi and Henninger [16] affirm that customers mainly perceive cost savings for wear-once items, such as a wedding dress, and generally decide based on efficient use of personal resources. In addition, the results collected by Lang et al. [13] highlight that several rental companies offer free shipping, increasing the economic benefits of the service.

Finally, the customers’ generic *attitude to rent* any type of object leads them to adopt the fashion renting model. Being involved in fashion renting is a rational process based on the customers’ attitudes and personal perceptions about rental services in general [5] or specifically towards fashion renting [18,19]. As confirmed by Becker-Leifhold [14], the more positive the attitude to fashion rental, the more robust the willingness to experience the service. Armstrong et al. [12] even suggest that rental services best suit younger customers, representing experiential and innovative approaches.

Moving to barriers to the fashion renting business model adoption, the most discussed is the *psychological risk*. In Lang [5], it negatively impacts both customers’ attitudes toward and perceived enjoyment of fashion renting. It has been explained that fashion renting could not be aligned with customers’ self-image, making them unable to enjoy the service. Even if rentals offer consumers the opportunity to access new items at a low cost, ownership could represent a status symbol, as also confirmed by Armstrong et al. [12] and Mukendi and Henninger [16]. Lang et al. [15] affirm that self-image and social standing could be harmed by concerns about wearing rented instead of purchasing items. Even McNeill and Venter [17] highlight the issue of ownership about fashion as a strong perceived barrier that pushes consumers more toward fashion consumption models that include owning the items rather than rental ones. Lee and Chow [19] state that owning products could create a stronger attachment with the fashion item, while renting provides only temporary usage. As suggested by Lang [5], retailers might mitigate this risk by proposing a more sustainable and environmentally friendly lifestyle, overcoming the evidence that lack of ownership is considered the main obstacle to enjoying the fashion rental process.

The second negative as listed in the table is *hygiene*. In the fashion renting business model, the same items could be rented multiple times to different consumers. This issue is discussed in the literature to investigate how this aspect may affect consumers’ attitudes toward renting and their perceived enjoyment of the rental service. Lang [5] confirms that hygiene issues of rental items raise customers’ concerns, while Armstrong et al. [12] highlight the key role covered by the provider’s reputation, especially about the hygiene they guarantee, making the rental service successful for companies with a well-established brand image. Lang et al. [15] add that unclear maintenance and cleaning processes carried out by companies for rented items could increase customers’ concern about hygiene issues. According to this, Lang [5] and Armstrong et al. [12] state that providing a clear policy and description regarding return policies represents an important strategy for fashion rental retailers to keep in mind. As stated by Mukendi and Henninger [16] and Kim and Jin [20], customers show more concern when renting from another consumer rather than a company because renting from a business is perceived as safer than renting from individuals. Authors even state that the hygiene perception is strictly related to the type of item, making bags more acceptable to rent than garments and footwear.

Besides the previously described psychological risk, perceived *performance* and *financial risks* negatively affect both consumers' attitudes toward fashion rental and the perceived satisfaction of the service.

In Lang [5], concerns about the performance of rented items refer to the evidence that many rental retailers only provide online rental services, making customers unable to try items on before renting them. In addition, Lang et al. [15] state that customers could be concerned about the product performance and whether or not what they receive is worth what they pay. The lack of trust in providers highlighted by Armstrong et al. [12] even refers to quality issues, making customers skeptical about the perceived quality of rental items compared to purchased ones. Poor fit, wrong sizes and bad quality, as well as not meeting expectations, are the main complaints collected by Lang et al. [13] in terms of performance issues for online-rented items.

Financial risks are related to financial losses perceived for a purchase decision. As reported by Lang [5], although rental offers consumers a greater variety of new fashion items at a relatively lower cost than retail prices, some consumers may still feel that it is not worth simply a temporary usage of the product. For those consumers, paying for limited use of clothing or accessories may therefore be perceived as wasteful. McNeill and Venter [17] highlight how customers could perceive renting as a waste of money because they can own the fashion item by paying a little more. Mukendi and Henninger [16] state that rental is perceived as illogical for everyday clothing because it could be more expensive than purchasing. In addition, the authors highlight that customers could perceive rental services to try before purchasing as "double paying"—the first for renting and the second to own. Lee and Huang [15] stated that customers could also perceive fashion renting to be too expensive for their lifestyle because most of the garments and accessories included in the service belong to the luxury market.

Finally, also related to the economic area, another factor that negatively affects the attitude to rent items is related to the fear of *item damage* during the rental period, as reported by Mukendi and Henninger [16]. In particular, as confirmed by Lang [5], the risk of paying more than expected in case of damage moves toward a negative perception of the rental process. Therefore, retailers need to consider consumers' concerns about the potential financial loss in their marketing strategy. As suggested by Lang et al. [15], retailers should provide a clear policy regarding item damage to alleviate financial concerns.

3. Design and Validation of PSS Offering

The shift towards the fashion renting business model requires traditional manufacturing companies to integrate into their offer portfolio a PSS solution. Manufacturing companies encounter many difficulties in formulating a service-oriented value position [21,22]. These are related not only to the impact of external factors such as market norms or customer preferences but are mainly concerned with the definition of processes, methods and techniques required to support its design, engineering and assessing before implementing it. Designing and implementing solutions that simultaneously cover both tangible and intangible aspects are far from traditional manufacturing design processes and even more from the fashion industry. Indeed, designing and engineering a satisfactory and profitable PSS from provider and customer viewpoints is a complex task mainly due to the long and unpredictable lifecycle and the number of interactions among them [23]. Several contributions emphasize the importance of balancing the value perceived by customers with the service delivery processes' internal efficiency and productivity along with the design, engineering and assessing of the PSS [24–27].

To design and assess the service delivery process, some authors suggest adopting simulation paradigms because they enable us to compare the performance of alternative service delivery processes and identify the most suitable process and its best resource configuration.

To balance the customer and company perspective in this research, a hybrid simulation approach is proposed for the dynamic analysis of a company system under a specific behaviour of the fashion renting customer. In particular, as also suggested by

Rondini et al. [28], this paper proposes a combination of Agent-based Modeling (ABM) and Discrete Event Simulation (DES) to depict the customer behaviour and the activities performed by the customer and the company, respectively. In the following paragraph, an analysis of how simulation has been used in the context of PSS sustainable design is proposed.

Simulation Modeling in Sustainable PSS Design

Recently, many studies have adopted different simulation paradigms to design and re-engineer the delivery of product and service solutions. Paradigms such as System Dynamics (SD), Discrete Event Simulation (DES), and Agent-Based Modeling (ABM) have been used for different purposes. Lee et al. [29] show the application of SD to a product-service system through a triple bottom line approach, whereas in Lovric et al. [30], the authors try to put together economic, social, and environmental sustainability through a decision support system based on ABM to capture the heterogeneous customers' preferences better.

Other studies focused on customer and company satisfaction. Garetti et al. [31] focused on the possible application of lifecycle simulation to PSS, whereas Bianchi et al. [32] reported an application of SD to analyse the impact of PSS in a manufacturing company. SD is also used in Lee et al. [29] to analyse the functional performance of a PSS through a four-step procedure for measuring long term dynamics, while Legnani et al. [33] applied SD to assess the introduction of preventive maintenance on the performance of a company offering farm machinery and maintenance service. Tateyamai et al. [34] applied simulation modeling to assess PSS performance. This study, based on the use of scene transition nets, tries to measure the performance of a PSS, but it focuses only on customer satisfaction losing the value co-created in the relationship between company and customers. This approach has also been cited and expanded by Watanabe et al. [35] to evaluate the PSS from multiple stakeholder perspectives.

In addition, few interesting applications of ABM have been found in the literature. Maisenbacher et al. [36] proposed an application to evaluate the optimal number of bikes to use in an e-bike system, while Lagemann et al. [37] proposed the adoption of an ABM for the strategic planning of an Industrial PSS network and argued the adoption of simulation as a decision-support system. Wrasse et al. [38] applied ABM to model a network of solar home systems to assess the company service level, relying on the ability of ABM to implement decentralized models. Farsi and Erkoyuncu [39] propose an agent-based cost-benefit simulation model to demonstrate the applicability of service contracts. Weidmann et al. [40] proposed the use of DES for modeling PSS through three examples: result-oriented (laundry system), use-oriented (car and ride-sharing), and product-oriented PSS (market system). They show the potentialities of DES as a tool for supporting decisions in all three cases, although underlining how uncertainty is mainly given by the use of stochastic variables rather than by the active behaviour of entities. In the last years, few authors have analysed how to improve and optimize the product-service delivery processes since the design phase through the adoption of DES [41–43].

Hybrid simulation is the mixture of these three paradigms, and it is considered in the literature as a suitable method for the quantitative assessment of the service delivery process [28,44]. Specifically, hybrid simulation integrating ABM and DES could have high potential in gathering data about those processes with a strong interaction with the customer. Indeed, as deeply investigated by Rondini et al. [28], ABM and DES are complementary in supporting the design and engineering of a PSS solution; in fact, ABM can be used to model the individual customer behaviour while experiencing the fashion renting service while the delivery process (i.e., shop) and the related supply chain processes (i.e., warehouse, cleaning) can be described through DES. Using a hybrid approach allows us to integrate the customer's emotional states while moving through queues and activities and interacting within the fashion renting shop and, at the same time, designing the general process and supply-chain-related processes to balance the customer and the company values. The only contribution that includes hybrid simulation to design fashion renting

business model does not analyse interactions between customers [6], missing in covering the influence of others' experiences on customers' attitudes to renting.

The considerations mentioned above, in regard to the peculiarity of the PSS and the theoretical contribution analysed, suggest that a hybrid approach that integrates DES and ABM is suitable to design a new fashion renting service. In fact, it allows us to analyse in a digital environment the implication at the customer, company and supply chain level of the transition towards the new business model, supporting them in designing and modeling activities that include customers' behaviours along with the supply chain processes and the influence of customer-to-customer interactions.

4. Model Description

Starting from the described state of the art, this section details the proposed hybrid simulation model. It is composed of two different parts, one developed using the Agent-Based Modeling (ABM) to describe the customer behaviour through the persona model and the other including the process description modeled through the Discrete Event Simulation (DES) following a data-driven approach. How the ABM and DES models are linked has therefore been described. The hybrid model has been implemented using the software AnyLogic[®], a commercial tool able to support different simulation approaches, where the ABM model can natively interact with the DES one.

The fashion renting process modeled in the following sections can be represented as shown in Figure 1, realised starting from the blueprint presented by Fani et al. [6]. Once customers entered the store, they tried on and selected the item to rent, waiting for the shop assistant to check its availability in the store. If not available there, the assistant will check if the selected item is available in other stores. If it is not available, the customer can find a substitutive item to rent or they can leave the store. In the case of rental, customers pay and receive the service. Once the agreed period has ended, the customer returns the item to the store and leaves it. On the other hand, the returned item has to be evaluated to understand if it is available to be rented again or not: if not, they are discarded, otherwise repaired if needed and cleaned before being sent back to the store.

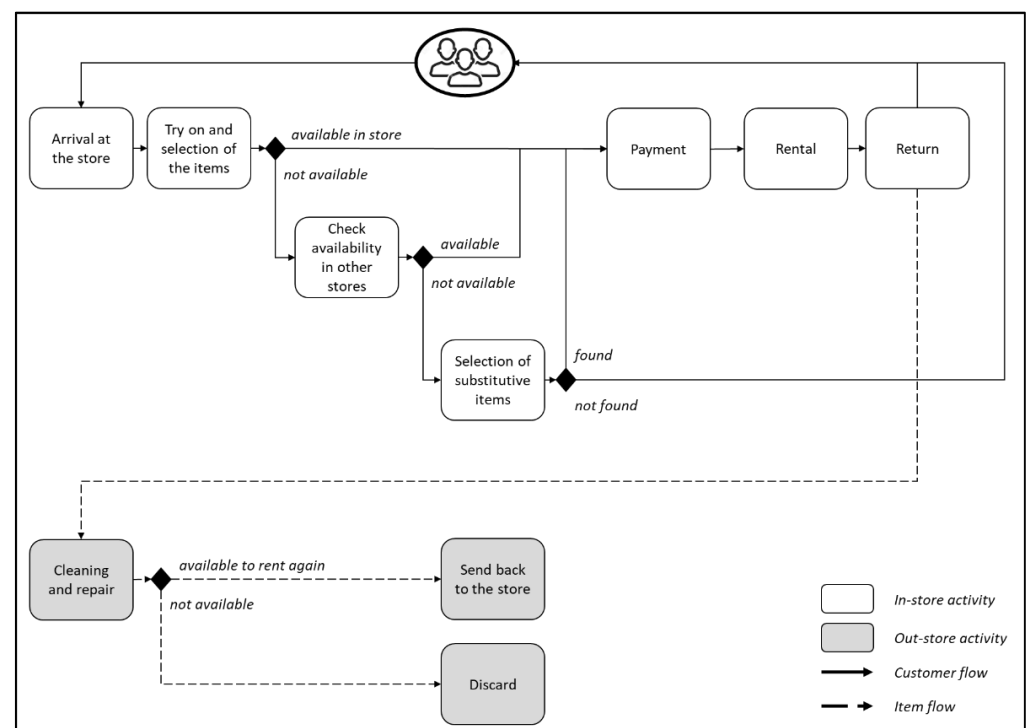


Figure 1. Fashion renting process.

4.1. ABM Model

This section describes the agent-based simulation model architecture, starting from the definition of the state chart. According to the process shown in Figure 1, the behavior of the modelled agent (i.e., the customer) has been described from its arrival at the store to the end of the rental service, after which the customer will decide to try the service again or not. As emerged from the literature, *experience* is the most important factor influencing customers' attitude to fashion renting. More in detail, both personal experience and others' feedback like reviews or Word of Mouth (WOM) impact the customers' willingness to use rental services, making it necessary to include two types of experience in the model: on the one hand, the experience proved by customers during the service; on the other hand, the overall experience, once the service has ended, that could influence potential customers that have never tried the rental service before. According to this, every agent included in the state chart is supposed to have different emotional states, divided into two groups. The first one is related to the experience during the service when the customer is in the store looking to rent an item (i.e., *Angry*, *Normal*, *Happy*, *Bothered*). The second one refers to the experience once the service ends when the customer leaves the store (i.e., *Satisfied*, *Unsatisfied*, *Indifferent*). Moreover, the agent model represented by the state chart has been used to define how the customer's emotional state may affect other customers, both within the store or once the service ends.

The persona model developed in AnyLogic® is shown in Figure 2.

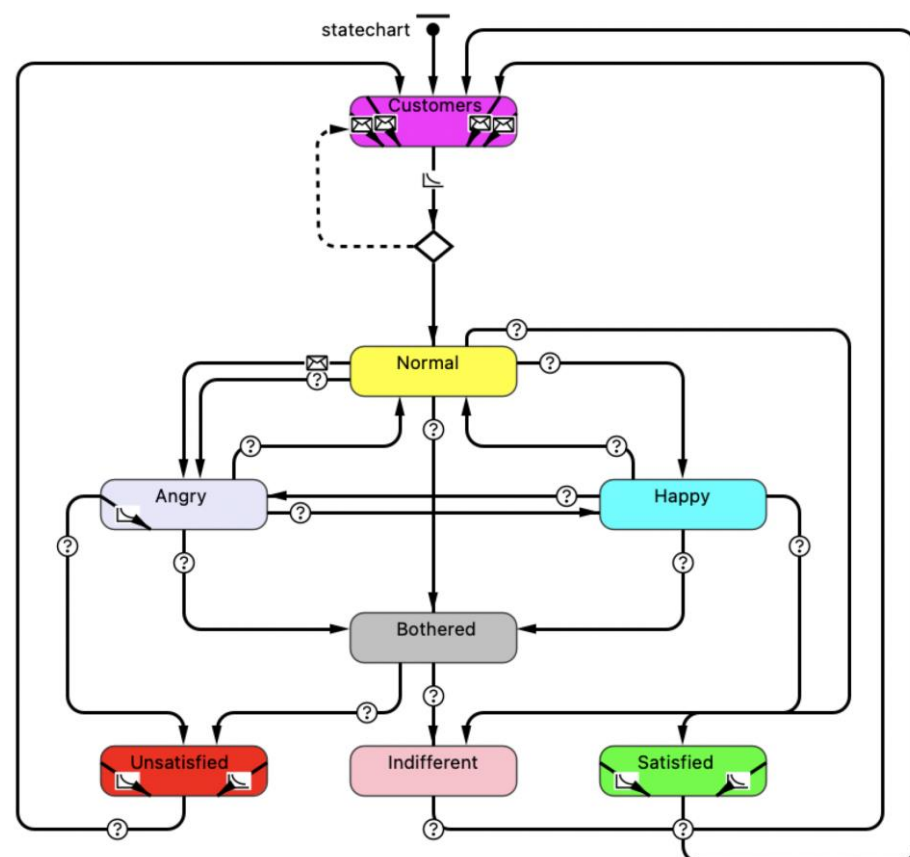


Figure 2. Customer statechart developed in AnyLogic®.

When the model starts, the population of potential customers is characterized by the *Customers* general state, as represented in the state chart. The *Rental_Interest* agent parameter defines customers' attitudes to the rental service according to a probability distribution. More in detail, the value of the *Rental_Interest* parameter at the model start-up reflects customers' attitude to the fashion renting based on personal motivators or barriers

far from the service experience itself, such as the attention to fashion, sustainability or price as well as the hygiene and psychological risks, as emerged from the literature. When *Rental_Interest* equals 1, it means that the customer is interested in trying the rental service, while 0 means that the agent does not intend to. Only agents with *Rental_Interest* parameter equal to 1 can enter the store to try the rental service, changing their state from *Customers* to *Normal*.

The perceived service level is traced with the *Star* agent parameter, which can increase or decrease during the rental experience, starting with the default value of 0. It will establish if the customers' experience during and at the end of the rental service is great or bad, pushing to them give positive or negative feedback, respectively.

Triggers on the DES model influence customer state that can move from *Normal* to *Angry* or *Happy* and from *Angry*, *Normal*, or *Happy* to *Bothered*. Agents in the *Angry* or *Bothered* states will decrease, with a different weight, the value of the *Star* parameter, while customers in the *Happy* state will increase it. According to the literature about the role of feedback and WOM, agents in the *Angry* state can also influence the other customers inside the store, particularly those with no previous rental experience (i.e., *Experience* parameter equals to 0), pushing them to leave the store and decreasing the value of their *Star* parameter.

Once customers rent an item, they could exit the store in the *Unsatisfied*, *Indifferent*, or *Satisfied* states, according to their experience (i.e., *Star* parameter lower, equals or higher than 0, respectively). In particular, customers in the *Angry* state will change in *Unsatisfied*, the *Normal* ones in *Indifferent*, the *Happy* ones in *Satisfied*, while the *Bothered* ones in *Unsatisfied* or *Indifferent* according to the value of the *Star* parameter. Customers who leave the store will then return to the initial *Customers* state according to the minimum time gap between two rental experiences as specified in the DES model.

According to the literature review, the attitude towards renting for agents in the *Customers* state can be influenced by reviews and WOM generated by customers who have left the store completing the rental only if they have not personally experienced the service (i.e., *Experience* parameter equals to 0). Only agents in the *Unsatisfied* or *Satisfied* states can give negative or positive reviews or WOM, respectively, according to a probability distribution that reflects the evidence that not all the customers share their experience with others (i.e., *Feedback* parameter equals to 1 or 0 if the customer give or not feedback, respectively). A probability distribution has also been defined to divide potential customers who are or are not influenced by external feedback (i.e., *WOM_Influence/Review_Influence* parameters equals to 1 or 0 if the customer is influenced or not by feedback, respectively). As shown in the literature [45–48], personal experience, WOM, and reviews have different weights in influencing positive and negative attitudes towards rental services. Previous experiences cover the first place: if a customer has already rented an item, he already has his opinion about the service and will not be influenced by external feedback. WOM comes second: if the rating of rental service has been received from a family member or friend, it will influence customers' attitude only if he has never tried the service. Finally, if a customer reads a review by someone they have never met before, it can positively or negatively influence the attitude towards rental service only if he has no direct experience and if WOM has not already convinced him. Reviews, therefore, have less power than WOM, which has less influence than experience. According to this, only agents in the *Customers* state, without experience in renting items and influenced by external feedback, can enter the store and try the rental service (i.e., their *Rental_Interest* parameter changes from 0 to 1) if they receive more positive than negative feedback.

The way potential customers can be influenced by external feedback is therefore resumed in Table 2: "Agent state" column refers to the agent leaving the store after rental service; "Agent parameters" column shows the parameters of potential customers that can be positively (i.e., "Attitude to rent" column equals to 1) or negatively (i.e., "Attitude to rent" column equals to 0) influenced by the leaving agent.

Table 2. Influence of external feedback on customers' attitude towards rental service.

Agent State	Agent Parameters	Attitude to Rent
<i>Satisfied</i>	(WOM_Influence = 1 AND Experience = 0) OR (WOM_Influence = 0 AND Review_influence = 1 AND Experience = 0)	1
<i>Unsatisfied</i>	(WOM_Influence = 1 AND Experience = 0) OR (WOM_Influence = 0 AND Review_influence = 1 AND Experience = 0)	0

4.2. DES Model

This section describes the DES part of the hybrid model, following the process shown in Figure 1. When the model starts, the population of potential customers is generated, having the *Customers* state as indicated by the persona model. As anticipated, the perceived service level is traced with the *Star* agent parameter that can be increased or decreased during the rental experience starting from the default value equal to 0. Once he enters the store (i.e., "Arrival at the store" in Figure 1), the first block for the agent is the queue where he waits for a shop assistant to be served. The first trigger that can change the agent state from *Normal* to *Angry* or *Happy* refers to the time customers spend in this queue: if the waiting time is higher or lower than the tolerance range, the agent state becomes *Angry* or *Happy*, respectively. In parallel, the *Star* parameter decreases or increases, with a different weight if the agent is influenced or not by the time spent in the queue (i.e., *Waiting_Influence* parameter equals to 1 or 0, respectively). The described trigger and parameter reflect the evidence that the emotive state of some customers and, consequently, the perceived service level are heavily influenced by the waiting time to be served, as suggested by Doniec et al. [49]. For instance, Table 3 shows how the *Star* value changes according to the waiting time and the *Waiting_Influence* parameter.

Table 3. Influence of waiting time on customers' perceived service level.

Waiting Time	Agent Parameters	Star Value
over waiting tolerance range	<i>Waiting_Influence</i> = 0	−1
over waiting tolerance range	<i>Waiting_Influence</i> = 1	−2
within waiting tolerance range	<i>Waiting_Influence</i> = 0	0
within waiting tolerance range	<i>Waiting_Influence</i> = 1	−0.5
under waiting tolerance range	<i>Waiting_Influence</i> = 0	+1
under waiting tolerance range	<i>Waiting_Influence</i> = 1	+2

Once the customer is served and selects the item to rent (i.e., "Try on and selection of the items" in Figure 1), the shop assistant has to check its availability in the store. If an item is available, customers influenced by the waiting time (i.e., *Waiting_Influence* parameter equals 1) will appreciate it because they can quickly complete the rental process. This is modeled by increasing the *Star* parameter more for influenced customers than for others.

On the other hand, if the selected item is unavailable, the shop assistant will check its availability in another store (i.e., "Check availability in other stores" in Figure 1). Similar to the time spent by an agent waiting for the shop assistant, a tolerance range has been defined for the time the customer waits to receive the item to rent from another store, and the increasing or decreasing value of the *Star* parameter has been equally managed. In this case, overcoming the tolerance range for waiting items from other stores represents a second trigger for the emotive state of the agent that changes from *Angry*, *Normal*, or *Happy* to *Bothered*. Customers in the *Bothered* state leave the store without renting.

The selected item could not be available, pushing the customer to evaluate alternative items to rent (i.e., "Selection of substitutive items" in Figure 1). The agent's choice is assigned according to a probability distribution: if the customer completes the rental, the *Star* parameter is slightly increased (i.e., +0.5); if not, the parameter decreases with

a different weight according to the value of the *Waiting_Influence* parameter (i.e., -1.5 if *Waiting_Influence* equals to 0, -2.5 if equals to 1) and the customer leaves the store without any item rented.

Customers who select the item to rent, both first or alternative, pay for service and start the rental period (i.e., “Payment” and “Rental” in Figure 1). Once it has ended, the customer returns the item (i.e., “Return” in Figure 1) and waits a predefined period before entering the potential customers’ population to reuse the rental service.

Finally, returned items are evaluated to understand if they could be rented again or not: if not, they are discarded, otherwise repaired if needed, and cleaned before being sent back to the store.

4.3. Links between ABM and DES Models

Once the persona model of the ABM and the blocks of the DES models have been defined, they are linked together. More in detail, transitions of customers’ states in ABM depend on triggers defined in the DES model. Customers enter the store according to the arrival rate defined in the DES model, changing in the ABM their state from *Customers* to *Normal*. Moreover, agents moving in the DES model increase or decrease the value of the *Star* parameter according to the perceived service level that changes across the modeled blocks. As previously described, changes in the value of the *Star* parameter influence the agents’ emotive state, and negative feedback can influence customer flow within the store. For instance, customers entering the store with the *Normal* state, as represented in the ABM statechart, can change to *Angry* or *Happy* according to the time spent in the DES queue block that models the waiting for the shop assistant, which consequently positively or negatively impacts the *Star* parameter value. Another example refers to agents in the *Angry* state that influence the customers inside the store with no previous rental experience, pushing them to leave the store and decreasing the value of their *Star* parameter. Similarly, a long waiting time could change the emotive state represented in the persona model into *Bothered*, which could push the agent itself to leave the store without renting (modelled in the DES). Finally, the emotive state of agents who complete the rental service could positively or negatively influence the attitude towards renting of the other potential customers: agents who leave the store with a *Satisfied* state can give positive reviews on the service, increasing the attitude of potential customers who never tried the rental service to try it (i.e., setting the *Rental_Interest* parameter equals to 1); on the other hand, negative feedback from agents leaving the store with an *Unsatisfied* state could discourage other potential customers from trying the service.

5. Discussion

The phenomenon of fashion renting is opposed to the widely established business model of fast fashion, ensuring a longer product lifecycle, reducing the consumption of raw materials, the pollution generated in the production and at the end-of-life phases, to promote environmental sustainability. Despite that, in fashion companies, there is no widespread knowledge and adoption of business models alternative to the classic transactional ones.

Because fashion renting can be considered under the PSS umbrella, PSS design principles and methodologies can be adopted to support fashion companies in designing and creating renting services concurrently, considering customers and company needs and processes at the same time. Indeed, introducing this new business model based on a sustainable service-oriented offering has many implications for both the customer and the company. Therefore, it is essential to propose an approach that can show companies the impact of redesigning their processes in a context where customers may have different attitudes and emotional states that can be influenced by their own experience during the renting process or by the experience of other customers.

To such scope, the fashion renting service delivery and supply chain processes have been investigated by adopting a hybrid approach based on the DES and ABM paradigms.

As reported in the literature, the integrated adoption of DES and ABM paradigms has allowed us to consider the customer and company perspectives concurrently [24,25,27]. Based on its characteristics and definition, the model developed with a hybrid approach allows us to design the fashion renting process, considering even subjective drivers related to the customer experience and emotional states. To this purpose, DES, thanks to the modelling of the main activities of the service, allows us to accurately (re)design the process in terms of actors and activities involved. For example, it allows us to modify back-office processes to include additional supply chain actors (e.g., delivering cleaning services or repairing clothes or accessories). On the other hand, the ABM component allows us to model the customer's interaction with the provider and to describe the customer's decision-making process considering their *attitude to rent*, the *performance* of the service in the store, their previous and current renting *experience* and the *experience* of other customers through word of mouth. Therefore, the focus of the modeling approach proposed in the paper is to be able to analyse the Fashion renting business process including the customers' behaviours both in-store (during the service) and once the rental experience has been concluded on the downstream supply chain. Thus, the significant benefit deriving from the adoption of such a hybrid model is given by the integration and the interaction of agents along the process, leading to a system behaviour that is not defined a priori, but resulting from the interaction of many individuals (i.e., customers and service providers), which is the main peculiarity of PSS and, in general, of all service environments.

Under this consideration, the integrated adoption of DES and ABM paradigms can be considered a proper decision-making approach for the manufacturing companies aiming at changing their business model from the sale to the rent of a fashion item because it allows them to model most of the drivers and barriers related to both company process and customer behaviour. For the knowledge of the authors, this model represents a step forward in the extant literature because the DES and ABM models available in the PSS literature are mainly focused on the analysis of objective process performance (e.g., costs, number of resources, spare parts availability) while, in few cases, only customer satisfaction has been considered as an additional measure of customer behaviour. Thus, the proposed approach shows that the combination of DES and ABM brings benefits compared to pure DES or ABM models because it becomes possible to have a process that reflects not only the flow of activities but also subjective reactions and interactions of customers. As reported in the literature, the customer in a PSS such as fashion renting is still little explored, and though the behaviour is complex to model, it is fundamental to integrate it in the design study because it allows us to have an overall vision of the solution to be implemented

Indeed, the adoption of a paradigm such as ABM integrated with DES, as in the model introduced in this paper, allows us to make more accurate analysis considering both objective and experience-based performance and to draw insights into how interactions among customers can change the customer's attitude toward the rental.

In particular, the customer's choice to use a fashion renting service based on subjective factors is easily represented in the hybrid model through the customer state charts. This would be much more complicated in the pure DES model, involving using several decision blocks to model a decision tree and preventing an in-depth study of the relationship and influence between customers in the system. More in general, all the possible situations in which the various types of customers can make multiple types of choices in the pure DES model must be planned and analysed manually, while in the hybrid model, they are the result of the interaction between the agents and the process.

Therefore, it becomes evident that the adoption of the hybrid paradigm is fundamental already in the design and engineering of a new and complex PSS such as the fashion renting, helping the decision makers to effectively understand what happens to all the levels of the system: customer, store and supply chain. Because manufacturing companies used to work in a transaction-based business model (i.e., selling the product), understanding in advance all the implications that a new business model can have on the supply chain represents a competitive advantage, avoiding time and cost waste. Last but not least, the adoption

of a decision-making approach based on a hybrid paradigm supports these companies to understand the implication not only on the internal processes but also on the customers' explicit and implicit needs.

6. Conclusions

The business of fashion renting is growing fast, together with the development of the acceptance of renting fashion items already used by unknown people. The idea of sustainability has been developed in all the industrial sectors jointly with the growth of an educational and cultural path for sustainability promoted by the governments. This has led to a source of innovation and creativity and the need for manufacturing companies to rethink their business model along their product lifecycle—from production to the sale and use and disposal.

Therefore, the purpose of the paper is to show how hybrid modeling can effectively support fashion companies in designing new business models and the related business process before implementing them in a real context. The main contribution of the proposed approach in the PSS arena refers to the evidence that the fashion renting business model is not widely studied in the literature, and its design requires a strong focus on customers' behaviour and influences among them that can be addressed following the hybrid approach we propose. This is why a deep description of the DES model, ABM model, and the way they influence each other represents the key value to effectively designing the fashion renting business model as one of the most popular new PSS for fashion companies.

From a practical point of view, the research clearly summarizes the main drivers and barriers to implementing a fashion renting business model. In fact, a concept such as circular economy represents a new direction in the fashion industry and represents a disruptive way to conceptualize the idea of ownership, and it is essential to have a clear understanding of the strengths and risks. In this perspective, the possibility of modeling the customer and the overall process—also considering the supply chain thanks to a hybrid approach that integrates DES and ABM paradigms—allows the manufacturing companies to understand the configuration of the operations and the implication of the customer's willingness to rent a fashion item. From an industrial perspective, indeed, the proposed hybrid approach supports companies in designing their fashion-renting model starting from mapped processes, customers' emotional behaviour and cross-influences. This allows companies to no longer focus in their modelling of the business process only on supply chain and delivery processes, but also on defining customer touch points and interactions with all stakeholders.

From a theoretical point of view, integrating DES and ABM paradigms has turned out to be the best approach to support the modeling of fashion renting PSS business models. It is essential to analyse the customer's behaviour and reactions because they are still not entirely known. From an academic perspective, the proposed hybrid approach to design a fashion renting business model is new, especially in terms of including influences among customers that have been highlighted as one of the main motivators to fashion renting. Moreover, this model can allow analysing of various customer behaviours or the evolution of the customer's behaviour related to the spread of new habits and the influence of endogenous situations (e.g., COVID).

The present research has different limitations, and further developments could be oriented in different directions. First, the proposed hybrid modeling approach has to be implemented in real contexts to present simulation results, in order to analyse improvement scenarios based on the definition of economic and environmental KPIs, such as lead time and transportation impacts. (e.g., How does the number of shopping assistants and/or the stock amount per store influence the number of rented items per period, considering the negative impact of waiting time due to unavailable assistants and/or item to rent? Which is the optimal value for the number of shopping assistants and/or stock amount per store according to the company's budget and supply chain constraints? Which is the renting supply chain configuration, for instance, in terms of delivery frequencies or number

and location of cleaning and repairing companies, warehouses and stores, to guarantee lower CO₂ emissions?). From this perspective, simulation will make it possible to clearly understand if the renting business model is more sustainable than the transactional one, as well as to identify the combination of inputs that mostly impact supply chain performances, giving a “from design to execution” decision-support tool to fashion companies. Due to the newness of renting business models applications in the fashion industry, the data collection needed to implement potential scenarios to be investigated through simulation represents the key challenge to reach. As second development, considering that the current work only considers one customer behaviour, the hybrid approach could be extended by considering different types of agents with different behaviour. Third, the present analysis is limited to the adoption of DES and ABM because it analyses the micro-level of the process, but it can be expanded to other paradigms such as system dynamic or lifecycle simulation.

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