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Author(s): Akhtar, Waleed Hassan; Watanabe, Chihiro; Tou, Yuji; Neittaanmäki, Pekka

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A New Perspective on the Textile and Apparel Industry in the Digital Transformation Era

Waleed Hassan Akhtar [1,*], Chihiro Watanabe [1,2], Yuji Tou [3] and Pekka Neittaanmäki [1]

[1] Faculty of Information Technology, University of Jyväskylä, 40014 Jyväskylä, Finland
[2] International Institute for Applied Systems Analysis (IIASA), 2361 Laxenburg, Austria
[3] Department of Industrial Engineering and Management, Tokyo Institute of Technology, Tokyo 152-8550, Japan
* Correspondence: waleed.akhtr@gmail.com

Abstract: The textile and apparel (fashion) industry has been influenced by developments in societal socio-cultural and economic structures. Due to a change in people's preferences from economic functionality to supra-functionality beyond economic value, the fashion industry is at the forefront of digitalization. The growing digitalization in the fashion industry corresponds to digital fashion, which can satisfy the rapid shift in consumers' preferences. This paper explores the evolving con-cept of innovations in digital fashion in the textile and apparel industry. Specifically, it centers on the evaluation of Amazon's digital fashion initiatives, which have made the platform the United States' top fashion retailer. An analysis of the business model of Amazon's digital fashion business showed that with the advancements in artificial intelligence (AI) powered by advanced Amazon Web Services (AWS), Amazon has introduced novel digital solutions for the fashion industry, such as advanced digital fashions (ADFs), on-demand manufacturing, neo-luxury, and, ultimately, cloud-based digital fashion platforms, that is, a supra-omnichannel, where all stakeholders are integrated, and their activities are visible in real time. This can be attributed to the learning orchestration externality strategy. This study concludes that with the advancement of digital innovations, Amazon has fused a self-propagating function that advances digital solutions. This study shows that Amazon is the largest R&D company. Its R&D process is based on users' knowledge gained by their participation through AWS-driven ICT tools. This promotes a culture of experimentation in the development of user-driven innovations. Such innovations have further advanced the functionality of AWS in data analysis and business solutions. This dynamism promotes the development of soft innovation resources and revenue streams. These endeavors are demonstrated in a model, and their reliability is validated through an empirical analysis focused on the emergence of ADF solutions. Therefore, based on an analysis of the development trajectories of Amazon's digital fashion technologies, such as ADFs, on-demand manufacturing, and neo-luxury, insightful suggestions and a framework for solutions beyond e-commerce are provided.

Keywords: Amazon; textile and apparel; fashion; advanced digital fashions; supra-omnichannel; non-contact society; beyond e-commerce

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1. Introduction

The textile and apparel (fashion) industry has social, cultural, and economic significance in many societies. Nevertheless, the word fashion has different meanings ranging from the way of doing things to textiles and apparel. Among others, Hansen's [1] study found that fashion implies discourses representing the developments in arts, social structure, and culture. In Western society, it is highly associated with "style", "dress", or "clothes" [2,3]. As these features make fashion a meaningful phenomenon, in this study, the fashion industry corresponds to fashion-driven textiles and apparel as well as other fashion-related products. It includes a wide range of business networks ranging from raw

materials production, design, manufacturing, and retail [4,5]. These advancements improve fashion, and apparel accelerates this development [6].

In response to shifting people's preferences towards suprafunctionality beyond economic value [7–10], and a prevalence of a non-contact society, the digital economy has accelerated the development of digital solutions that transform the traditional fashion industry [11–13].

In the digital economy, the traditional fashion industry is at the center of global dynamic change [11,12] driving its volatility, velocity, variety, complexity, and dynamism [14,15] which necessitate digital solutions.

The United States is one of the leaders in new technological innovations in the global fashion industry. For example, among technology giants (GAFAM), Amazon is a leader in digital services provision. Its heavy R&D investments enabled it to develop a novel R&D-based disruptive business model that converts its investments and R&D activities into a new concept of R&D that serves as a locomotive for innovations in Amazon's businesses ranging from Amazon's brick-and-mortar to e-commerce-based businesses [4,16,17].

Previous studies have examined the identical features of fashion such as cultural aspects, supply chain management, designing, manufacturing, marketing, and technological developments in the fashion industry towards sustainability (e.g., [18–24]), and also Amazon's R&D system from the viewpoints of technology operation strategy as well as financial management system (e.g., [25–27]), no one has analyzed their co-evolutionary progression leading to further development of solutions provided by the digitalization of the fashion industry and Amazon's R&D-driven, customer-centric virtuous cycle toward stakeholder capitalization. Nevertheless, consideration of practical beyond e-commerce solutions, supporting tools such as high-performance computing, and its impact on the global fashion industry has also not been actively pursued. Finally, the lack of conceptualization on practical solutions that encounter fashion-driven luxury brands' internet dilemma that hinders the development of the fashion industry in the digital era, which is critical to transforming the global fashion industry to survive and compete in a non-contact society.

At the same time, the significance of stakeholder capitalism is gaining momentum in a newly emerged non-contact society [28]. It enables companies to protect and satisfy stakeholders' concerns by engaging them to create a shared and sustained value. This can be achieved by corresponding to their changing preferences. Thus, while analyzing the co-evolutionary paths of Amazon's business model and the fashion industry, an approach toward stakeholders' capitalization is attempted.

Amazon develops its business empire by undertaking frontier innovation and companywide experimentation based on heavy investments in "technology and content" that generates a big data collection system enabling it to harness the power of users which functions as a virtuous cycle leading to the transformation of "routine or periodic alterations" into "significant improvement" during the R&D process [27]. For example, recently, a few studies have suggested that Amazon's strength lies in artificial intelligence, whereas Amazon web services (AWS) are a locomotive for AI-driven innovations reflecting sociocultural, economic, and technological changes in society [29–31].

The new socio-economic conditions, such as the emergence of a noncontact society during COVID-19, urged the digital transformation of the fashion industry [32]. Digital transformation indicates company-wide changes that result in the emergence of new business models [33]. The digital transformation of the fashion industry refers to "the reception of the digital environment by the industry" [34], whereas digital fashion represents an overlying area between fashion and ICT tools [35].

In this study, advanced digital fashions (ADFs) are referred to as fast fashion products which are developed by studying the effects of prior digital innovations and are powered by Amazon's recommendation engines. Their enabling tools and preceding innovations are illustrated in Table 1. They represent Amazon's fashion catalog, influencer styles, Amazon's labels, and third-party fashion lines, whereas supra-omnichannel is a cloud-

based fashion platform that emerged by the co-evolution of ADFs, ODM, and neo-luxury, all stakeholders are combined in a cloud-based fashion platform so that their activities are visible in real-time.

Table 1. Functions and enabling core technologies for ADFs development.

ADFs	Functionality	Preceding Innovations	Core Technology
Prime Wardrobe (2017)	Try at home before purchase service, customers can receive up to 15 items at home and pay only for the selected outfit. Sizing and returns are the biggest online shopping barriers; this feature has removed such barriers.	Endless.com, my habit.com, Body Labs, 3D body modeling AI (ML), IoT, VR/AR, and mobile devices.	AI-based matching recommendations, Amazon fashion catalog, recommender system
AI Algo. fashion designer (2017)	The algorithm learns about a particular style of fashion from the web, and social media (images, videos), and generates new items in similar styles.	Body labs based on ADFs technologies	ML and DL-based Generative Adversarial Networks (GAN)
EchoLook (2017)	Smart speaker, voice assistant, and hands-free camera. It was introduced to train Alexa in becoming a fashion advisor.	Echo Look (2017) has emerged from the classic Echo (2014) device and is similar to Echo Dot (2016). Its features are based on previous, Outfit Compare (share photos), and Style Check (second opinion)	Based on AI, Echo Look (2017) incorporates CV, NLP, and ML.
AR Mirror (2018)	A mirror-based display system that enables users to interact with virtual objects. The blended AR systems combine images reflected by a mirror with the images that are transmitted from the screen behind the mirror.	Further development of Echo Look. BodyLabs software, and Lab 123 hardware.	Two-way mirror with electronic display, depth-sensing camera, projectors, CV algorithms, blended reality
Personal Shopper (2019)	Customized clothing box. Incorporates curation function, consumers co-create with Amazon's designers. This curation function satisfies customers' personalized requirements.	Further evolution of Prime Wardrobe, sophisticated curation ability accumulated through the series of ADFs development.	With the addition of the Personal Shopper (2019) to Prime Wardrobe (2017), the company uses ML and personalized recommendation algorithms along with personal human stylists.
Style Snap (2019)	Fashion recommendations are based on user-submitted photos in real-time. Connects high-profile social media fashion influencers to Amazon fashion and customers.	Amazon Associates, Amazon influencers.	CV and DL identify apparel in a photo. DL classifies the apparel items in the image.
The Drop (2019)	Social media fashion influencers and Amazon fashion designers co-create limited edition apparel available only for 30 h.	Amazon influencers program, Influencers drove the fashion line.	SM, BDA

Sources: Authors' elaboration based on [36–41].

Applying techno-economic analysis and in-depth literature reviews, an empirical co-evolutional analysis was conducted on Amazon's recent AI-oriented R&D-driven developments in fashion, i.e., the introduction of advanced digital fashions (*ADFs*) leading to the development of supra-omnichannel, and the contribution of digitalization towards sustainable fashion. Thus, this paper investigates the development status of the textile and apparel industry in the digital transformation era, starting from an analysis of Amazon's fashion business and presents the technical frameworks in developing e-commerce-based ADFs, on-demand manufacturing (ODM), neo-luxury, and construction of the supra-omnichannel. It also discusses the future development of Amazon beyond e-commerce endeavors leading to a metaverse society [32,42].

Section 2 introduces fashion as a representation of social life and the historic development of the fashion industry, and Section 3 introduces the contributing factors for growth in Amazon's fashion business such as Amazon web services, artificial intelligence, and the emergence of soft innovation resources. Section 4 introduces the Amazon's learning orchestration externality in developing digital fashion business that covers the concept of learning orchestration externality in the development of ADFs, ODM, and with their dual co-evolution emergence of the supra-omnichannel. Section 5 introduces a framework encompassing learning orchestration externality beyond e-commerce, and the conclusion part summarizes the development of this paper and, finally, provides direction for future research.

2. Fashion as a Representation of Social Life

2.1. Global Fashion Industry

The contemporary fashion industry is based on social and cultural phenomena referred to as the "fashion system". The fashion system is a highly influential force that encompasses art, design, manufacturing, branding, and retail. For example, art and design contribute to the formation of fashion trends in society [43,44] as illustrated in Figure 1.

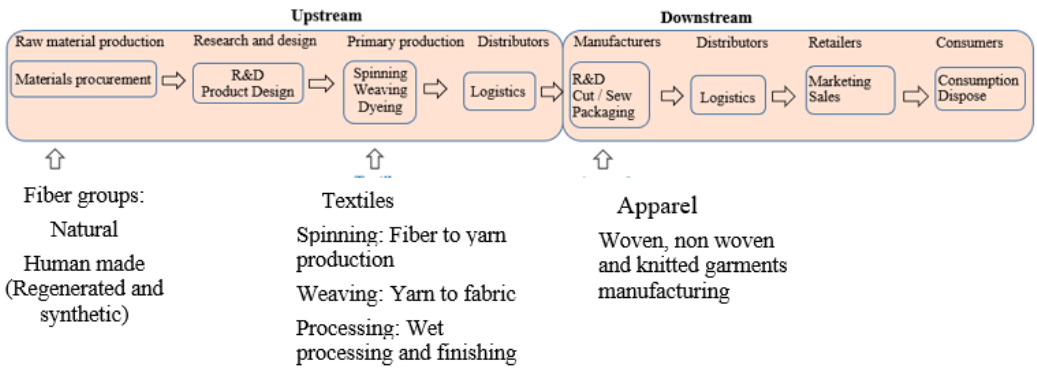

Figure 1. Value chain structure of the fashion industry.

In recent years, the fashion industry has seen a paradigm shift from traditional retailer-driven manufacturing to modern (fast fashion) consumer-driven manufacturing [45]. This industry is well-known for its unpredictable demand–supply relationships, long production lead times, short fashion cycles, choice of raw materials, seasonal demands, and heterogeneity [46,47].

The contemporary fashion value chain has transformed from forecast-based bulk production to season-based assortments. Apparel retailers can receive and deliver orders with shorter lead times. Today, industrial trends such as fast fashion and fashion mass customization are all supported by quick response and delivery speed [48].

Given the economic benefits for developed and developing economies, several constraints, such as shorter life cycles, tariff barriers, speed to market, and seasonality, have obstructed the balanced development of the industry. However, in addition to recent policies for removing trade impediments, the fashion industry is advancing toward dig-

ital solutions, for instance, real-time supply chain visibility, supply chain optimization, on-demand cloud manufacturing, stock-level optimization, and adjustment with demand planning. The most common type of digital platform is a digital marketplace, and the hyper-personalized solutions provided by e-commerce solutions eliminate geographic constraints among the stakeholders in the value chain. Thus, digital solutions can transform the contemporary value chain of the fashion industry into a disruptive platform [4].

2.2. Historical Development of the Fashion Industry

The fashion industry is a highly globalized industry, and its value chain is spread over different countries. For example, a fashion brand in the United States might source raw materials in China, have the apparel produced in Vietnam, and ship it to warehouses in Europe and the U.S. for distribution to retail outlets globally. This is mainly due to the quota system, rising materials and labor costs, as well as environmental regulations. However, the fashion industry is transitioning from mass production in standard-size systems to consumer-driven personalized manufacturing. This fragmented value chain and employment shift is not only responsible for a significant share of world economic output but has also gained momentum worldwide [9,49] in response to the shift in consumers' preferences from economic functionality to supra-functionality beyond economic value, encompassing social, cultural, emotional, and aspirational value, as illustrated in Figures 2 and 3.

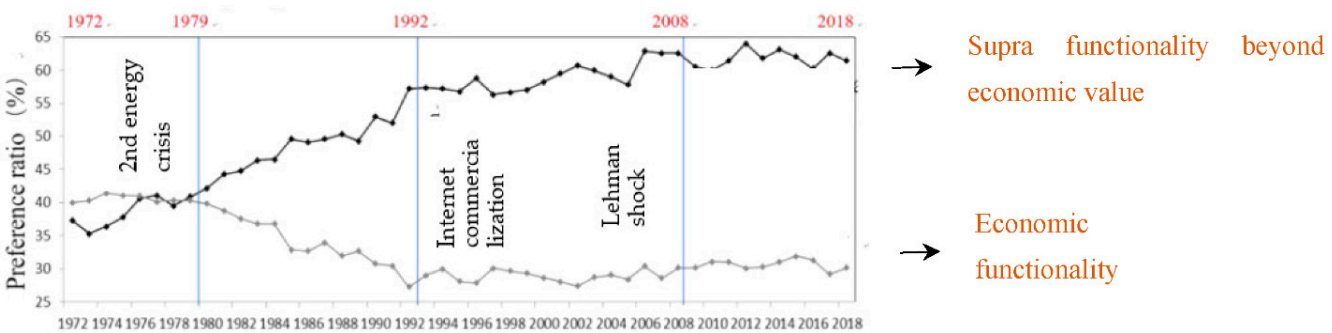

Figure 2. The trend in the shift of people's preferences in Japan (1972–2018). Source: National Survey of Lifestyle Preferences [50].

For example, in aging societies, consumers tend to buy products that correspond to both their functional and supra-functional (emotional, social, and cultural) requirements. Consumers are more demanding and prefer products that are best suited to their lifestyles. A psychological barrier develops when a product or service is unable to satisfy an individual user. This barrier hinders customers from developing relationships with those products and services; as a result, products are abandoned [7,51].

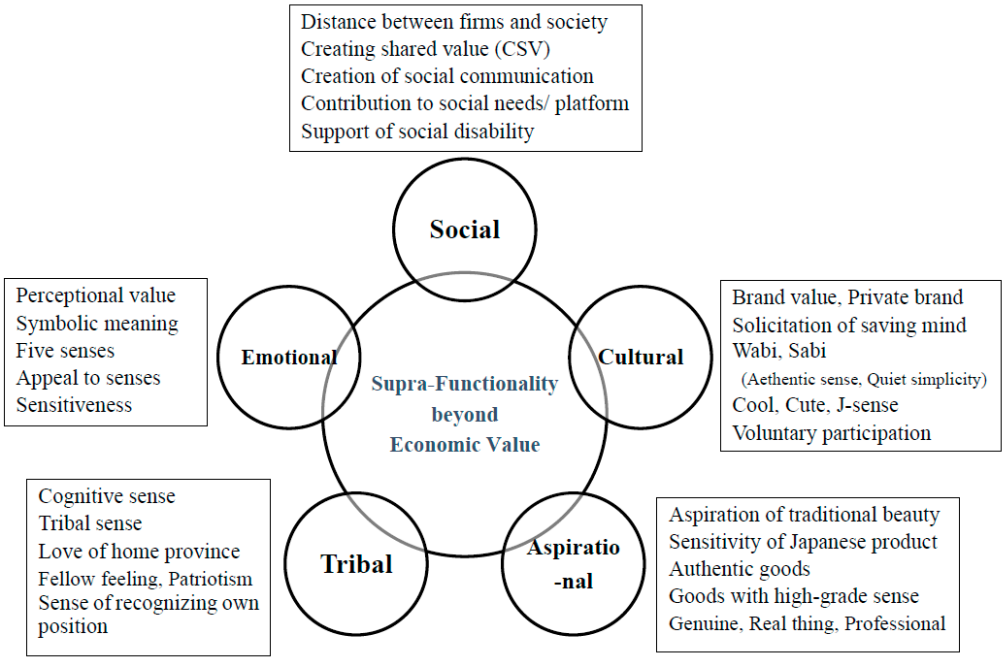

Figure 3. Concept of supra-functionality beyond economic value. Sources: [7–9].

3. Contributing Factors for Growth in Amazon's Fashion Business

3.1. Growth of the Fashion Industry

The recent COVID-19 pandemic exerted a shock on the global economy. However, despite this crisis, the fashion industry has been an engine of economic growth. Historically, the fashion industry, including textiles and apparel, has been a method for industrializing. For example, the market size of the global fashion industry improved substantially from USD 1.05 trillion in 2011 to USD 1.25 trillion in 2015, USD 1.40 trillion in 2017, and USD 1.65 trillion in 2020 (40% is shared by the EU and the US) [52]. It developed more rapidly than the global economy: in contrast to the average growth rate of 2.70% in the global gross domestic product (GDP) from 2011 to 2015, the global apparel market increased by 4.70% in the same period. The fast fashion industry established a larger increase (10.0%) during this period, as shown in Figure 4. The GDP elasticity to fashion ε_{FG} (1% increase in GDP increases ε_{FG} % increase in fashion) is more than double the GDP elasticity of textile and apparel, as shown in the right of Figure 4.

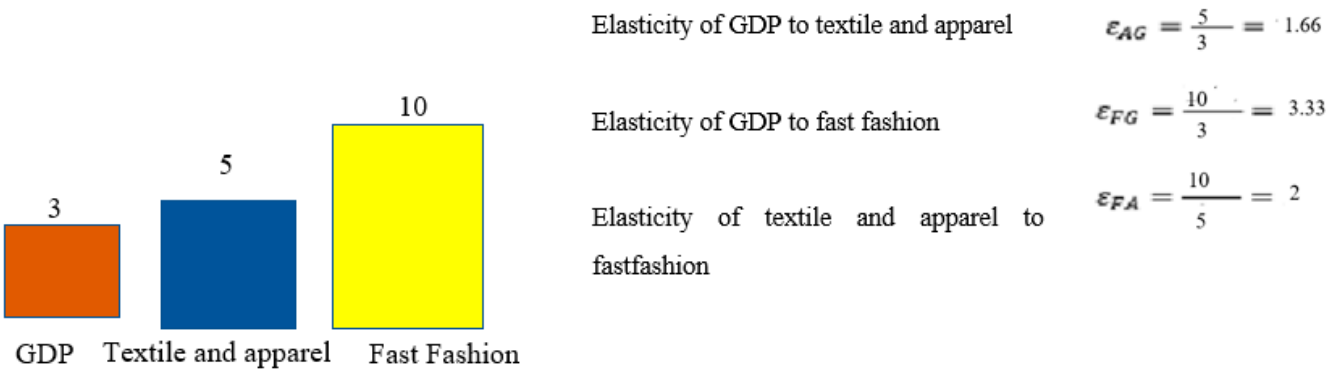

Figure 4. Comparison of the average growth rate of global GDP, total textile and apparel, and fast fashion (2011–2015).—%*p.a.* Source: Authors' elaboration based on [53,54].

3.2. Fashion Industry in the Digital Economy

Fashion represents people's lifestyles. It is a means of communication among people with common preferences, trends, and traditions that collectively form and represent

the taste and lifestyle of that society. Such fashionability, including tastes, preferences, and lifestyles, is converted into art and fashion concepts and then translated into fashion products [55].

In the fashion industry, traditional approaches to the production and selling of fashion products are being challenged [56]. The key problems are longer production lead times, fragmented supply chains, time to market, and increased fashion seasons encompassing volume, variety, and velocity [43]. With these features, supply systems in the fashion industry that are fast-moving and trend-driven are categorized by shorter lead times in terms of responsiveness, production, and high fashionability [57]. This indicates that flexibility is critical in fast fashion to ensure the rapid delivery of trendy products. As fast fashion is unpredictable, the implementation of a lean manufacturing system including just-in-time, agile supply chains, and quick responses is expected to reduce the processes involved in the buying cycle and lead times for getting new fashion products into stores [14].

The advancement of the digital economy has accelerated the demands described above. At the same time, it provides the fashion industry with a new solution, a digital solution. As suggested by Sun and Zhao [58], advancements in digital technology, from AI, robotics, and agile and on-demand manufacturing to the virtual dressing room, e-commerce, and social media, are becoming key growth drivers in the fashion industry. In addition, these advancements have emerged in new environments, shifting to a sharing economy and a circular economy, which is driving the fashion industry to change to a disruptive business model.

Advancements in ICT have accelerated digital innovations in the fashion industry. For instance, cyber-physical systems, the Internet of Things, personalization, customization, AI, and high-performance computing are accelerating digital innovations. Fashion brands use these innovations to improve customer experiences. For example, AI is used to offer personalized recommendations and curation. Augmented reality and virtual reality are used before buying in a simulated environment [59]. Therefore, confronting the demands of fast fashion and incorporating technological breakthroughs, particularly digital solutions utilizing the dramatic advancement of digital innovation, is expected. Noteworthy endeavors at the forefront of the fashion industry are described in Table 2.

Table 2. Digital innovations supporting the fashion industry toward advanced digital fashions.

Artificial intelligence (AI)	Fashion design, real-time, recommendation, forecasting, and trend analysis
Machine learning (ML)	Product development, demand forecasting, complex data analysis
Virtual reality/Augmented reality (VR/AR)	Creates virtual world, 3D body scanning, customer experience monitoring, virtual stores, and metaverse society
Big data analysis (BDA)	Enables real-time personalization based on purchase history and preferences
Social media	Explores influencers to enhance curation function.
On-demand manufacturing	Satisfies every individual customer's needs, automation
AWS	Locomotive for innovations by providing cloud computing platforms.
IoT	Enable wearables, optimize product assortment and customize recommendations.

3.3. Customer-Centric R&D-Driven Advancement in the Digital Economy

According to Jeff Bezos, "Our success at Amazon is a function of how many experiments we do per year, per month, per week, per day" [60]. In the digital economy, companies have easy access to customer data generated with every digital interaction. Such big data are extremely useful in driving insights that are used for experimentation.

Amazon's business model is based on customer-centric R&D-driven developments. Company-wide experimentation and R&D have been key to Amazon growing its empire. This is achieved by continuous interaction with users based on an architecture of participation, and an advanced assimilation capacity based on rapidly increasing R&D investment.

For instance, Amazon's R&D investments increased from USD 16 billion in 2016 to USD 56 billion in 2021 [61]. The significant increase in Amazon's R&D investment in the digital economy suggests the possibility of a structural change in the concept of R&D, similar to its output. Amazon's concept of R&D refers to technology and content. This indicates thoughtful insights into the R&D model in the digital economy [16,62,63]. The substantial increase in R&D enabled Amazon to become the world's top R&D firm in 2017, with a skyrocketing increase in its market capitalization, making it nearly the world's biggest company, as shown in Figures 5 and 6.

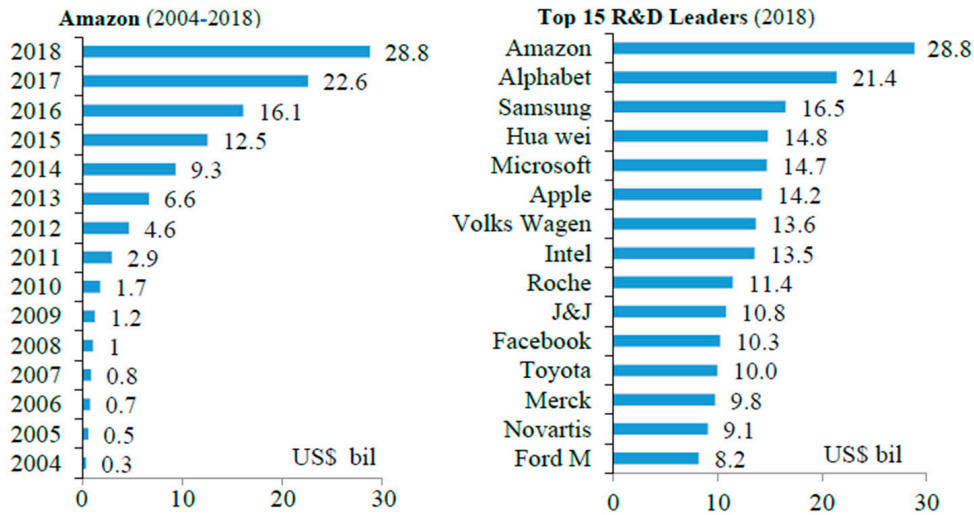

Figure 5. Amazon's conspicuous jump to become the world's top R&D leader—R&D investment. Sources: [64,65].

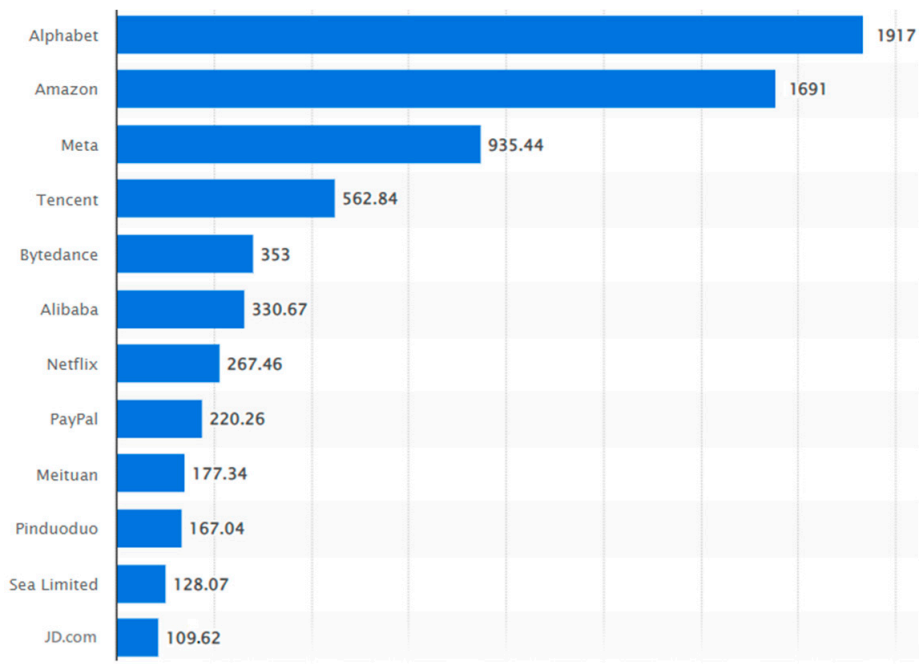

Figure 6. The market capitalization of the largest internet companies worldwide (June 2022). Source: [66].

Amazon also absorbs soft innovation resources (SIRs) from external sources and incorporates them into its business model, which converts "routine or periodic alterations" of business activities into "significant improvement" [32,67]. Thus, user-driven innovation

accelerates the co-emergence of SIRs enabled by the advancement of the internet and communication technologies in the digital economy.

SIRs trigger a self-propagating function to satisfy changing customers' preferences beyond economic value. Amazon succeeded due to its customer obsession approach, talented employees, AI/AWS-powered products and services, and timely decision-making, as shown in Figure 7.

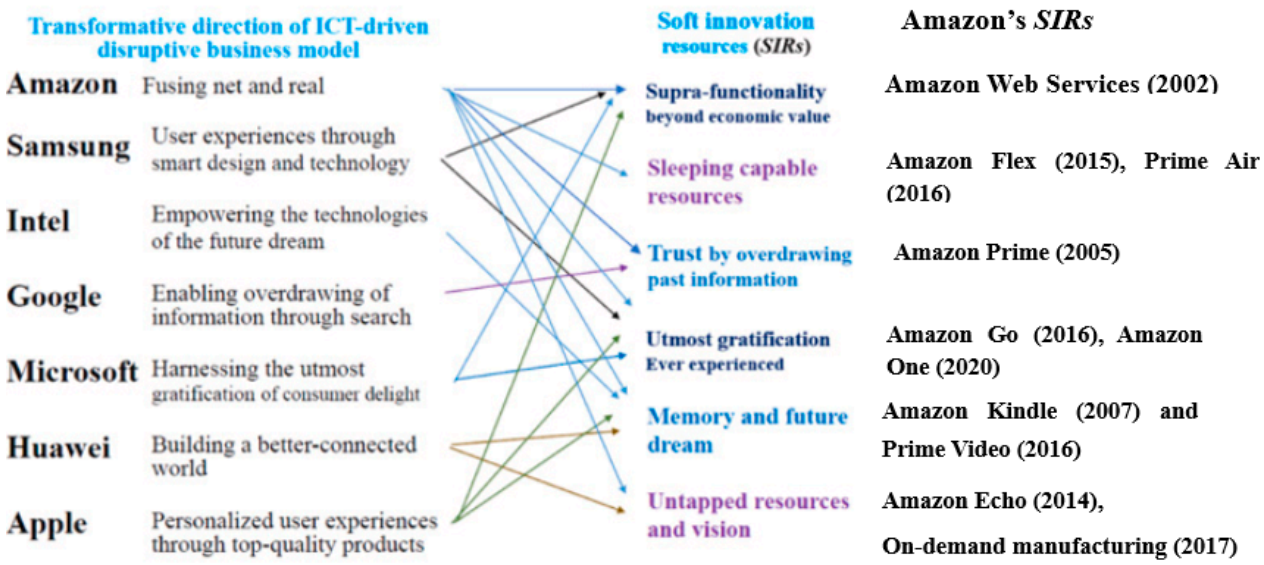

Figure 7. Soft innovation resources developed by top ICT leaders and corresponding examples in Amazon.

Amazon's endeavor to develop SIRs is shown in Figure 7. The SIRs comprise Amazon's initiation of user-driven innovation, such as (i) a shift in preferences toward supra-functionality (e.g., AWS in 2002), (ii) sleeping resources (e.g., Amazon Flex in 2015 and Prime Air in 2016), (iii) drawing on previous information and fostering trust (e.g., Amazon Prime in 2005), (iv) providing the most gratification ever experienced (e.g., Amazon Go in 2016 and Amazon One in 2020), (v) memory and future dreams (e.g., Amazon Kindle in 2007 and Prime Video in 2016), and (vi) untapped resources and vision (e.g., Amazon Echo in 2014 and ODM in 2017).

These SIRs are in line with customers' changing preferences, and Amazon's R&D investments in the development of the digital fashion business are associated with the integration of these resources. Fashion with artistic and functional features accelerates developments in SIRs, ranging from supra-functionality to untapped resources and vision. These SIRs, comprising aesthetic features, lead to advances in the fashion industry.

Thus, Amazon endeavors to create co-evolution between the development of SIRs and fashion advancement. Amazon has been developing a digital fashion business powered by AWS that acts as a locomotive for innovation and a carrier of digital solutions, which is a highly profitable category for the company [52]. Innovations in Amazon's digital fashion business create synergies with each other in an ecosystem rather than behaving individually. Inspired by the digital innovations illustrated in Figure 8, Amazon emerged as the second-largest retailer of apparel in the US, with a 7.9% share (after Walmart, 8.6%) in 2017, from a 3.7% share in 2016 [32]. Thus, Amazon has been expanding its highly profitable fashion-driven apparel business.

Fashion, including apparel and footwear, became Amazon's best-selling segment in 2018–2019, from fourth in 2017–2018, surpassing books, beauty, and electronics, and Amazon silently became the leading apparel retailer in the U.S. in 2019 [68]. In line with this growth and significant improvements in private-label fashion, Amazon attempted

to move from selling basic apparel as traditional value to more fashionable higher-value categories.

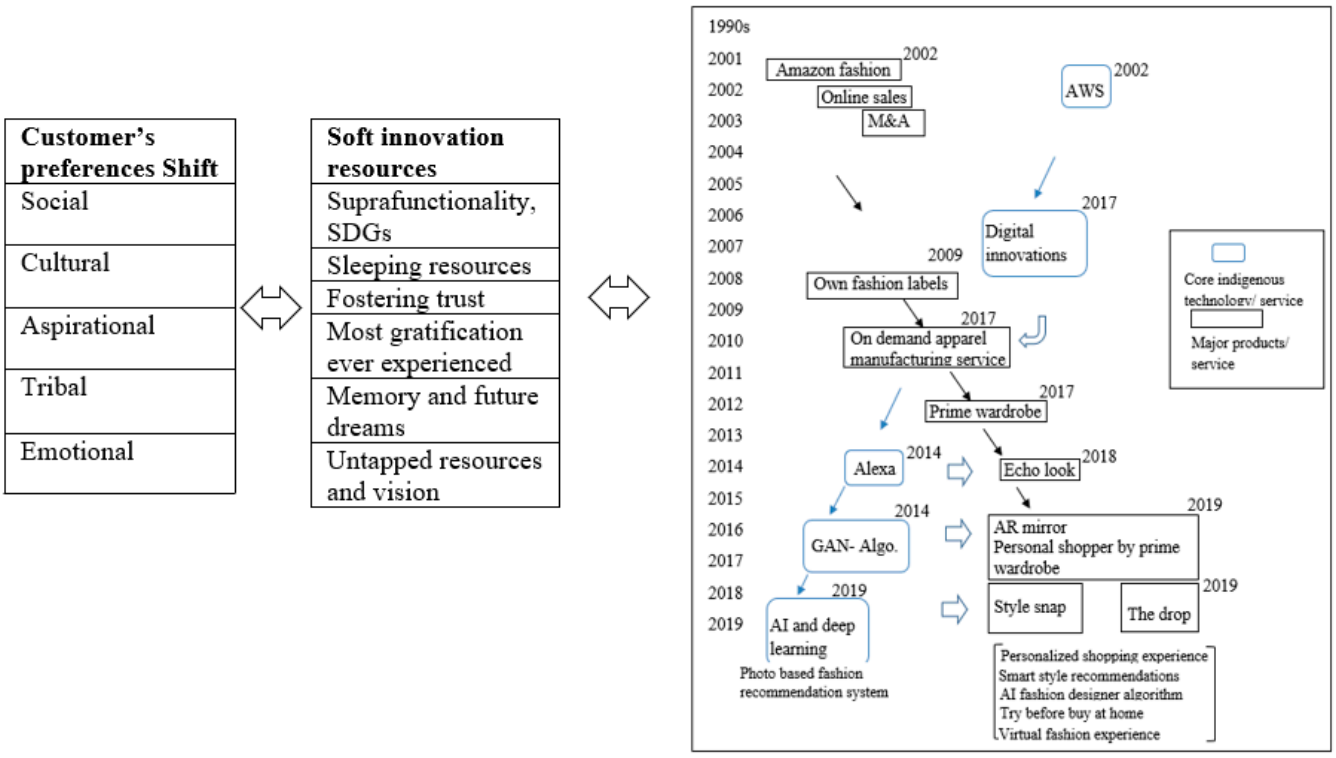

Figure 8. Co-evolution between SIRs-induced innovation and Amazon's digital fashion business.

This was not Amazon's first attempt to break into the luxury fashion market. The company tried similar moves in 2007 with endless.com and in 2012, when endless.com was renamed Amazon Fashion [69]. The increasing share of apparel sales in all of Amazon's online sales, as well as in the U.S. market, is shown in Figure 9. Among other business lines in 2018–2019, Amazon fashion was the most profitable business, with a 9.5% share in 2019. Amazon emerged as a leader in fashion sales in 2019. Since then, the company has maintained its leadership, with a 56.7% share of the U.S. market and a 14.6% share in online sales during 2021–2022.

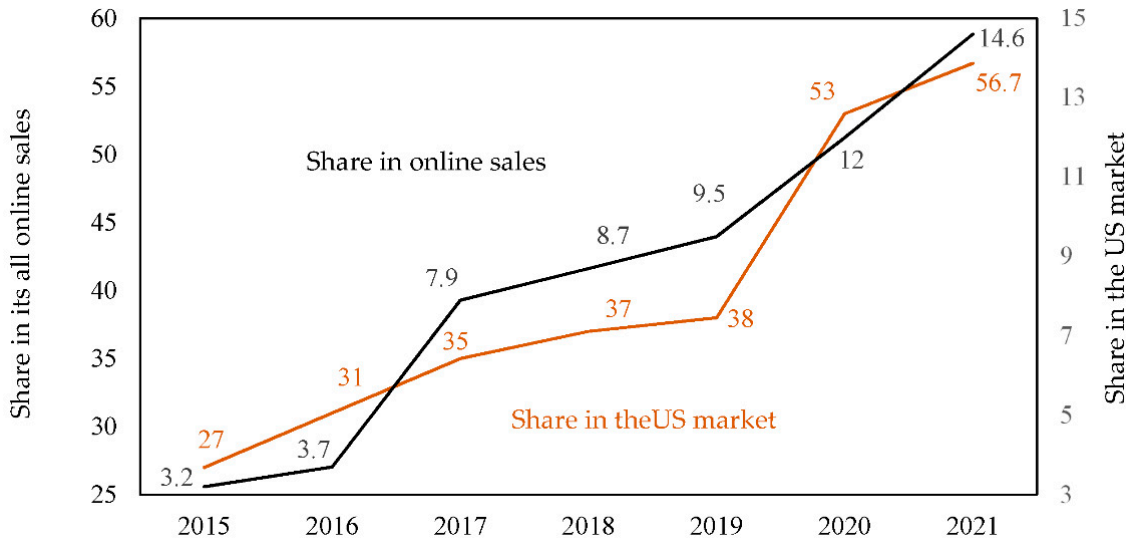

Figure 9. Trends in Amazon's apparel sales share (2015 to 2021): percentage. Sources: [70–76].

4. Amazon's Learning Orchestration Externality in Developing Digital Fashion Business

4.1. Lessons from the Past Experiences

Since 2002, Amazon has made several abortive attempts to capture the high-end fashion market. Its mission to capture this market has faced several historical hindrances, as customers have not trusted buying apparel online out of a desire to try on the items first, and Amazon was not perceived as a "cool" brand.

Amazon debuted endless.com in 2007 followed by myhabit.com in 2011, when the e-tail model was in its early stages. Both were discontinued. Part of the problem was the e-commerce brand's image in the luxury fashion industry. Moreover, luxury brands have been reluctant to adopt digitalization and an e-commerce presence. The prevalence of the "internet dilemma" in which luxury brands have been reluctant to adopt advanced digital solutions and e-commerce impeded Amazon from attracting them [4,77]. These challenges turned into learning experiences that accelerated Amazon's endeavor to develop its fashion empire with its own labels, powered by in-house AWS technology [78,79].

4.2. Creation of Advanced Digital Fashions (ADFs)

Developments in ICT are changing the buying habits of young luxury fashion consumers [4,80]. To capture this segment of the digital economy, Amazon undertook the following initiatives:

1. Entered the virtual assistant (Alexa) business with the introduction of Amazon Echo (2014). It trained Alexa to be a fashion advisor.
2. Activated its AWS team followed by Body Labs in the development of AI-led advanced digital fashions solutions (2017–2020).
3. The acquisition of brick-and-mortar Whole Foods (2017) led to the introduction of Amazon Go (2018) technology in Whole Foods stores. This is a unique venture because Amazon's other products and services are online and AWS-based.
4. Activated Prime Video in the acquisition of the rights to the Lord of the Rings series (2017).

These AI–AWS ventures do not act as stand-alone businesses; they create synergies for innovations. For example, they enabled Amazon to advance its fashion business and laid the foundations for e-commerce-based advanced digital fashions (2017–2020) and the brick-and-mortar fashion store Amazon Style (2022). This was an attempt to capture young affluent consumers, as acquiring a hot digitally native vertical brand is essential for shedding the company's "uncool" image [4].

By developing core AI-, IoT-, virtual- and augmented-reality-based digital tools, and mobile devices as reviewed in Section 3.2 and Table 2, Amazon has presented numerous innovations intended to advance its fashion-driven apparel business by using its big data collection system, user-driven innovation, and advanced logistics system, as illustrated in Table 1.

One of the earliest digital solutions in the ADFs series was Prime Wardrobe (2017), a subscription clothing box service that allows customers to try at home before buying. It was followed by Personal Shopper by Prime Wardrobe (2019). The Personal Shopper service is based on a co-creation and curation function in which customers and Amazon's designers create fashion items. It debuted on the Alexa-powered device Echo Look (2018), which contains a "hands-free camera and style assistant." The addition of a camera on the Echo device enables it to record and comment on its owner's clothing choices using a combination of machine learning and human stylist feedback. Echo Look provides recommendations that drive revenue to Amazon fashion. Specifically, Amazon created an AI algorithm for its private-label brands to design clothes (2018) by analyzing images, copying them as new items, and patenting AR Mirror (2019) that shows customers wearing virtual clothes in virtual locations. In addition, Amazon launched The Drop (2019), which sells limited-edition items designed by influencers. The detailed development paths of these ADFs are shown in Figure 10.

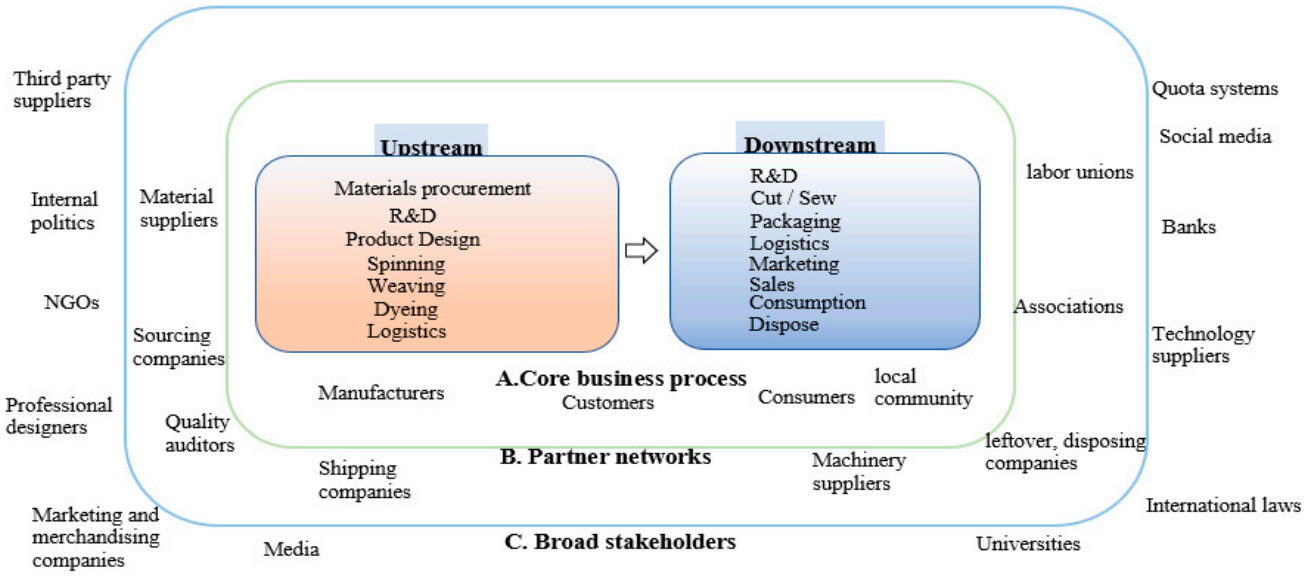

Figure 10. Relative importance of stakeholders in the Amazon fashion business. Source; Authors.

The Drop (2019) service is based on internal and external SIRs that combine broad designer and fashion influencer channels, including entertainment, social media, blogs, videos, webinars, and fashion shows. Moreover, the SIRs-driven The Drop (2019) is a platform for limited-edition designer collections. In this innovative service, broad stakeholders, such as external brands and designers, present their collections for an extremely short period. However, the incorporation of the curation function and ODM broadened the scope of stakeholders' participation more than that of stakeholders in the traditional fashion industry, as shown in Figure 10.

These broad external stakeholders provide Amazon with unstructured data in the form of documents, posts, audio/video, and reviews. Amazon's R&D hub has developed an AI-based algorithm that uses generative adversarial networks to extract meaningful content from the data. It can create a new design by analyzing trendy images on the web. This whole process can be defined as learning effects.

4.3. Learning Orchestration towards Advanced Digital Fashions (ADFs)

A firm's innovation culture is based on its higher capacity to assimilate internal and external knowledge [8]. The capacity to integrate knowledge is a function of the richness of the pre-existing knowledge structure. This indicates that learning is cumulative, and that learning performance is highest when the substance of learning is relevant to what is already known. Moreover, preceding knowledge allows for the integration and exploration of new knowledge [8].

Amazon follows a learning orchestration externality strategy and effectively utilizes the learning effects of similar challenges in three pillars (learning by orchestration), as illustrated in Figure 10:

(i) Customer-centric R&D-driven advancement.

Amazon emerged as a customer-centric company where R&D is the core of its business model.

(ii) Frontier innovation and companywide experimentation.

Amazon's founder Jeff Bezos has always stressed company-wide experimentation. It has become Amazon's culture of innovation. It enabled the growth of Amazon's empire and subsequent big data collection system.

(iii) User-driven innovation.

Amazon demonstrates communication with users for user-driven innovation based on the architecture of participation and a high level of assimilation capacity based on a significant increase in R&D spending [81]. Amazon's development of ADFs is a typical case, as illustrated in Figure 11.

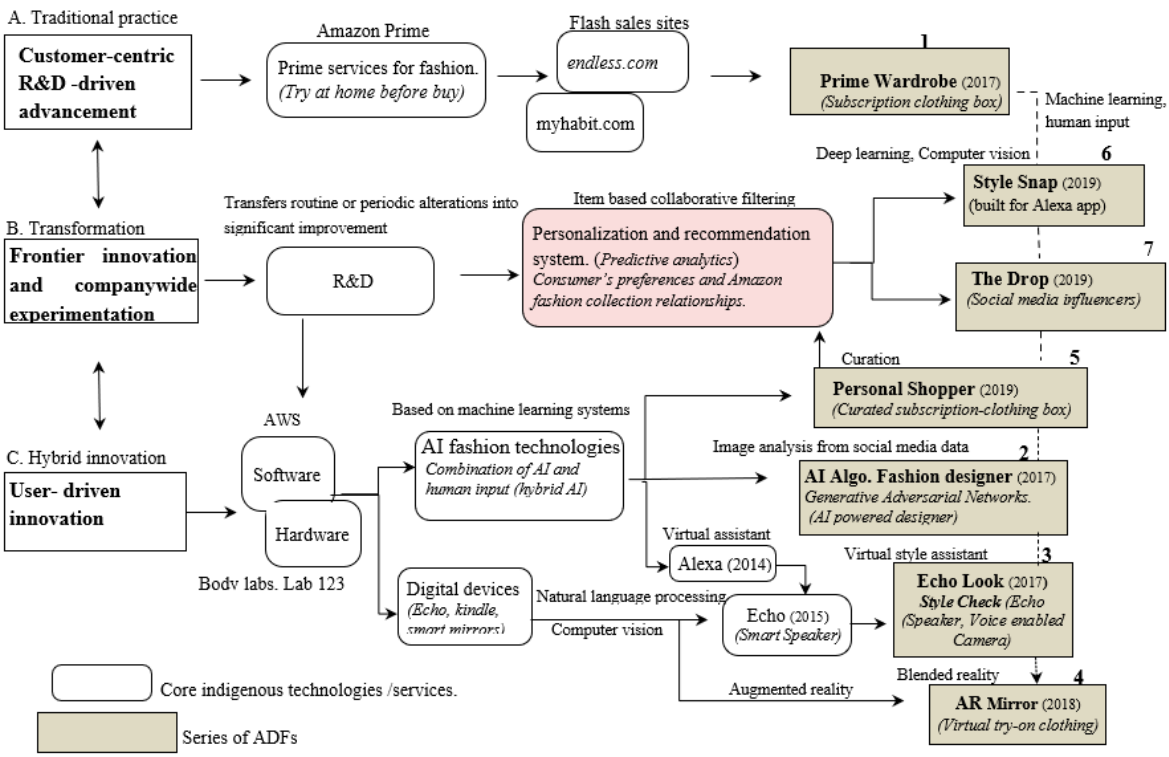

Figure 11. Amazon's ADFs development by learning from preceding innovations. Source: Authors' elaboration based on [10].

A detailed version of this process flow can be found in the authors' previous study [10]. This process flow indicates that Amazon initiated a series of ADFs successively by deploying an orchestration strategy for innovations by learning effectively from previous innovations.

According to [10], the Prime Wardrobe service was created with the mission of changing Amazon's brand image from a basic apparel retailer to a cool fashion brand. This service constructed the foundation of the business model to understand customers' needs and product and style preferences, as well as the measurement of personal data.

Prime Wardrobe was upgraded to Personal Shopper by Prime Wardrobe in 2019. It incorporates a curation function that lets customers co-create with Amazon's designers. At the same time, Amazon developed the AI algo. fashion designer that creates fashion styles without human involvement. This algorithm enhances video and imagery-based fashion services, such as AI-powered Echo Look and its derivatives. Amazon also introduced an ML-based Style Snap service to find similar styles from customers' provided photos. Echo Look's voice-enabled selfies and short videos trained Alexa to become a fashion advisor. Given the potential cost-efficiency benefits in the fashion supply chain, its functionality was transferred to mobile apps. The device was discontinued due to privacy, trust, and ethical issues. If a customer is not satisfied with the algorithmic recommendations provided by Echo Look, it then suggests ordering specific styles from Amazon's fashion catalog. This suggests that Amazon's ODM will soon be able to produce hyper-customized outfits. Moreover, instead of uploading photos to Style Snap and then waiting for recommendations, customers can use Amazon's patented AR Mirror, which provides real-time recommendations. The Style Snap service provides Amazon with customers' behavioral data and encourages collaboration with fashion influencers; ultimately, the scope of external stakeholders is broadened. This has led to the development of The Drop service. It provides limited-edition styles curated by celebrity fashion influencers on social media. Notable fashion influencers present trend-led limited collections for 30 hours. Items recommended by The Drop are from either Amazon's fashion catalog or designers' creations

5. Creation of Supra-Omnichannel during COVID-19

Amazon has transformed the traditional fashion value chain, as illustrated in Figure 1, into a supra-omnichannel. Due to the COVID-19 pandemic, there has been a major drop in textile and apparel sales, and Amazon has been undergoing a digital solution-oriented transformation [82].

During this crisis, Amazon accelerated its strategic actions in developing more advanced digital solutions to support the declining fashion business. Amazon has been growing its fashion empire by introducing a series of ADFs comprising physical and digital commodities. This service increased Amazon's omnichannel dependence based on seamless switching by utilizing its innovative assets. Capturing an e-commerce-based luxury fashion market has always been Amazon's long-awaited vision. To solve this challenge, the company has endeavored to shed its uncool brand image and advanced the AI-driven curation function by introducing an e-commerce-based series of ADFs. Other services, Style Snap and The Drop, enabled Amazon to collaborate with external resources such as global influencers to co-design trendy fashion manufactured in line with demand.

In 2020, Amazon introduced Luxury Stores, a unique digital platform for luxury and high-end fashion. This was in response to the decline in the luxury business during the COVID-19 pandemic and the increasingly non-contact society, which necessitated the addition of extra channels for luxury brands [10,62]. At the same time, luxury brands are confronting "the Internet dilemma" [52], which is the reluctance to incorporate ICT and e-commerce technologies into their business models [83]. The internet dilemma impedes luxury brands, such as the luxury giant LVMH (Kering and Hermes) Group, from collaborating with Amazon [84]. Despite these challenges, the Luxury Stores initiative is gaining momentum; thus far, more than 50 luxury brands have collaborated with Amazon, as illustrated in Figure 12.

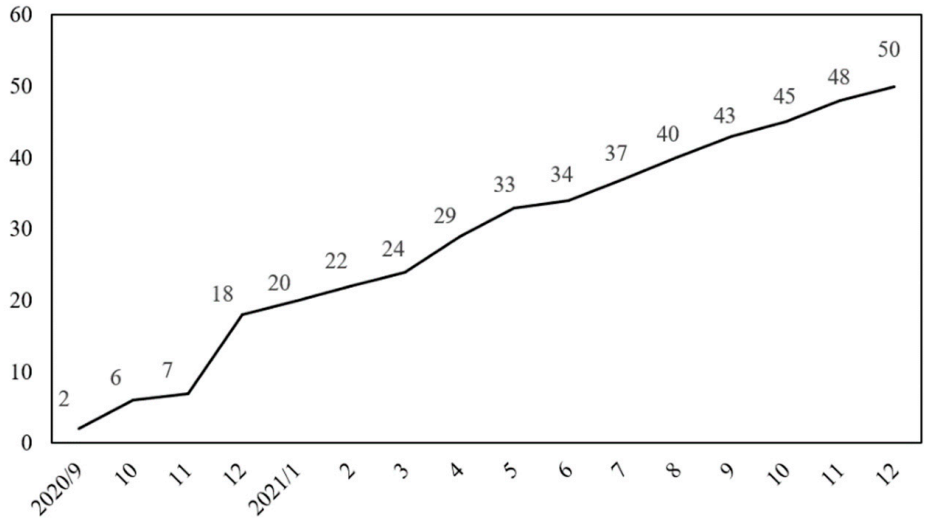

Figure 12. The trend in the cumulative number of luxury brands joining Amazon.

The Luxury Stores platform provides the following advantages to Amazon and its stakeholders:

(1) The millions of Amazon Prime members provide feedback. This initiates an iterative process in which users' feedback is used for significant improvements, experimentation, and innovations.
(2) In contrast to Amazon's traditional business model the company provides freedom to luxury brands in controlling inventory, pricing, and distribution. Amazon provides digital tools and customer data for creating and personalizing content for each brand's identity.
(3) This digital store-within-a-store concept and freedom to control can build trust between Amazon and luxury brands to solve the historic internet dilemma.
(4) Amazon provides luxury brand customers with an opportunity for free shipping and returns.

Amazon reduces luxury brands' dependency on brick-and-mortar stores by providing an independent digital space.

In the same light of solving the internet dilemma, Amazon received a patent for ODM in 2017 that enables luxury brands to consolidate their supply chains. This challenge can be expected to be solved by synchronizing ADFs, Luxury Stores, and ODM. This endeavor suggests a solution to the historic internet dilemma as well as the shift from multichannel and cross-channel to omnichannel [52].

The mission to be a fashion-driven apparel leader has led Amazon to focus on following a three-dimension approach consisting of (i) involving customers in the co-creation of their preferred styles, (ii) improving brand image with the curation function, and (iii) capturing the luxury fashion market with digital services. Co-evolution and synchronization of these three initiatives are expected to lead to ODM for the fashion business, together with shedding Amazon's uncool brand image and diving into the luxury fashion business, as illustrated in Figure 13.

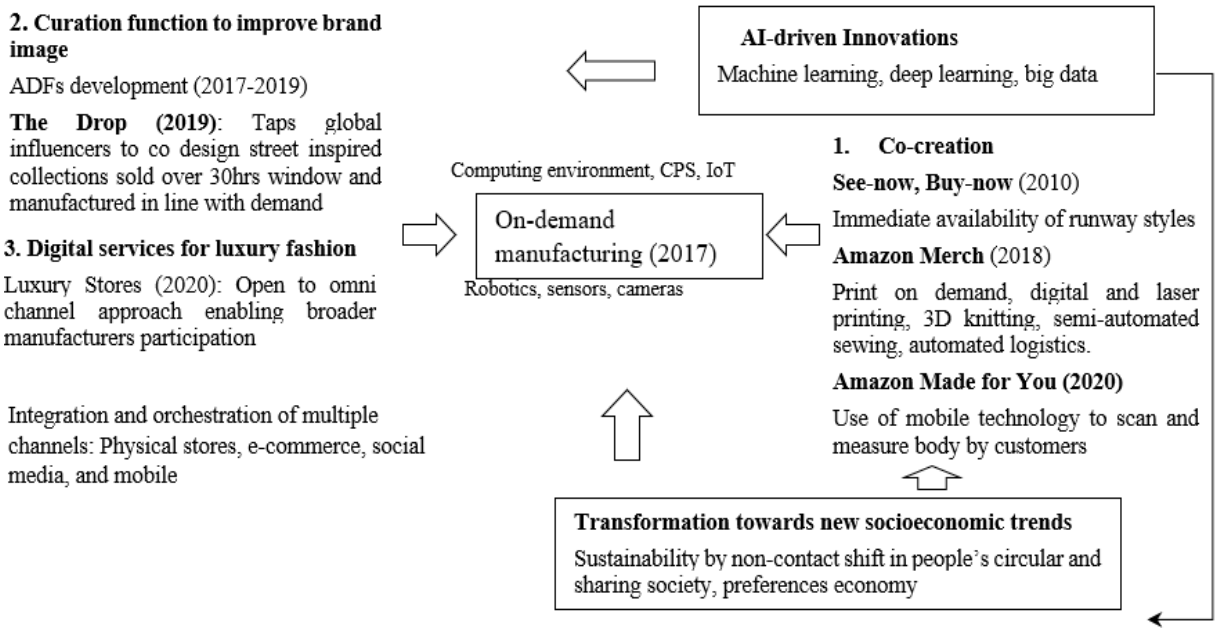

Figure 13. Amazon's initiatives toward on-demand manufacturing in the luxury fashion business.

5.1. Involving Customers in the Co-Creation of Their Preferred Styles

Amazon started inducing customers' preferences with co-creation initiatives such as See Now Buy Now (2010), Amazon Merch (2018), and Amazon Made for you (2020). This corresponds with the increasing trend of prosumers (consumers as producers) in response to the increasing anger of consumers at remaining non-producers, in contrast to their desire to enjoy an exciting story with their initiatives as heroes/heroines of a drama [9,85].

5.2. Improving Brand Image by Curation Function

Amazon introduced the curation function to shed its uncool brand image in the fashion industry. It improved customers' abilities in fashion co-designing by developing a series of ADFs leading to collaboration with global social media fashion influencers to co-design the most fashionable collections sold and manufactured in line with demand.

This development of a series of ADFs corresponds to the shift from multichannel and cross-channel to omnichannel [52].

5.3. Capturing the Luxury Fashion Market with Digital Services

Amazon's core multichannel fulfillment service enabled it to delve deeper into the luxury fashion business. For example, the Luxury Stores initiative allowed luxury brands to make decisions about their inventory, selection, timing, and pricing. Oscar de la Renta, Elie Saab, and Altuzarra were early partners of Luxury Stores.

This challenge started with the co-existence of luxury brands' traditional channels and Amazon's channels. However, the goal is to transform this co-existence into co-evolution, as illustrated in Figure 14.

With this co-evolution, Amazon can provide a solution to the previously impossible conundrum "the Internet dilemma" [77,86]. Thus, a possible solution is a cloud-based fashion platform that combines ADFs, luxury brands, and all sales channels. This also transforms the traditional value chain of the fashion industry into a digital platform that combines stakeholders and consumers at one point. With a cloud-based fashion platform, the digitalization of the upstream will provide real-time information on changing customer preferences and enable downstream industries to use digital solutions. Additionally, increasing environmental consciousness enables stakeholders to adopt green practices when the value chain of fashion is visible, and customers know the origin of their fashion products.

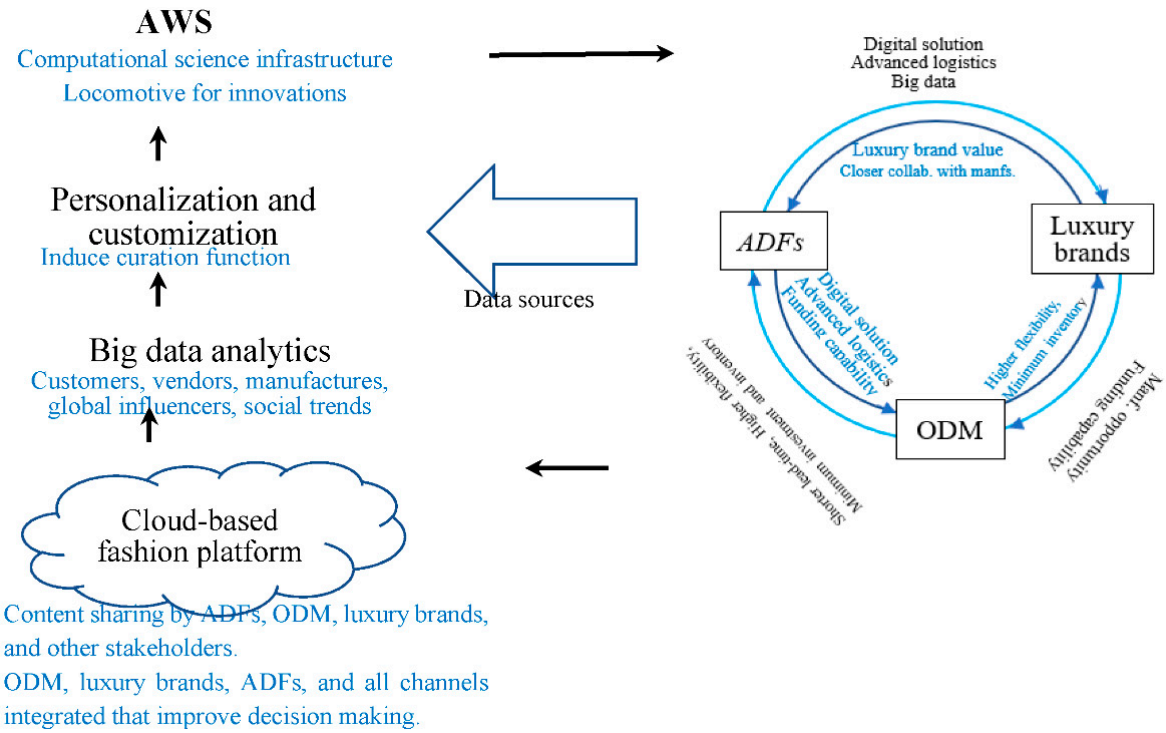

Figure 14. Dual co-evolution Among ADFs, luxury brands, ODM co-evolution, and cloud-based fashion platform advancement.

A cloud-based fashion platform enables personalization and customization with an advanced curation function by way of seamless switching on an on-demand basis. Consequently, big data on customers, vendors, manufacturers, global influencers, and social trends can be analyzed, which further improves AWS's functionality with learning orchestration externality. AWS, as a computational science infrastructure, grows and expands by learning digital advancements initiated by preceding endeavors [32,87]. AWS provides solutions to big data analytic requirements, so that companies focus on business problems instead of managing these tools. Advanced AWS, in turn, further accelerates co-evolution among ADFs, luxury brands, and ODM. Activated co-evolution has led to a cloud-based fashion platform, resulting in a virtuous cycle. Thus, dual co-evolution occurs among ADFs, luxury brands, and ODM, and a cloud-based fashion platform.

6. Learning Orchestration beyond E-commerce

In the previous sections, Amazon's ambitious goals of becoming a digital fashion leader based on digital innovations in fashion were shown and discussed. Considerable R&D investment, ADFs, luxury brands, and ODM emerged. Moreover, their dual co-evolution resulted in a cloud-based fashion platform representing a supra-omnichannel that combines all the stakeholders.

Amazon's new CEO, Andy Jassy, suggested that "customers will eventually do their shopping from their *Fire TV, Omni, or Fire TV 4-Series*. It's part of the company's effort to shift you away from tapping on apps, an experience that will soon feel outdated" [88]. E-commerce apps could be replaced by voice (Alexa), buying while viewing the same fashion show on TV, and digital–physical shopping, such as Amazon Style (2022). Thus, based on Andy Jassy's suggestion, it is crucial to investigate a digital solution that leads beyond e-commerce endeavors. Our research beyond e-commerce focuses on the emergence of Amazon's innovations during the COVID-19 pandemic by following learning orchestration externality strategies, such as the following:

1. Amazon Aware (2022) represents a circular and sharing economy in a carbon-neutral society.

2. Amazon Style (2022) represents on-demand manufacturing
3. Luxury Stores (2020) represent co-creation and customization.
4. Making the Cut (2020) for sociocultural engagement.
5. Amazon Braket (2019) for quantum computing.

When learning orchestration externality is applied, the emergence of beyond e-commerce solutions can be expected, as illustrated in Figure 15.

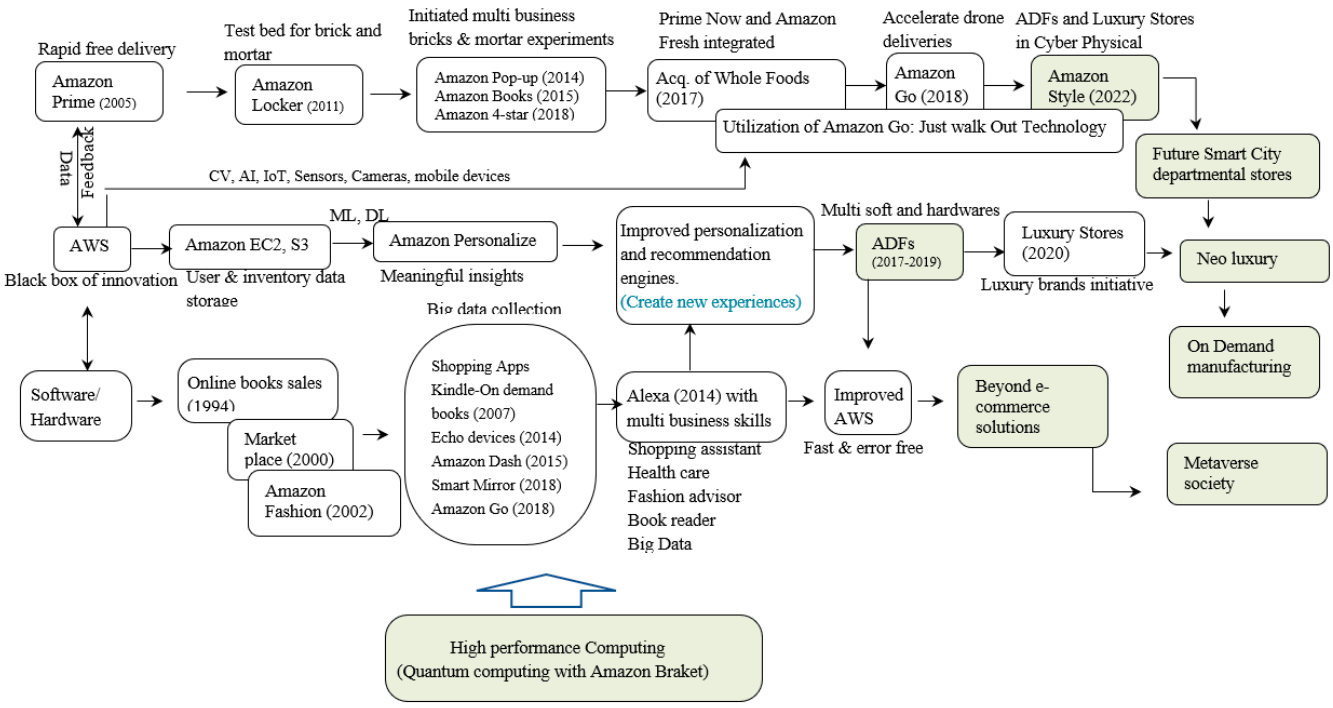

Figure 15. Learning orchestration beyond e-commerce.

6.1. Amazon Aware

Amazon introduced a new fashion brand Amazon Aware (2022). All items including fashion are certified as Climate Pledge Friendly. Since Amazon Aware (2022) is its private label, it is expected that fashion items representing this label will be available at Amazon Style (2022). Both, ODM and Amazon Aware (2022) also correspond to sharing and circular economy [89].

6.2. Amazon Style

Its preceding ADFs (programs, algorithms, devices) and in-store technologies collect insights on customers' digital shopping preferences as well as their brick-and-mortar behaviors. Such first-party data enable Amazon in creating feedback (preferences, reviews, ratings, suggestions) channels in finding what customers value and enable it in creating highly curated and personalized products, recommending them to every visiting customer in real-time. This data leads to effective, personalization, experimentation, and optimization. Amazon's ability to adjust its offerings (curation) based on customer preference data leads to on-demand satisfaction. Since customers expect responses to their demands quickly, Amazon Style is designed to provide on-demand satisfaction to every visiting customer by using enabling technologies consisting of the mobile app, QR codes, cameras, screens, and sensors [90].

6.3. Luxury Stores

Luxury Stores was initiated with Oscar de la Renta (September 2020), followed by Roland Mouret (September 2020), Altuzarra (October 2020), Cle de Peau (October 2020), Car Shoe (October 2020), and Revive Skin Care (October 2020). Since 2020, Amazon

endeavored to expand Luxury Stores. In solving the internet dilemma, the success of this endeavor depends on the construction between the traditional business model in brands and Amazon's efforts for a more sophisticated omnichannel approach [91].

6.4. Making the Cut

"Making the Cut" (reality TV fashion show) is a transition from traditional e-commerce to TV commerce, which allows entertainment and shopping at the same time. While using Amazon's devices, customers can purchase their desired styles as soon as a TV episode ends. Along with dramatic features, "Making the Cut" demonstrates a glimpse into what could prove to be the future of shoppable videos. Thus, "[t]ying the content with the opportunity to purchase" as soon as the episode ends is a novel method that goes beyond traditional e-commerce [92].

6.5. Amazon Braket

The emergence of a non-contact society during the COVID-19 pandemic increased people's dependence on ICT, social media, and mobile devices. This increased dependence has changed customers' buying habits. With growing big data, traditional computing impedes efficient solutions to large-scale complex problems [93].

With the amalgamation of the IoT and AI approaches, it is assumed that great insights beyond mere knowledge are achieved. However, as indicated by several studies, there are several data challenges with classical AI approaches. First, most big data are unstructured [94,95]. There are also a lack of personalized data [13] and uneven data flow [96].

To gain meaningful insights (wise decision-making) from the growing big data generated by ADFs, ODM, Echo devices, and other IoT products, more advanced optimization solutions that also require high-performance computing are required. Moreover, classical computing becomes inefficient over time [97]. This suggests the integration of quantum computing with classical AI, IoT, and data analytics. Compared to classical algorithms for computation, quantum algorithms are expected to solve a set of challenges, including computational optimization for the information and natural sciences, with improved efficiency. To gain strategic advantages, technology giants such as Amazon [98] and government organizations are heavily investing in the research and development of these systems.

7. Conclusions and Suggestions

This paper presented the contribution of Amazon's preceding innovations (learning orchestration strategy) that led the company to become a largest digital fashion retailer in e-commerce, brick-and-mortar, and future endeavors beyond e-commerce business. Over the years, Amazon's considerable R&D investments have contributed significantly to the development of the disruptive business model. This achievement is also associated with a virtuous cycle of user-driven innovation, AWS, and SIRs that activate the self-propagation function. Amazon's complex customer-centric R&D process transforms routine changes into numerous significant improvements. These practices led to the advent of digital fashion solutions that turned the COVID-19 pandemic into a springboard for innovations in Amazon's fashion empire.

Fashion is a mode of self-expression that reflects changes in aesthetic, economic, political, cultural, and social life. These changes, in turn, change fashion, and apparel boosts this change. Thus, in response to a shift in people's preferences, the fashion industry has been gaining momentum worldwide. At the same time, digital solutions in terms of communication, devices, services, and e-commerce in fashion are gaining momentum. An analysis of Amazon's endeavor to develop advanced digital fashion with aggressive AI-oriented R&D, an empirical co-evolutional analysis of the development trajectories of Amazon's ADFs, and the fashion industry with special attention to the role of AI advancement was conducted.

The findings include the following:

(1) Amazon's innovations are transforming the traditional value chain of the fashion industry into a platform that harnesses data directly from consumers to develop more customer-centric products and services.
(2) The recent COVID-19 pandemic contributed as a springboard for innovations.
(3) The fashion industry must accelerate digital innovations through emerging tools, such as AI, cloud computing technology, AR/VR, blockchain, etc. These digital technologies can transform the traditional fashion industry into a digital platform industry. For example, Amazon's fashion business secured a timely digital solution by developing a series of ADFs, a supra-omnichannel, and ODM based on the digital tools described above.
(4) The advancement of AWS, ADFs, and ODM led to the development of Luxury Stores in 2020, which emerged as neo-luxury. Amazon's enthusiastic efforts to become an AI giant enabled this success. The Luxury Stores initiative has the potential to solve luxury brands' historic e-commerce dilemma.
(5) The activation of dual co-evolution among ADFs, luxury brands, and ODM is driven by advancements in AWS/AI that contribute to the development of the supra-omnichannel. This incorporates a generative function and evolves a cloud-based fashion platform that integrates internal and external stakeholders. The fashion value chain can be synchronized with ODM in real time, and stakeholders and customers can communicate within the system.
(6) Amazon has been advancing AWS as an innovative, advanced composite cloud infrastructure. This infrastructure incorporates a generative function and develops a cloud-based fashion platform by integrating all stakeholders into one place. These developments have enabled Amazon to gain the outcomes of learning orchestration externalities.

Future research could investigate Amazon's latest innovations during the COVID-19 pandemic, leading beyond e-commerce endeavors in a non-contact society. It would also be interesting to examine the contribution of Amazon Braket, a quantum computing platform, to solve non-e-commerce challenges, such as a carbon-neutral society, an age of meaning, on-demand satisfaction, shopping by amusement, and immersive technologies that correspond to a non-contact society. It is also important to examine the role of advanced preceding innovations such as ADFs, ODM, neo-luxury, and supra-omnichannel that emerged with the dual co-evolution of ADFs, ODM, and neo-luxury beyond e-commerce endeavors.

Thus, the emergence of a non-contact society has created more demand for digital solutions for the fashion industry due to lockdowns, store closures, and social distancing, etc. Future research should focus on advanced digital solutions to develop functioning beyond an e-commerce non-contact society, such as a metaverse society [32,42].

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