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Digital Innovations in Fashion

Mapping the Co-evolution of Technological Advancements and Fashion Industry

UNIVERSITY OF JYVÄSKYLÄ

FACULTY OF INFORMATION
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Lovingly dedicated to Professor Muhammad Saeed Akhtar (1947-2021), my beloved late father. A brilliant physicist, a passionate knowledge seeker, and an astounding poet.

Dear Father, each day spent without you reminds me of the void your absence has created, but in every cherished memory, you live on, vibrant and inspiring. Although you are no longer with us physically, our spiritual connection is profound and comforts me. I miss your voice, long phone calls, your heartwarming loud laughter, your thoughtful smile, and wisdom. I cherish your consistent visits in my dreams; please keep visiting. Your legacy continues to inspire my path. Thank you for everything; words truly fall short of expressing my gratitude. This dissertation is a testament to my academic journey and a tribute to you and Mother, whose unconditional love and care have enriched my spirit. To Grandfather Muhammad Sharif Warsi, whose affection was limitless. Following in his footsteps, I take my place in the third generation of my family's academic tradition, marking this moment with the completion of my doctorate.

Waleed Hassan Akhtar
12 November 2023

ABSTRACT

Technology and fashion have distinct growth patterns. Their evolutionary trajectories have typically been analyzed separately, overlooking their potential for coevolution by changing and advancing each other through feedback. This thesis seeks to bridge this gap by highlighting the dependence of contemporary digital fashion evolution on technological advances and paradigm shifts in people's preferences toward supra-functionality beyond economic value. Thus, fashion can evolve in response to changing times. Based on advancements in the Internet and communication technology (ICT), digital fashion is more data-driven, collaborative, and crucial for a growing non-contact society. Conversely, traditional fast fashion has struggled with many challenges throughout its value chain. The emerging non-contact society necessitates novel digital solutions to transform the fashion industry further. As the digital fashion field is still in its early stages, more cohesive research and a well-defined map are needed for this field. This dissertation considers solutions to these challenges. The empirical analysis of the dissertation focuses on the transformative directions of fashion innovations in the coevolution of advanced technologies and the fashion industry.

This thesis defines an advanced digital fashion development trajectory and the underlying conceptual framework that utilizes the external strategy of learning orchestration. The conceptual framework of a cloud-based fashion platform is explored in response to single-channel, multi-channel, and omnichannel implementation issues. With a dual coevolution, this platform leads to a supra-omnichannel approach. Contrary to previous studies, this dissertation has explored the development framework of the neo-luxury paradigm. The findings bring new perspectives on innovation, suggesting the transcendence of traditional e-commerce and the possible progression toward a metaverse society. Further, the digitalization of the complex fashion industry does not follow straight paths, as historical dilemmas exist, such as the two-faced nature of ICT, the Internet dilemma of luxury brands, and the shift in people's preferences toward supra-functionality and aesthetics. Our findings not only elucidate the trajectory of digital transformation in the fashion industry but also provide invaluable insights for other industries and guide future policy decisions.

Keywords: learning orchestration, productivity paradox, digital fashion, artificial intelligence, advanced digital fashion, supra-omnichannel, neo-luxury, Amazon

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Teknologialla ja muodilla on omat erilliset kasvumallinsa. Niiden evoluutiopolkujen analyysi on tehty erikseen. Tämä ohittaa niiden potentiaalin muuttaa ja edistää toisiaan palautteen kautta, mikä johtaisi yhteisevoluutioon. Tämä väitöskirja pyrkii kaventamaan tätä kuilua. Nykyajan digitaalisen muodin kehitys johtuu teknologisista edistysaskeleista ja ihmisten mieltymysten paradigman muutoksista ylitoiminnallisuuteen taloudellisen arvon ulkopuolella. Internetin ja viestintäteknologian (ICT) edistymisen pohjalta digitaalinen muoti on tietopohjaisempaa, yhteistyöllisempää ja tärkeää kasvavalle ei-kontaktiyhteiskunnalle. Päinvastoin perinteinen pikamuoti on kamppaillut monien haasteiden kanssa koko arvoketjussaan. Nouseva ei-kontaktiyhteiskunta edellyttää uusia digitaalisia ratkaisuja muotiteollisuuden edelleen muuttamiseksi. Digitaalisen muodin alue on vielä alkuvaiheessaan, ja alalle tarvitaan tiiviimpää tutkimusta ja paremmin määriteltyä karttaa. Tämä väitöskirja käsittelee näitä haasteita. Väitöskirjan empiirinen analyysi keskittyy muotiuudistusten muuttaviin suuntiin edistyneiden teknologioiden ja muotiteollisuuden yhteisevoluution myötä.

Tämä väitöskirja tutkii kehittyneen digitaalisen muodin kehityspolkua hyödyntäen oppimisen orkestraation ulkoisuusstrategiaa ja ehdottaa pilvipohjaista muotialustaa, joka käsittelee yksikanavaisia, monikanavaisia ja omnikanavaisia (kanavasta riippumattomia) toteutuskysymyksiä, johtaen kaksoisyhteisevoluutioon ja yliomnikanavaisuuteen. Lisäksi se poikkeaa aiemmista tutkimuksista tutkimalla uusluksusparadigman kehityskehystä. Löydökset tuovat esiin uusia näkökulmia innovaatioihin ehdottaessaan perinteisen sähköisen kaupankäynnin ylittämistä ja mahdollista siirtymistä metaversaaliin yhteiskuntaan. Monimutkaisen muotiteollisuuden digitalisaatio ei myöskään seuraa suoria polkuja, sillä on olemassa historiallisia dilemmoja, kuten ICT:n kaksinaismoraalisuutta edustava tuottavuusparadoksi, luksusbrändien Internet-dilemma ja ihmisten mieltymysten siirtyminen ylitoiminnallisuuteen ja estetiikkaan. Tuloksemme valaisevat digitaalisen muodin polkua muotiteollisuudessa mutta tarjoavat myös arvokkaita oivalluksia muille toimialoille ja ohjaavat tulevia poliittisia päätöksiä.

Avainsanat: oppimisen orkestrointi, tuottavuusparadoksi, digitaalinen muoti, tekoäly, kehittynyt digitaalinen muoti, yli-omnikanavaisuus, uusluksus, Amazon.

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PREFACE

Pygmalion meets Galatea

In the Roman Empire, around 8 CE, Publius Ovidius Naso, known as Ovid, mentioned the tale of Pygmalion and Galatea in his work Metamorphoseon. The word Metamorphoseon means metamorphosis or transformation. In it, Pygmalion, an artist and king of Cyprus, creates a unique sculpture named Galatea. The Greek goddess Aphrodite intervenes and softens the Galatea piece of art into life, uniting with Pygmalion. The Ovidius literature named "Metamorphoses" as one of the greatest examples of creative imagination (Bauer, 1962).

Metamorphosis resonates with the essence of the fashion industry, where artistic creation is reshaped by creativity and innovation. This metaphor suggests how the digital economy, driven by advancements in information and communication technologies, mutually transforms and revitalizes both technology and fashion. Against this backdrop, the coevolution of advanced technologies and fashion is transforming the industry. As we explore the coevolutionary dynamics of technological advancements embodied by Pygmalion and the artistic aesthetics of fashion represented by Galatea, it is clear that advancements in information and communication technologies have accelerated the fashion industry's transformation. Leveraging artificial intelligence, big data analytics, virtual experiences, augmented reality, and real-time personalization in the fashion industry can echo the themes of innovation and transformation reminiscent of the "Pygmalion and Galatea" narrative.

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Though brief, this acknowledgment encapsulates my profound gratitude to all who have been integral to this significant chapter of my life.

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EXPLANATION OF NEW CONCEPTS

Advanced Digital Fashion (ADF): The ADF concept can be defined as a new fast fashion business model that leverages digital innovation assets and the learning effects of preceding development. ADF is based on a series of seven Amazon-owned fashion technologies. It acts as prospecting soft innovation resources (SIRs), leading to neo-open innovation in balancing the two-faced nature of ICT (see Article II and Chapter 2 of this thesis).

Neo-open innovation: ADF has pioneered a new business model that uses external innovation resources. Neo-open innovation refers to a novel concept of innovation that ensures sustained growth. It avoids the challenge of declining productivity by increasing gross research and development (R&D) investments and incorporating SIRs by harnessing their vigor.

Supra-omnichannel: The supra-omnichannel concept refers to an integrated cloud-based platform arising from the coevolution of ADFs, luxury brands, and on-demand manufacturing. This integrated platform, boosted by the advancements in Amazon Web Services, enables seamless switching, on-demand personalization, and customization, bridging luxury exclusivity and Amazon's mass customization in a digital, non-contact society (see the introduction of Article III and Chapter 2 of this thesis).

Neo-luxury: In contrast to the prevailing concept that luxury brands should not be sold online, the concept of neo-luxury has been developed. Neo-luxury can be traced from the supra-omnichannel approach. During COVID-19, two trends were observed: (1) a decline in non-essential item sales, that is, apparel, and (2) store closures that raised the significance of digital space for luxury brands. Neo-luxury emerged from the coevolution between ADFs and luxury brands that joined Amazon during the COVID-19 period. The goal was to increase relative apparel intensity, which led to increased sales, further investments in R&D, and the Internet dilemma of luxury brands (see Chapter 2 and Article IV).

Soft innovation resources (SIRs): An innovation in goods and services that primarily affects aesthetic or intellectual appeal rather than functional performance.

GLOSSARY

ADF	Advanced Digital Fashion
AI	Artificial Intelligence
AR	Augmented Reality
AWS	Amazon Web Services
CV	Computer Vision
DL	Deep Learning
LGDCC	Logistic Growth within a Dynamic Carrying Capacity
ML	Machine Learning
ODM	On-Demand Manufacturing
RAI	Relative Apparel Intensity
SIRs	Soft Innovation Resources
SL	Statistical Learning
SLG	Simple Logistic Growth
VR	Virtual Reality

FIGURES

TABLES

LIST OF INCLUDED ARTICLES

I   Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2020). Fashion-driven textiles as a crystal of new stream for stakeholder capitalism: Amazon's endeavor. International Journal of Managing Information Technology, 12(4), 19–42.

II Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2021). Amazon's initiative transforming a non-contact society: Digital disruption leads the way to stakeholder capitalization. Technology in Society, 65, 101596.

III Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2021). Amazon's new supra-omnichannel: Realizing growing seamless switching for apparel during COVID-19. Technology in Society, 66, 101645.

IV Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2022). A new perspective of innovation toward a non-contact society: Amazon's initiative in pioneering growing seamless switching. Technology in Society, 69, 101953.

V   Akhtar, W., Watanabe, C., Tou, Y., & Neittaanmäki, P. (2022). A new perspective on the textile and apparel industry in the digital transformation era. Textiles, 2(4), 633–656.

Author contributions

The author of this dissertation, Waleed Hassan Akhtar, conducted this research under the direct supervision of Professor Chihiro Watanabe, who was involved in the research process as a co-author. Professor Pekka Neittaanmäki, the author's primary supervisor, provided consistent guidance, insights, and all well-needed resources throughout the research process. The contributions of the authors are detailed in the results of each article in Chapter 7.

CONTENTS

1   INTRODUCTION

In the modern technology-centric world, the digital economy is structured around three fundamental pillars: (1) foundational infrastructure, (2) electronic business processes, and (3) electronic commerce (Mesenbourg, 2001). Essentially, this structure encompasses the software and hardware necessary for conducting business operations electronically and facilitating online transactions. Advancing this foundation, the breakthroughs in information and communication technologies (ICT), as studied by Bergeron et al. (2004) and Sia et al. (2016), have catalyzed the development of sophisticated platforms and tools for optimizing business operations, thereby reshaping these three pillars of the digital economy. As more businesses increasingly incorporate advanced ICTs, technology firms, in turn, increase their research and development (R&D) investments to develop innovative solutions, as extensively elaborated by Watanabe and Tou (2019).

The iterative innovation in technology solutions is largely a response to the evolving needs of businesses (Bharadwaj et al., 2013; Nylén et al., 2015; Nair et al., 2020; Ojala et al., 2018). This dynamism represents mutual coevolution: businesses' growing dependence on ICT encourages technology firms to innovate and improve their offerings (Galliers et al., 2012; Vial et al., 2021). In this coevolution, both business and technology firms engaged in this virtuous cycle, aiming to grow and expand in a dynamic digital economy. This thesis examines this coevolution, particularly focusing on the ways it manifests within the fashion domain, with an in-depth analysis of Amazon's R&D endeavors and their profound impact on the fashion industry's growth and digital transformation.

Regarding the coevolution of businesses and ICT in the digital economy, it is evident that advancements in ICT are transforming and blending traditional boundaries among different sectors. Particularly noteworthy is the coevolution of emerging technologies and the fashion industry, a domain that has experienced significant digital disruptions in its transformative journey (Galliers, 2011; Yeow et al., 2018). This development can be traced from the earlier roaring engines of the first industrial revolution through the subtle advancements of the digital era to the contemporary Industry 4.0 revolution. These transitions represent significant socioeconomic and technological milestones. Driving this

digital transformation is a continuous stream of technological innovations driven by rapid advancements in ICT. The impact of ICT is evident in the rise of the digital economy and has been well-documented by researchers (Brynjolfsson et al., 2002). These advancements have introduced modern technologies, such as search engines, social networks, smartphones, e-commerce, and advanced digital platforms. These platforms have evolved to supplement human intermediaries, fostering a direct relationship between consumers and manufacturers (Brynjolfsson et al., 2002; Scholz, 2017). As advanced technologies increasingly replace manual and routine tasks, new business models are emerging in parallel, offering rapid and personalized solutions. Thus, the primary narrative is clear: the digital economy, driven by relentless ICT advancements, is revolutionizing how we live, consume, and interact with each other (Bodrožić et al., 2022; Flyverbom et al., 2019).

A prime example of an industry experiencing this transformation is the fashion industry, which is currently in a transformative phase. Although fashion is a social concept, some scholars suggest that the fashion phenomenon goes beyond mere clothing, and certain studies suggest that fashion is an overlapping field and should be independent of specific domains. Nonetheless, most studies relate fashion primarily to clothing (Akhtar et al., 2022; Aspers et al., 2013; Frings, 1987). The evolution of fashion represents itself as a sequence of recurring shifts in peoples' preferences, serving a particular purpose (Hurlock, 1929). The traditionally fragmented fashion industry has undergone significant transformation due to the strong impact of technological advancements (Anguelov, 2016). The fashion industry is interwoven with culture, economic development, and innovations. Its uniqueness lies in its capacity to build pioneering methodologies and innovation trajectories (Bertola, 2016). This progress has become an ideal context for exploring technological innovations, their implications, and their role in transforming economies, industries, and societies (Bertola et al., 2018; Bertola, 2021; Noris et al., 2021). These transitions shape fashion trends, with apparel playing a significant role in driving this transformation (Nakano, 2020).

Digital fashion, a transformative convergence of the virtual and real worlds within the fashion industry, is a product of technological advancements and shifting consumer preferences. Despite its growing significance with multiple interpretations, the concept of digital fashion has yet to attain a standardized definition and map. According to Baek et al. (2021), digital fashion explanations have changed over time. Initially, it was associated with e-commerce fashion platforms, but it soon expanded to encompass wearable computing devices (Berzowska et al., 2005; Park et al., 2001) and later incorporated virtual and 3D technology (D'Apuzzo, 2007). Most recently, its scope has broadened to non-fungible tokens and blockchains (Joy et al., 2022), metaverse (Kim et al., 2023), and custom designing with quantum computing (Akhtar et al., 2022; Qiskit, 2021).

At its core, **digital fashion** can be defined as the digital transformation of the entire fashion value chain, encompassing designing, manufacturing, and retail that foster innovations and the impact of digitalization on society (Nobile

et al., 2021). This transformation is not only about technology implementation but also about innovations that transform industry and society as a whole. The key driver of this transformation is digitalization, which in this context highlights the integration of digital technologies to create value and new business models (Gray et al., 2015; Gartner Glossary, 2023; Ojala et al., 2023). Digital fashion orchestrates the interplay between cyber and physical realms, fundamentally revolutionizing how people interact with fashion and styles. This shift involves a wide range of technologies introduced during previous industrial revolutions, encompassing the Internet, e-commerce, artificial intelligence (AI), wearable electronic devices and computers, virtual try-on, 3D modeling, and body scanning (Baek et al., 2022; Bertola, 2021; Fumo, 2015; Park et al., 2001).

The fourth industrial revolution, representing a paradigm shift, is leveraging new advanced technologies as the fulcrum for transformation across traditional industries. This revolution represents the integration of diverse technologies across other industries and disciplines, leading to a revival of the cyber realm within the physical world. Its value creation dynamics emphasize integrating advanced production and operations techniques with advanced tools (National Academies of Science, 2017; Nokia, 2023). Notably, the integration of advances in technologies and fashion has been a consistent motif, as noted in the work of Särmäkari (2023). Quinn (2002) noted, "Looking back over the past two centuries reveals how fashion itself can be considered to be a history of technology." This narrative is weaved with changing people's preferences from economic functionality to adapting supra-functionality beyond economic value, compounded by the emergence of a non-contact society during and after COVID-19, and catalyzing the transformation of the traditional analog fashion industry toward digital fashion (Bebchuk et al., 2023; Berg, 2022; Watanabe et al., 2020).

The emergence of a non-contact society during and after the COVID-19 pandemic necessitates a fundamental paradigm shift. It compels companies across various domains to transform their business models, incorporating innovative solutions to meet the demands of a post-pandemic non-contact society. This transformation is critical to responding to the shift in peoples' preferences toward supra-functionality and societal norms, ensuring sustained growth (Baber et al., 2020). For example, leading fashion companies are shifting their trajectories toward AI-driven advanced digital fashion (ADF) solutions to satisfy changing people's preferences for supra-functionality. Evidencing this shift, global AI investments in fashion have increased from USD 229 million in 2019 to USD 352.58 million in 2020. Projections indicate a valuation of USD 1260 million, with a CAGR of 40.8% by 2024 (Markets and markets, 2022). The USA holds a leading position in integrating AI into the fashion industry and fashion R&D, as well as in AI-driven fashion investments. AI investments in fashion in the USA alone were estimated at USD 375.8 million in 2022, and Amazon Web Services (AWS) and Amazon's Lab 126 are among the top solution providers (Research & Markets, 2023; Zou et al., 2021). Amazon's Lab 126 has developed an AI fashion designer, an algorithm that learns trendy styles from online images and videos and regenerates new styles from scratch (Knight, 2017). Amazon has made heavy

investments in its digital fashion business, which has enabled Amazon to be a leader in fashion retail, see Fig. 1.
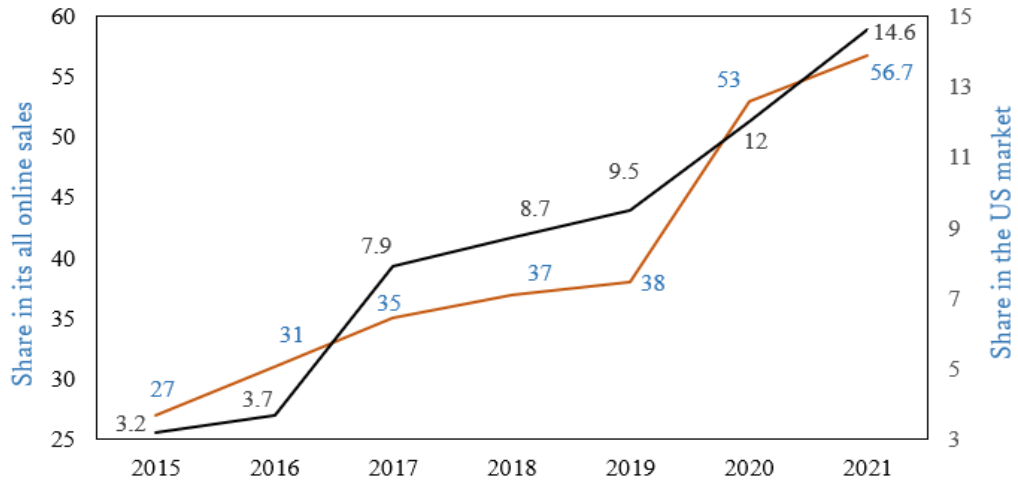
FIGURE 1.   Trends in Amazon's apparel sales share (2015 to 2021): percentage. Source: Articles II and V

Figure 1 illustrates the growing share of fashion sales in the domestic market. In 2017, Amazon emerged as the second-largest fashion seller, with a 7.9% share. In 2019, fashion became the most popular category, enabling Amazon to become a top fashion retailer between 2019 and 2021–2022. With this significant increasing inertia of the fashion domain, considering the robust growth of fashion, represented by significant income growth elasticity (see Fig. 7 in Section 3.2), Amazon recognized the opportunity to go beyond traditional fast fashion by introducing AWS-driven digital fashion solutions.

Considering the above background, digital transformation is often used to capture the interlinked and coevolutionary aspects of technologies that transform industry and society (Bodrožić et al., 2022; Hanelt et al., 2021). However, it is essential to note that advanced economies face the historic dilemma of increasing inputs and diminishing outputs. This reflects the dual nature of ICT in economic systems. The findings show that Amazon incorporates the vigor of external resources, such as soft innovation resources (SIRs), into its R&D-driven business model. This leads to the novel concept of neo-open innovations that maintain sustainable growth in business by avoiding the dilemma between R&D expansion and a decline in productivity (Watanabe et al., 2021a; Watanabe et al., 2022). Amazon is a leading technology company in diverse fields, excelling in cloud computing data storage by developing AWS and e-commerce. Unlike other online companies, its business models are complex and focus on rapid innovations. Developments in AI-driven technologies, including fashion, are one of Amazon's core strengths. Amazon Web Services (AWS) incubates new innovations, reflecting sociocultural, economic, and technological dynamics in society (Akhtar et al., 2022; Dubey et al., 2020; Watanabe, 2021b).

This dissertation introduces advanced digital fashion (ADF), a new fast fashion business model that leverages digital innovation assets and the learning effects of preceding development (Watanabe et al., 2021a, 2021b; Watanabe et al., 2022). These ADFs, along with their coexistence with other technologies, serve as the conceptual foundation of this research. AI has become a critical frontier of innovation in this ecosystem and has enabled revolutionary transformations in the fashion industry (Gartner, 2017; Noris et al., 2021; Seyed, 2019; Watanabe et al., 2021a). This technological forefront addresses many application innovations, from electronic retailing, personalized styling, big data analysis encompassing photos and videos, recommendation systems, trend forecasting, design systems, and social networks (Choi et al., 2019; Liang et al., 2020). Recent progress in augmented reality (AR) and virtual reality (VR) technologies has fundamentally changed the fashion e-commerce experience by enabling virtual try-on features. AR introduces virtual features into the real world, while VR offers an immersive virtual experience (Tan et al., 2021). The Internet of Things (IoT) has accelerated the development of intelligent clothing that incorporates embedded sensors (Chen et al., 2016). Similarly, the fashion industry's robotics, such as sew-bots, has contributed to sustainability and higher efficiency by reducing waste. One of the leading fashion groups is experimenting with digitalizing assets, such as non-fungible tokens, along with the upgradation of IT systems, platforms, and e-commerce (Wang et al., 2022).

Amazon's recent AI-driven fashion innovations, such as a series of ADFs acting as SIRs toward neo-open innovation, cloud-based fashion platforms, supra-omnichannel, on-demand manufacturing (ODM)-driven neo-luxury concepts, solutions to growing seamless switching, and its ambitions in the metaverse, hold significant potential in transforming the fashion industry (Akhtar et al., 2022; Watanabe et al., 2021a, 2021b; Watanabe et al., 2022). Given the above background, the emergence of the USA as a top R&D investor in AI technologies and Amazon's position as a world leader in R&D investments, a top digital fashion retailer, and a solution provider highlight the significance and potential of AI-driven innovations in the fashion industry, thus serving as the compelling focus for research within this domain.

The foundational objectives of this research endeavor are twofold. First, it aims to explore the way new advanced technologies are transforming the fashion world. This exploration is based on empirical investigations that understand the contribution of new advanced technologies in orchestrating the digital transformation of the fashion industry. Second, it aims to provide insights into the development of new AI-driven business models, paving the way for the transformation of the fashion industry. Hence, this work envisions the coevolution of technology advancements and fashion, where new advanced technologies are interwoven with fashion dynamics, redefining the emerging concept of digital fashion and creating new trajectories for growth in the digital economy.

1.1 Research objectives and motivation

In the digital economy, the ongoing debates on the evolution of the fashion industry are complex and significant due to its fragmented nature and complex value chain. It is a three trillion dollar industry, corresponding to 2% of the world's gross domestic product (GDP). The primary motivation for this research is rooted in examining the coevolution between advanced digital technologies and the fashion industry. This examination encompasses their influence on each other, mutual advancement, and, as a result, the emergence of new business models. This research endeavor is fundamentally oriented toward the exploration of digital solutions that are user-centric and operationally efficient. The following objectives guide this motivation:

1. Assessing digital solutions that transform the traditional analog fashion industry: This involves a comprehensive assessment of digital solutions transforming the fashion industry. Amazon is used as a case study to address research gaps and to suggest solutions for transformative directions.
2. Addressing the dilemma of the productivity paradox (higher investments in IT inversely correlating with declined productivity): This dissertation elucidates the trajectory adopted by Amazon in balancing this dilemma by turning crises into a springboard for new innovations without compromising growth.
3. Exploring the synergy between R&D transformation and digital solution: The synergy between R&D transformation and the role of digital solutions in shaping the transformative direction of the fashion industry is explored, and the role of AWS in driving fashion innovations is also investigated.
4. Enriching the boundaries of the scholarly domains encompassing fashion platforms, digital fashion, seamless switching and omnichannel, the age of meaning, metaverse, and stakeholder capitalization.
5. Unveiling new concepts that emerge by the coevolution of fashion and advanced technologies such as ADFs, supra-omnichannel, neo-luxury, and beyond e-commerce digital solutions.

Amazon is studied as a case because it is one of the largest ICT giants and R&D investors within the USA's big-tech GAFAM group (Google, Apple, Facebook, Amazon, and Microsoft). Amazon distinguishes itself as a leading web service provider in cloud computing, data storage, and processing with the development of AWS. Before its success, Amazon confronted historic failures in the digital fashion business. In its R&D infrastructure, referred to as technology and content development, Amazon invested USD 73.2 billion in 2022. Amazon applies the strategy of frontier innovation and company-wide experimentation, supported by increasing investments in "technology and content." This approach contributes to a big data collection system that effectively leverages users' data. Thus, Amazon and its users establish a virtuous cycle in which data drive the

transformation of "routine or periodic amendments" into "significant improvements" during the research and development process.

1.2   Research phases

The present work is completed in three phases. In Phase 1, the focus is on the fashion industry—how the classical cycle of continuous improvements is boosted by the systematic exploitation of the coevolution of supporting technologies. Amazon's fashion business is chosen as a case study due to its rapid developments in fashion technologies and its emergence as the USA's top fashion retailer, followed by historic failures in the digital fashion domain. This is examined in Articles I and II. The results of Phase 1 indicate that in advanced countries' R&D, intensive firms are often trapped in a vicious cycle of increasing investments and decreasing productivity, indicating the two-faced nature of ICT advancement. Amazon, a world leader in R&D investments, turned this dilemma into a springboard for new innovations in a non-contact society. The relationships and dynamics of critical variables in this success are proposed in a model. As a result, institutional systems enabled Amazon to develop Amazon's ADFs. This development is proposed in a framework reflecting Amazon's strategy of incorporating learning orchestration externality.

In Phase 2, the focus is on technology and its ability to boost innovations in the application domain. The objective is to develop conceptual frameworks that reflect Amazon's aims of providing customer-centric innovations. Detailed empirical analysis can be found in Articles III and IV. The results of Phase 2 extend the existing literature on multichannel and omnichannel. The development of the supra-omnichannel introduces a new concept of luxury and generative design-driven innovation (explained in Chapter 2). Phase 2 provides possible solutions to the problems raised in Phase 1. Amazon introduced a new platform, Luxury Stores, to offer a separate channel for luxury fashion. This advancement can be attributed to neo-luxury. By synchronizing ADFs, Luxury Stores and ODM can overcome the industry's reluctance to integrate emerging technologies. This research suggests how this combination contributes to the development of a cloud-based fashion platform, which leads to a supra-omnichannel approach. Phase 2 also demonstrates the significance of self-propagating generative functions, AWS advancement, and fashion platforms in fostering a dual coevolution. The findings suggest that the fashion industry can learn from Amazon's fashion strategies and use a similar approach to innovations in a non-contact society.

The synthesis of Phase 1 and Phase 2 culminates in Phase 3. So far, one article, Article V, has been published, with another forthcoming. The latter is not incorporated into this dissertation. There needs to be more research on the implications of metaverse on fashion. Phase 3 examines Amazon's digital fashion solutions, leading a path toward a beyond-e-commerce metaverse society, and how it can be achieved while using high-performance computing. Metaverse is a

rapidly evolving concept, and some top-tier fashion brands have begun experiments. Phase 3 suggests how the learning orchestration externality strategy contributes to the development of new solutions for a metaverse society.

1.3   Research questions

Based on this background, this research is guided by the question, How do digital technologies and the fashion industry co-evolve and give birth to new sustainable business models? The following questions address this problem:

RQ1   What are the critical socioeconomic, and technological factors that contribute to the digital transformation of the fashion industry?

RQ2   How AI driven R&D integrates consumer driven software innovation to transform the fashion industry?

RQ3   How do technological advancements and fashion innovations contribute to developing a cloud-based fashion platform, and how does this enable a more integrated omnichannel approach?

RQ4   How did Amazon's R&D approach in integrating AWS for developing ADFs and neo-luxury contribute to growth during COVID-19, and what implications does it offer for new business models in post-pandemic non-contact society?

RQ5   How do Amazon's latest fashion innovations and advancements in cloud computing provide sustainable solutions beyond e-commerce?

RQ1 is addressed in Section 3 and Article I. An empirical analysis of the coevolution of Amazon's R&D-driven business model and the fashion industry is constructed. It reveals the virtuous cycle of soft innovation resources and user-driven innovations, which leads to new functionality development and effectively solves the dilemma of balancing R&D expansion and a decline in productivity. This virtuous cycle gains momentum by integrating digital solutions and fostering robust coevolution between the fashion industry and digital solutions. This dynamism, in turn, creates unprecedented opportunities for stakeholder capitalism.

RQ2 is addressed in Section 4 and Article II. An empirical coevolutional analysis of Amazon's development of ADFs and the fashion industry is conducted. Two noteworthy problems—R&D expansion and decline in productivity, and the fashion industry's Internet dilemma, in which fashion companies are reluctant to integrate advanced digital solutions—are addressed. The development framework of a series of AI-driven ADFs that correspond to people's preference shifts and overcoming the dilemma between R&D expansion and sustainable growth and the implementation of ODM is proposed.

RQ3 is addressed in Section 2, Section 4, and Article III. An empirical analysis is undertaken, focusing on learning orchestration externalities that

enabled the development of a series of ADFs and luxury fashion brands. A theoretical solution is proposed: the coevolution of ADFs, Luxury Stores, and ODM leads to the development of a cloud-based fashion platform that solves customers' expectations of rapid on-demand personalization and customization. This virtuous cycle enables a dual coevolution, leading to the development of a supra-omnichannel.

RQ4 is addressed in Section 2 and Article IV. A techno-economic empirical analysis is undertaken, focusing on Amazon's ADFs and neo-luxury before and during the COVID-19 pandemic. The study demonstrated that Amazon's success rests on utilizing learning orchestration externalities through an iterative design process. Integration of AWS's self-propagating generative function further expands the supra-omnichannel strategy with seamless switching capabilities.

RQ5 is addressed in Section 2 and Article V. A comprehensive literature survey is carried out, and new theoretical solutions were proposed, such as incorporating high-performance computers that could shift traditional e-commerce practices toward metaverse.

In summary, Section 2 addresses RQ3, RQ4, and RQ5 by examining digital fashion innovations, ADFs' development, neo-luxury's emergence, and the development of cloud-based fashion platforms leading to supra-omnichannel strategies. Sections 1 and 3 address RQ1 by analyzing the fashion industry's evolution in response to cultural, societal, and technological advancements. Section 4 responds to RQ2 and RQ3 by examining the coevolution of fashion and advanced digital technologies, with a focus on AI and the digital transformation of the industry.

1.4   Thesis structure

The present dissertation is structured as follows: Chapter 2 discusses the significance of coevolution in the digital fashion domain that leads to the development of new business models such as ADFs, supra omni channel, and neo-luxury. Chapter 3 describes the fashion industry's philosophical and operational mechanisms. Chapter 4 discusses the transformative role of AI in fashion and the way Amazon solves the dilemma of the productivity paradox through ADFs. Chapter 5 describes the research methodology. Chapter 6 provides an overview of the original articles. Chapter 7 provides a summary of the articles, results, and authors' contributions. Chapter 8 concludes the thesis, followed by the original articles. This dissertation includes five published articles (see Figure 2).

Fashion Industry	Digital Fashion Innovations	Consumers

Phase 1: Explored the co-evolution between fashion industry and Amazon's AI Driven R&D Dynamism

Rapid transformation of fashion industry

Article 1: Fashion driven textiles as a crystal of new stream for stakeholder capitalism: Amazon endeavor

Dramatic development of digital technologies and platforms

- Evolution of fashion industry
- Structural impediments in fashion industry
- Need for digital solutions

- The development of fashion technologies
- Co-evolution between R&D transformation & digital fashion solutions

- Unprecedented shifting consumer preferences towards supra functionality beyond economic value during and post COVID-19

Article 2: Amazon's initiatives transforming a non-context society: digital disruption leads the way to stakeholder capitalization

- Emergence of ADFs model
- Co-evolution between SIRs & ADFs
- Learning orchestration externality strategy

- ADFs act as SIRs in solving dilemma of productivity paradox
- Leading to neo open-innovation

Phase 2: Explored novel business models encompassing ADFs, cloud-based fashion platform, supra omnichannel, neo-luxury

Article 3: Amazon's new supra-omni channel: Realizing growing seamless switching for apparel during COVID-19

- Emergence of cloud-based fashion platforms
- Co-evolution between ADFs, luxury brands and ODM
- Dual co-evolution leads to supra omni-channel approach

- Inferior mirage

Article 4: New perspective of innovation towards a non-contact society Amazon's initiative in pioneering growing seamless switching

- Solution to Internet dilemma of luxury brands
- Design driven innovations

- AWS as generative function
- Homeostasis & resonance management strategy
- Design driven innovation

- Cultural shift towards new era of meaning
- Neo-luxury

Phase 3: Proposed a new framework for future development of fashion industry in a metaverse society beyond e-commerce

Article 5: A new perspective on the textile and apparel industry in the digital transformation era

- Sustainable fashion industry

- Development of digital fashion technologies (AI, cloud computing, quantum computing, metaverse etc.), and business models beyond e-commerce
- Homeostasis and resonance management strategy
- Amazon's fashion solutions during COVID 19 pandemic
- High performance computing
- Amazon bracket-quantum computing
- Learning orchestration strategy towards metaverse society

- Exploring digital solutions beyond e-commerce

- Emergence of metaverse society

FIGURE 2.   Research framework and relationship between articles

2 DEVELOPMENT OF NOVEL CONCEPTS IN CO-EVOLUTIONARY DYNAMICS

In this chapter, the significance of coevolution is briefly discussed, a concept that has implications beyond biological sciences to reshape different disciplines, such as economics, digital innovation management, and ICT progress. This chapter explores Amazon's role in advancing digital solutions within the fashion industry. It explores the development trajectories of ADFs, the transformative approach of supra-omnichannel strategies in fashion, and the evolution of neo-luxury in response to technological advancements and shifts in consumer behavior accelerated by the COVID-19 pandemic.

2.1 Why we study coevolution

Originating in the biological sciences, the concept of coevolution demonstrates how species influence and change each other. This concept has been extended from biology to various other disciplines to understand human–natural world relationships, advances in socioeconomic systems, evolutionary economics, ecological economics, innovation management, and technological progress (Bergh et al., 2003; Norgaard, 1981; Norgaard, 1984; Norgaard, 2006; Watanabe et al., 2019; Watanabe et al., 2022; Winder et al., 2005). Moreover, this concept has been explored within various organizational settings (Hewitt, 1986; Hsieh et al., 2022; Marchionini, 2002; Okamura et al., 1994; Watanabe et al., 2009).

In the ICT context, coevolution is characterized by the dynamic relationship between evolving business domains and supporting ICT tools and frameworks encompassing software systems and platforms, among other elements. Technological infrastructure's flexibility and assimilation capacity in evolving business domains are essential in maintaining relevance. However, using advanced technologies is indispensable for businesses to achieve efficiency and growth. Thus, coevolution emerges as a sophisticated connection between business development and technological advancement. In response to the shift in people's preferences toward supra-functionality, businesses should be equipped

with the assimilation capacity to learn and promptly adjust their business models. This necessitates the need for significant improvements in ICT infrastructure. Digital technologies are rapidly advancing, and novel solutions are constantly emerging. These innovative developments pave the way for new innovations and catalyze the emergence of new business models. For instance, pioneering platforms such as Amazon have harnessed advanced technologies to optimize and expand their business operations (Jovanovic et al., 2022; Wardboys et al., 1999; Wardboys et al., 1999).

Fashion is a social phenomenon that mirrors societal changes. Nevertheless, a significant historic socio-technical gap exists, often referred to as "the divide between what we know we must support socially and what we can support technically" (Ackerman, 2000). Societal practices are flexible and encompass diverse perspectives, whereas technical systems are characterized by predefined functionalities and resistance to change (Hewitt, 1986; Marty, 2005). This divide highlights the challenges of combining evolving social dynamics and the inflexible nature of technological infrastructure. It is difficult for computer-mediated collaborative systems such as platforms to fully correspond to users' ever-changing needs. Users adjust their needs and preferences to fit within the system's boundaries and expect the system to change in fulfilling their needs. This dynamic relationship reflects coevolution (Marty, 2005).

Against this background, we have used the coevolutionary concept to describe how the fashion industry and advanced technologies change and advance each other and how new business models emerge with this coevolution. Due to the sociotechnical gap in the fashion industry, computer-mediated retail platforms—for example, online marketplaces, e-commerce websites, and subscription services—often do not offer features that perfectly cater to the evolving social preferences of consumers. As a result, consumers frequently adjust their fashion choices based on the offerings and limitations of these platforms. However, they expect these technological platforms to change and evolve with a continuously changing fashion and societal trends. Based on these shortcomings, we present a coevolutionary framework in which technology and fashion grow and reshape each other based on user's preferences.

Researchers often need help developing collaborative systems that co-evolve with changing user preferences because these needs cannot be predicted in advance. To address this problem, researchers have been conducting theoretical and conceptual research approaches (Schmidt, 1996; Marty, 2005). In light of the above background, our conceptual frameworks reflect coevolution and dual coevolution.

2.2   Concept of ADF development

Numerous studies have examined the identical characteristics of fashion and the fashion industry, as well as analyzed Amazon's R&D dynamism from both technological, operational strategy, and financial management perspectives, but

their coevolutionary advancement, which has led to the development of digital solutions for the fashion industry, is missing in the literature (Burns et al., 2016; Christopher et al., 2004; Tou et al., 2019; Watanabe et al., 2019). Amazon's business model is based on customer-centricity. Through this approach, it seeks company-wide experimentation and frontier innovations to expand its influence and develop an extensive big data collection system. This strategy results in significant user interaction, prompting innovation driven by users' input within the framework of active participation. Additionally, it demonstrates an impressive assimilation ability to absorb and integrate new ideas and technologies based on high investments in R&D. This enables harnessing users' power who seek SIRs, as demonstrated in Figure 3.
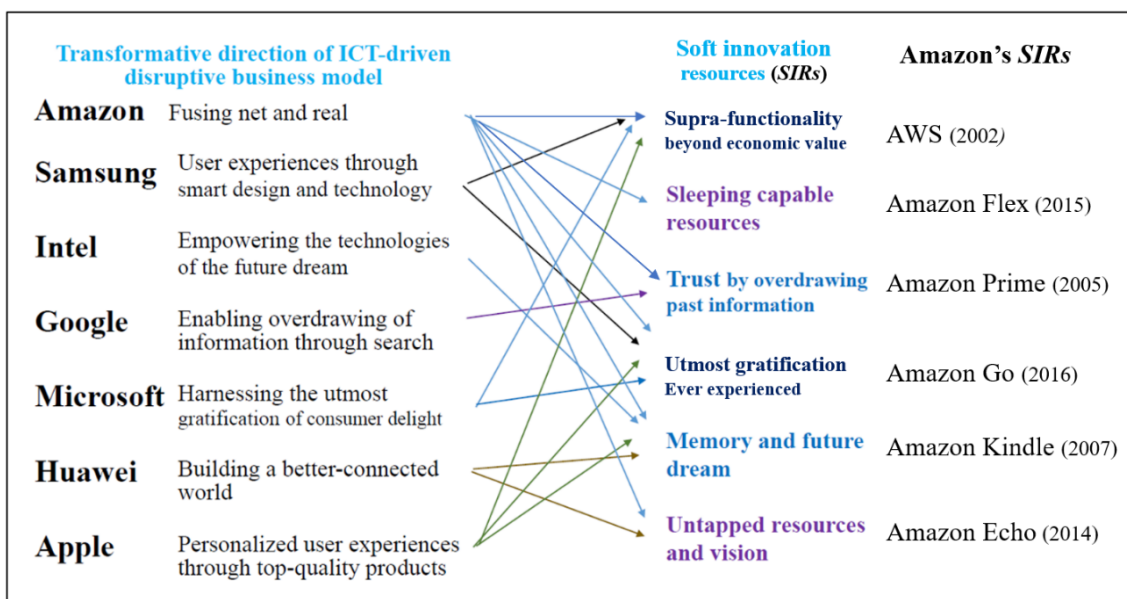
FIGURE 3.   Soft innovation resources from global ICT leaders: Notable instances in Amazon

Figure 3 illustrates Amazon's approach to innovation, representing the trajectory in which Amazon efficiently combines innovative business models with higher investments in R&D. Amazon blurs the line between digital and physical—that is, it fuses the net and the real—in developing a virtuous cycle of innovation that strengthens its market dominance, capabilities of data collection, and architecture of participation through different channels, such as AWS, Kindle, Alexa (Echo), Amazon GO, Amazon Prime, and Amazon Flex. This approach to innovation and the assimilation of SIRs fuels the neo-open innovation model. By continuously investing in R&D and assimilating new insights, Amazon maintains a growth trajectory in the digital economy. These SIRs correspond to shifts in consumer preferences from economic functionality to supra functionality beyond economic value and Amazon's success in balancing the dilemma between investments in R&D and sustainable growth.

Fashion advances all of these SIRs, as demonstrated in Fig. 3, leading to further advancement of the fashion industry. Amazon's approach to the fashion

industry has evolved into a new business model, such as ADFs, by introducing Prime Wardrobe, AI Algo. Fashion designer, Echo Look, AR mirror, Personal Shopper, Style Snap, and Drop. These initiatives serve as a crystal of SIRs and exist in Amazon's sophisticated virtuous cycle. These developments have enabled Amazon to shed its uncool image in the fashion industry. The development trajectory of ADFs while using the concept of learning orchestration externality can be found in Fig. 10 (see Section 4.3). Fashion advances the development of SIRs, contributing to the continuous advancement of the fashion industry. Consequently, Amazon strives for coevolution between the development of SIRs and progress in fashion, as depicted in Fig. 4.

Customer's pre-ferences shift	Soft innovation resources (*SIRs*)	Amazon's innovation	Advanced digital fashions (*ADFs*)
Social	Supra-functionality, SDGs	AWS	Prime Wardrobe
Cultural	Sleeping resources	Amazon Flex	AI Algo. Fashion Designer
Aspirational	Fostering trust	Amazon Prime	Echo Look
Tribal	Most gratification ever experienced	Amazon Go	AR Mirror
Emotional	Memory and future dreams	Amazon Kindle	Personal Shopper
	Untapped resources and vision	Amazon Echo	Style Snap
			The Drop

FIGURE 4.   The coevolution between SIRs and advanced digital fashion development

In a non-contact society, the broader field of "digital fashion" is growing dramatically, indicating the demand for innovative solutions in the fashion industry. However, it lacks a clear map or framework, suggesting a need for more structured and systematic approaches. We define ADFs as a new fast fashion business model that leverages digital innovation assets and the learning effects of preceding innovations. With seven AI-based software, hardware devices, and services, ADFs stand out as a specific subset (a new business model) within the broader digital or virtual fashion scope.

Although there is overlap between the two areas, ADFs diverge by integrating Industry 4.0 technologies, real-time customer response, learning orchestration externality, and neo-open innovation principles. They go beyond surface-level digitalization, introducing concepts such as virtual try-ons, avatar-driven fashion recommendations, personalized curation with designers, and algorithm-based designs without human supervision. These characteristics make ADFs a powerful subject for research in this dissertation.

2.3   Supra-omnichannel development

Traditionally, omnichannels, and supra-omnichannels share overlapping goals related to seamless switching and unified experiences across cyber and physical platforms. Problems associated with omnichannel alternatives have been

addressed in several disciplines, including marketing, operations, and information technology (Hajdas et al., 2022; Simone et al., 2018). However, traditional omnichannel businesses confront challenges such as cross-channel switching, higher cost of physical realms, and data security and privacy. Hence, there is a growing need for a supra-omnichannel model. Coined by us, a supra-omnichannel goes beyond traditional omnichannel approaches to a high level of sophistication, advanced technology integration, and the exploration of new models.

Amazon's digital fashion solutions, built on cloud platforms, embody a paradigm shift from traditional value chains. These solutions offer interactive real-time recommendations and algorithmic personalization with A/B testing and address the hesitations of luxury brands, enabling ODM. This innovation promotes coevolution among ADFs, luxury brands, and ODM, leading to the development of cloud-based fashion platforms, as illustrated in Fig. 5.
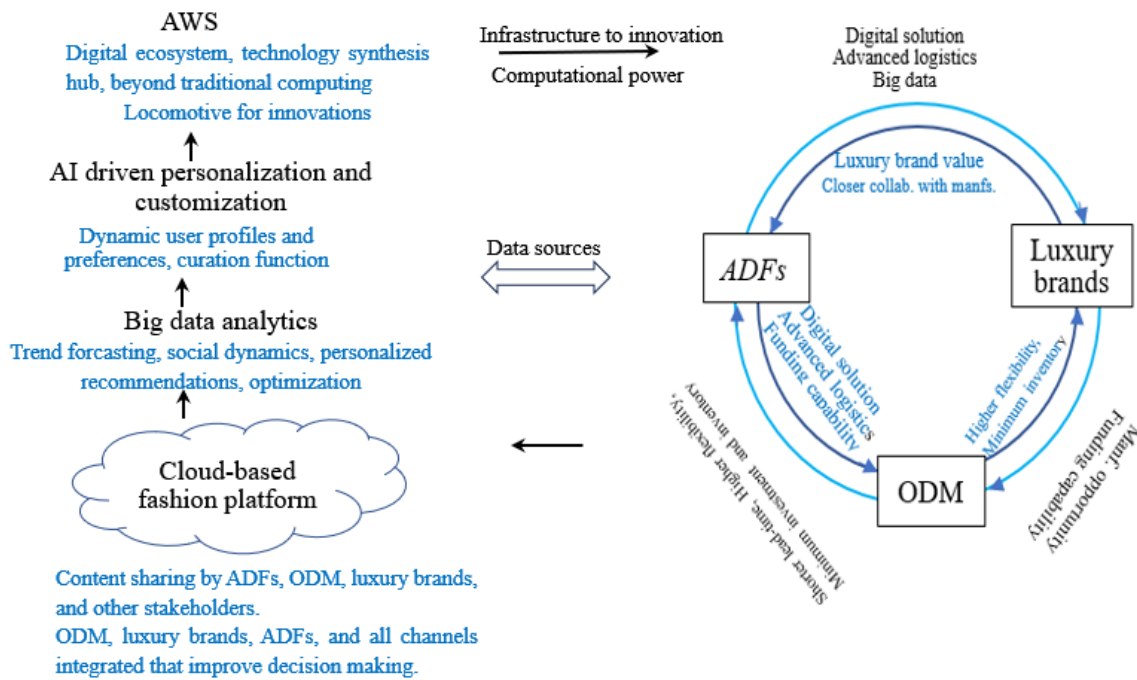
FIGURE 5.   Dual coevolution among ADFs, luxury brands, ODM coevolution, and cloud-based fashion platform advancement. Source: Article III

The above-mentioned platform solves the historic Internet dilemma of luxury brands through ODM integration. Through synchronization between ADFs, ODM, and luxury brands, this platform suggests an integrated cloud-based marketplace. This coevolutionary approach offers on-demand customization and personalization to every individual user. It collects big data from diverse sources, such as consumers, suppliers, and societal trends, for example, among Amazon's ADF AI Algo. Fashion designers continuously learn and update from web-based global fashion trends. Subsequently, these data, in turn, enhance the functionality of the platform's cloud infrastructure, rendering it more efficient and adaptive through the learning orchestration externality approach. Due to Amazon's

higher assimilation capacity in its R&D-driven business model, its infrastructure absorbs digital innovation assets and soft innovation resources from diverse sources. This self-optimization fuels its growth and increased efficiency while providing solutions to customer's needs. The optimized cloud-based fashion platform accelerates coevolution among ADFs, luxury brands, and ODM. This cyclic reinforcement between the platform's advancement and the mutual growth of its components propels a positive feedback loop, leading to a dual coevolution. There is coevolution among ADFs, luxury brands, and ODM on one layer. Simultaneously, in another layer, the advancements of the cloud-based platform are continually shaped by this triangle's progression. This progress leads to the development of a supra-omnichannel that not only resolves the historic dilemma of luxury brands but also encourages users to produce their desired fashion individually. Through this dynamism, new innovations emerge that are highly user centric.

2.4 Emergence of neo-luxury

Historically, luxury brands have been confronting the Internet dilemma—that is, the conundrum of whether luxury brands should avoid online sales (Kapferer et al., 2012; Kapferer, 2015). However, concerns over exclusivity, direct relationships with customers, and quality made them cautious adopters in the digital realm. The emergence of tech-savvy customers and the challenges that emerged during COVID-19 have intensified the necessity for innovative digital solutions to reconcile with evolving market dynamics. The COVID-19 pandemic has recently led to a paradigm shift toward a new normal state as a non-contact society. It was observed that the demand for non-essential retail items, including apparel, dropped significantly. Further, the demand for overcoming the Internet dilemma of luxury brands increased due to regulations and store closures. This enabled Amazon to develop digital solutions for luxury brands. Due to the decrease in apparel intensity and the increase in online sales share, the need to increase the intensity of luxury brands becomes evident (Article IV). This can be achieved by addressing the Internet dilemma of luxury brands with digital solutions, for example, through the coevolution of ADFs and luxury brands that joined Amazon during COVID-19, as illustrated in Fig. 6.
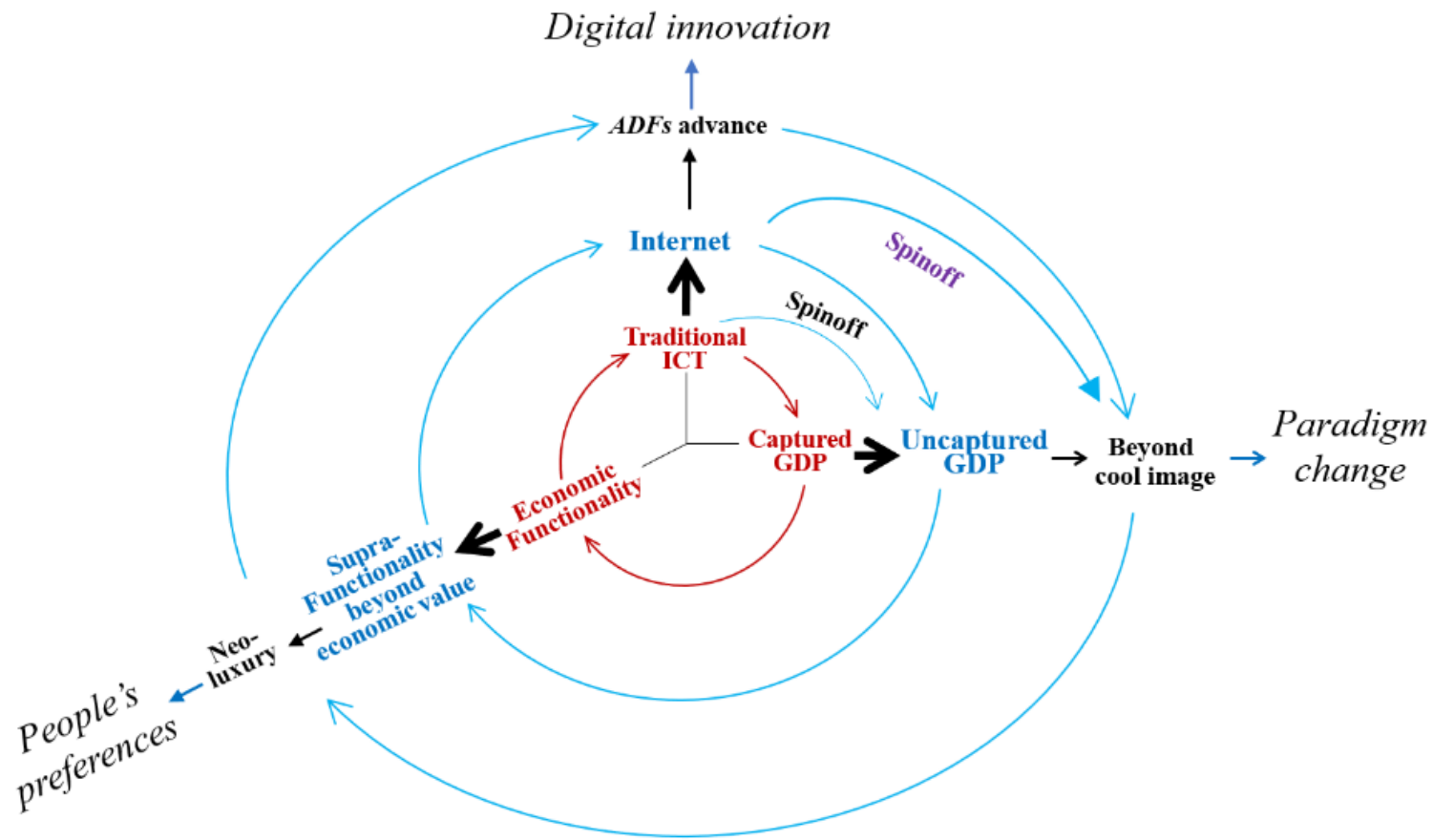
FIGURE 6.   Co-evolutionary development of neo-luxury. Source: Article IV

This coevolution is a spin-off from the prior coevolution among digital innovation, paradigm shifts, and consumer preferences. This strategic move comes as Amazon addresses structural barriers and collaborates with luxury brands while offering a new platform—Luxury Stores. As we move into the age of meaning, where emotional and symbolic connections are significant, the role of digital solutions becomes more critical. According to our research, advanced digital platforms allow brands to create immersive, personalized online experiences. We explore digital solutions through a cloud-based fashion platform where ADFs, ODM, and luxury brands co-evolve in the digital space. Luxury brands can benefit by providing immersive experiences and optimized supply chains. The rise in relative apparel intensity supports sales growth, further R&D investments, and improved online sales of luxury brands.

3 PERSPECTIVES ON FASHION EVOLUTION

In this chapter, the complex ecosystem of the global fashion industry is analyzed, presenting historical and philosophical explanations I the context of the industry's global operations. The chapter explores the fashion industry's significant advancement influenced by cultural, societal, and technological shifts; the discussion examines the contemporary fast fashion industry that necessitates integrating digital solutions. Here, the entire value chain is explored, acknowledging the advancements and challenges that define the current and future state of fashion.

3.1 Fashion system

Fashion has been a topic of academic discourse for centuries, encompassing both favorable and unfavorable schools of thought. In Europe, French scholar and philosopher Jean-Jacques Rousseau (1712–1780) linked fashion with materialism and viewed it as an opposing force that destroys values and thoughts (Kawamura, 2005). Nonetheless, the term "fashion" encompasses varying interpretations. The pioneering works of Georg Simmel (1858–1918), a sociologist and philosopher, laid the foundation for understanding the different dimensions of fashion. He noted that fashion constantly transforms, and innovation and assimilation are vital. It can be related to clothing, is a social phenomenon, and represents changes in people's preferences in a society, enabling the capture of innovations from the past (Simmel, [1904] 1971, 1957). Hansen (2004) noted that fashion reflects arts, social structure, and cultural advancements. Zorbaugh (1929) indicated that fashion and transformation happen "too rapidly." Tungate (2012) stated that fashion goes beyond apparel and plays a significant role in expressing people's identities and lifestyles. Style is the main product of the fashion industry and an "obligatory transformation of taste" (Cappetta et al., 2006; Simmel, 1985).

According to Abernathy et al. (1999), apparel can be divided into three categories: fashion, fashion basic, and basic. They view fashion as apparel made

for one short season, and the rest of the categories vary for different periods. Consequently, this interplay reflects the aesthetic, socio-economic, and cultural dynamics of peoples' lives, resonating within the domain of apparel fashion (Bertola, 2016; Langevang, 2017; Tigert et al., 1976; Torán et al., 2018). These dimensions represent the meaningful nature of fashion within this research's context, and the fashion industry encompasses textiles, apparel, and related fashion products. Fashion's nature is characterized by complexity and multifaceted dynamics; its growth progresses through several societal acceptance stages before becoming a trend. For a long time, fashion research has been neglected by scholarly attention, with scholars hesitant to investigate the way people consume and express their identities through fashion (Kawamura, 2005; Niessen et al., 1998).

3.2   Contemporary fashion industry

Originating in the USA and Europe, the fast fashion system enables companies to react profitably to changing market demands. Today, fast fashion is a globalized and outsourcing-based industry with complex networks. Before the mid-19th century, fashion products were custom-made. However, during the 20th century, technological innovations in fashion production, such as sewing machines and spinning machines, and the emergence of electronic and digital technologies initiated the industry's transformation toward a factory-oriented low-cost mass production system (Brooks, 1979). Until then, the USA maintained a strong domestic apparel industry, contributing to significant economic growth. However, due to rising costs, socio-economic conditions, and the globalization of supply chains, the industry has shifted to low-cost developing countries. Despite this shift, which led to a decrease in employment, the industry corresponds to global economic growth and to changing people's preferences toward supra-functionality. This trajectory gave rise to the concept of outsourcing while focusing on changing people's preferences (Doeringer et al., 2006). These shifts led to the emergence of a fast fashion system. The contemporary fast fashion model encompassing trendy, luxurious products was initiated in the 1980s by global fashion retailers. In this model, fashion designs are developed in one country, manufactured in another, and sold in global retail stores at low prices (Steele, 2005).

The digital transformation of contemporary fast fashion began in the early 21st century with the rise of social media, smartphones, e-commerce expansion, cloud computing, and AI. In 2020–2021, the fashion industry's growth rate reached 21% in revenues (MC Kinsey & Company, 2023). Recently, the global consumption of fashion products has experienced a twofold increase. Moreover, the global fashion market is estimated to reach $2.25 trillion in 2025 (Centobelli et al., 2022; Shirvanimoghaddam et al., 2020). The market size of the global fashion industry experienced significant growth, rising from $1.05 trillion (2011), $1.25 trillion (2015), $1.4 trillion (2017), and $1.65 trillion (2020). The USA and the

EU contributed 40% of the combined figure. Notably, the growth of the apparel industry has been faster than the growth of the global economy. The global economy, particularly between 2011 and 2015, exhibited notable trends in the fashion industry, as reflected in the growth rates and GDP elasticity calculations. During this period, the global GDP grew on average by 2.7%, and the apparel sector outpaced this with a growth rate of 4.70%. More noticeable, however, was the performance of the fast fashion sector, which experienced a significant surge in market share as illustrated in Fig. 7.

Elasticity of GDP to Textile and Apparel
$$\varepsilon_{AG} = \frac{5}{3} = 1.66$$
Elasticity of GDP to Fast Fashion
$$\varepsilon_{FG} = \frac{11}{3} = 3.66$$
Elasticity of Textile and Apparel to Fast Fashion
$$\varepsilon_{FA} = \frac{11}{5} = 2.2$$
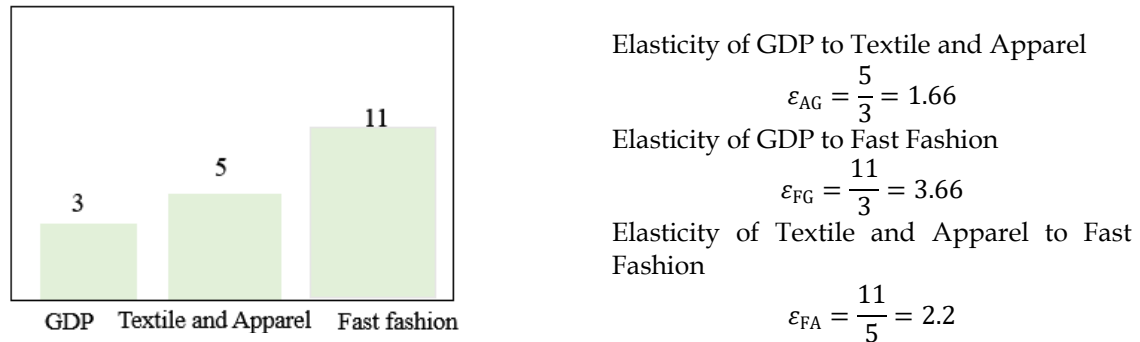
FIGURE 7. Comparison of the average growth rate of the global GDP, total textile and apparel, and fast fashion (2011-2015). % p.a. Source: Articles I and V

Figure 7 provides a quantitative analysis through graphs and elasticity calculations. It represents the specific relationships within the fashion industry subsectors and their response to GDP changes. The Elasticity of GDP to Textile and Apparel (EAG) is computed as 1.66, suggesting a relatively proportional response within this sector to changes in GDP. It suggests that 1% increase in GDP might be expected to result in a 1.66% increase in the sector's output. This is a critical insight, as it represents the sensitivity of the textile and apparel sector to economic conditions. However, the fast fashion sector exhibits a more dynamic response to GDP. The Elasticity of GDP to Fast Fashion (EFG) is calculated at about 3.66, indicating that the fast fashion sector is relatively more sensitive to GDP changes compared to the broader textile and apparel sector. This means that a 1% increase in GDP would likely lead to a 3.66% rise in the output of the fast fashion sector, a figure representing the sector's elastic nature. Moreover, the relationship between the textile and apparel sector and the fast fashion industry is highlighted by the Elasticity of Textile and Apparel to Fast Fashion (EFA), which is at 2.2. This ratio indicates that for each 1% increase in the textile and apparel sector, there is a corresponding 2.2% increase in the fast fashion sector's output, illustrating an intricate relationship between these two segments of the fashion industry. The analysis suggests that the fashion industry's growth and its relationship with global economic trends reveal an interdependent structure. The fast fashion sector grows faster and demonstrates a higher sensitivity to global economic conditions. It is a critical factor that fashion industry's stakeholders must analyze during the forecasting and planning phases.

In summary, this mathematical representation provides valuable insights into the economic behavior of the fashion industry, highlighting how different sectors are variously impacted by changes in broader economic conditions. Such insights are crucial for stakeholders in the fashion industry, including policymakers, investors, and customers, as they navigate the complex economic environment and make informed decisions.

3.3   Fashion industry's value chain

Technological advancements have enabled innovations in natural and synthetic raw materials, which have contributed to removing distinctions between fashion and apparel (Anguelov, 2016). This indicates the initial stage of the fashion value chain, where R&D leads to material production innovations. This innovation also encompasses the development of environmentally safe raw materials. The traditional fashion industry is a segment of the broader fashion system that encompasses cultural and social aspects that embrace commercial and aesthetic aspects (Ciarniene et al., 2014). It covers the entire value chain, including design, production, distribution, retail, and disposal, as illustrated in Fig. 8.

Upstream

Downstream

Fashion design

Textile industry

Service providers

Apparel industry

Retail industry

Research and design   Raw material production   Primary production   Distributors   Clothing production   Distributors   Retailers   Consumers

| R&D Product Design | → | Fibers and materials procurement | → | Spinning Weaving Dyeing | → | Logistics | → | R&D Cut / Sew Packaging | → | Ready to wear Apparel. | → | Distribution Sales | → | Consumption Dispose |

FIGURE 8.   Value chain of the fashion industry

The value chain of the traditional fashion industry is multifaceted, with several complex networks spread worldwide, particularly in developing countries, where working conditions are substandard and unhealthy (Niinimäki et al., 2020). The value chain consists of four distinct levels. The first level deals with producing and procuring natural and synthetic raw materials. These raw materials consist of fibers and other relevant accessories. The second level deals with primary production, where fabric formation takes place. In the third level, the designs that resonate with market demand are transformed into actual fashion products. Contract manufacturers carry out this process and ship fashion products to brands or retailers. Strategically positioned retailers then showcase the fashion products. In the final stage of the value chain, marketing and promotional activities occur. Each tier acts independently yet is controlled by buyers. Hence, the value chain of the traditional fast fashion industry is long and complex. Maintaining environmentally friendly practices throughout the supply chain is a massive challenge for fashion brands (Abernathy et al., 1999; Gereffi et al., 2003; Niinimäki., 2023).

3.4 Characteristics of the fashion industry necessitating digital solutions

The fast fashion industry's fundamental challenges lie in complex global manufacturing networks with rapid production cycles and long lead times. The lead times are longer than customers are prepared to wait. Longer lead times limit responsiveness and lead fast fashion companies to rely on forecasting and increased seasonality. The features that have transformed the industry into fast fashion are illustrated in Fig. 9.

FIGURE 9.   Key characteristics of traditional fashion industry seeking digital solutions. Source: Authors' own elaboration based on Bhardwaj et al. (2010) and Ciarniene et al. (2014)

The fundamental feature of fast fashion encompasses season-based mass production at lower prices in a near real-time manner. Moreover, it is attributed to low quality and waste generation (Niinimäki, 2023). Adopting and implementing agile and lean manufacturing systems, ODM, digitalization and automation, supply chain transparency, and data-driven decision-making are expected to reduce intermediaries in a fashion production and consumption cycle. The digital economy complements these solutions and contributes to the fast fashion industry in becoming more responsive and environmentally friendly, and satisfying people's preferences shifts from economic functionality to supra-functionality beyond economic value (Watanabe et al., 2020).

4 DIGITAL TRANSFORMATION AND ITS IMPLICATIONS

This chapter explores the synchronization of fashion and digital innovation, emphasizing how AI technologies are reshaping the industry toward digital fashion. It examines the productivity paradox and discusses possible solutions for overcoming this dilemma. Attention is given to Amazon's strategic use of data, AI, and Industry 4.0 technologies to craft a new digital frontier in fashion. Moreover, a framework of a learning orchestration strategy for developing ADF solutions is provided.

4.1 Productivity paradox in the digital economy

The digital economy is growing at an impressive rate, advancing GDP growth. However, the rate of productivity improvement has been less significant. This discrepancy reflects the observations made by Nobel Laureate Robert Solow's postulate of the productivity paradox or computer paradox, which emerged in 1987. Solow (1987) noted that, "You can see the computer age everywhere but in the productivity statistics" (see also Acemoglu et al., 2014; Claeys et al., 2021). Brynjolfsson (1993) further examined this postulate by dividing it into four categories: (a) mismeasurement of outputs and inputs, (b) lags due to learning and adjustment, (c) redistribution and dissipation of profits, and (d) mismanagement of information and technology. Later, Brynjolfsson and McAfee (2011) challenged the theory of productivity paradox, suggesting that USA institutions have been and will be transformed by ICT investments.

Brynjolfsson and McAfee (2011) also found that ICT-intensive firms enjoy higher growth and productivity, and that the digital economy is intended for greater productivity by reducing routine and manual tasks (Acemoglu et al., 2014; Brynjolfsson et al., 2011). Moreover, in 2012, the total market capitalization of oil giants such as Shell, British Petroleum, Exon, and Chevron was overtaken by technology giants such as Amazon, Apple, Facebook, and Alphabet. This was

because ICT giants realized that "data is a new oil," and computing power advanced from mathematical calculations to real-time communication devices (Kodama, 2018).

According to Brynjolfsson et al. (2018), AI-related productivity discussions are categorized into two groups: optimists and pessimists. They found that technologists and venture capitalists are optimistic, whereas economists, sociologists, statisticians, and government officials are skeptical regarding the direct correlation between technology investment and productivity improvement. Although both groups conveyed opposite views, the authors considered it part of evolution, not as conflicting statements. They theorized that rapid advancements in AI have significant potential for economic growth and productivity. Moreover, they suggested that traditional measurements such as GDP need to be readjusted to reflect the value of AI. Bonsay et al. (2021) examined the relationship between GDP and AI in China, Singapore, Japan, and India. They suggested that AI is designed to improve productivity and economic growth. AI-oriented growth is improved through trade regulations and the proper integration of AI, as examined in Japan.

In the Industry 4.0 context, due to the availability of high-quality data and recent advancements in data analysis methods, there are positive results of technology that were previously not envisioned. As Industry 4.0 is an emerging concept, more research is needed to understand its potential to improve productivity (Furstenau et al., 2020; Moeuf et al., 2018; Oztemel et al., 2020).

4.2   Evolution and emergence of digital fashion

Technological innovations have been transforming the fashion industry, ranging from water and steam power technologies during the initial Industrial Revolution to the widespread adoption of electricity during the Second Industrial Revolution and the rise of ICT and electronics during the Third Revolution. The digital economy has affected all facets of the fashion industry, from design and production to consumption. It has transformed predictions, trend analysis, customer engagement through platforms, and new fashion experiences through virtual try-on and demand-driven personalization (James et al., 2016; McQuillan, 2020; Noris et al., 2021; Watanabe et al., 2021b). On this premise, the trajectory of technological development has influenced the transformation of traditional fashion practices, evolving from sewing machines and power looms to digital fashion and, recently, AI-driven fashion (Ghobakhloo, 2018; Kawamura, 2023; Watanabe et al., 2021a). Amid transformative periods, numerous structural changes and new fashion cycles have emerged, fueled by the rapid development of new technologies.

Traditionally, the fashion industry is based on a mass production approach, in which professional designers shape styles in Europe, while production is completed through complex and fragmented value chains in Asia. Nowadays, technology has disrupted this equation; due to the Internet for democratizing

design creation, anyone with a mobile phone or computer can curate their own styles (Breward et al., 2005; Watanabe et al., 2021a). However, the definitions of digital fashion have changed based on continuous technology development. Some pioneering technologies accelerated the digital transformation of the fashion industry, as illustrated in Table 1.

The definitions and applications of these technologies are influenced by the changing nature of the fashion industry. However, the term digital fashion was first used with the rise of e-commerce platforms (Baek et al., 2022).

TABLE 1. Pioneers in digital fashion transformation

Enablers	Functionality	Source
Wearable technology	Smart electronic devices healthier lifestyle, monitoring services	Ferreira et al. (2021)
3D body scanning	Aesthetic possibilities, 3D shapes, 3d measurements, mass customization, visualization	D'Apuzzo et al. (2007), Isatook et al. (2001)
3D printing	Additive manufacturing, mass customization, open source designs, on-demand personalization	Shahrubudin et al. (2019)
Computer aided design (CAD)	Enhanced design process, 3D prototyping, collaboration, 3D simulation	Burke et al. (2015)
Robotics	Customization, material handling, quality, manufacturing process, fulfillment, on demand manufacturing, data collection and analysis	Song et al. (2021), Christensen et al. (2021)
Virtual try on	Contributed to the hedonic dimension of online shopping, entertainment, virtual modeling, can be combined with other technologies for virtual try and fit, AR/VR	Kim et al. (2008)

4.3 Amazon's strategy in orchestrating advanced digital fashion technologies

The contemporary era is being transformed by data-driven computational technologies, such as Industry 4.0 (Bodrožić et al., 2022; McKinsey& Company, 2022; Nobile et al., 2021). Amazon incorporates data-driven fashion design, where customer preferences data can inform fashion technology development. Amazon has been at the forefront of developing Industry 4.0 technologies and their integration into fashion. Driven by data, Industry 4.0 further advances the scope of previous digital innovations by seamlessly integrating AI into its recommendation systems, Amazon Go, Alexa, etc. AR is used in Amazon apps to visualize online products in physical space. VR is used for virtual shopping experiences. IoT is used in its hardware devices and AWS-IoT. Robotics in fulfillment centers and cloud computing represent AWS. These forefront enablers have broader implications extending to decision-making,

responsiveness, and human-machine interaction in producing high-quality products and services that satisfy changing people's preferences (Kipper et al., 2021; Maier., 2017; Sun et al., 2021). This dynamic ecosystem of advanced technologies represents their interconnected and coevolutionary nature, and their broader implications extend beyond production processes (Bughin et al., 2018; Schwab, 2016).

Amazon's basic principles for its R&D advancements are:

1. Customer-centric R&D-driven advancement: Its R&D is based on users' preferences data.
2. Frontier innovation and company-wide experimentation: This emphasizes innovation, technology breakthrough, experimentation, and big data collection systems.
3. User-driven innovation: Interaction with users via technology, the architecture of participation, and a high level of assimilation capacity based on high R&D investments.

Amazon's business strategy is based on an intensive R&D approach with a customer-centric orientation that has noticeably synchronized AI into its operations and fashion product lines. This integration of AI is beyond functional; it is hierarchical, resonating with people's cognition and decision-making processes. AI is Amazon's strategic tool that enhances its ability to satisfy people's needs in real time, provide personalized experiences, and streamline its offerings. Central to this approach is the concept of learning orchestration externality, which Amazon employs for innovation by using learning effects from the challenges across the three pillars mentioned above. By collecting big data and insights gained from preceding innovations, Amazon incorporates the multilevel application of AI. This approach represents Amazon's learning orchestration strategy.

Moreover, Amazon has transformed its business model from network externality to big data externality. This represents the crux of learning orchestration externality, in which big data is a dynamic and intellectual asset that powers digital innovations. This transformation suggests that learning not only reflects internal organizational processes but extends beyond to accelerate industry-wide improvements that further transform the whole ecosystem. This is not an isolated strategy; it demands the involvement of broad stakeholders and external resources. Therefore, by integrating customers, soft innovation resources, partners, and competitors into the learning loop, Amazon has expanded its fashion empire. Due to COVID-19, the emergence of a non-contact society has intensified the need for Amazon's learning orchestration strategy, especially in areas such as digital fashion and ODM.

Amazon's strategy is tuned with societal trends, harnessing learning externalities to shape emerging trends and consumer behaviors. Central to this transformation are the concepts of Amazon's ADFs (Watanabe et al., 2021b). The aim of developing ADFs serves as a typical case, as illustrated in Fig. 10.
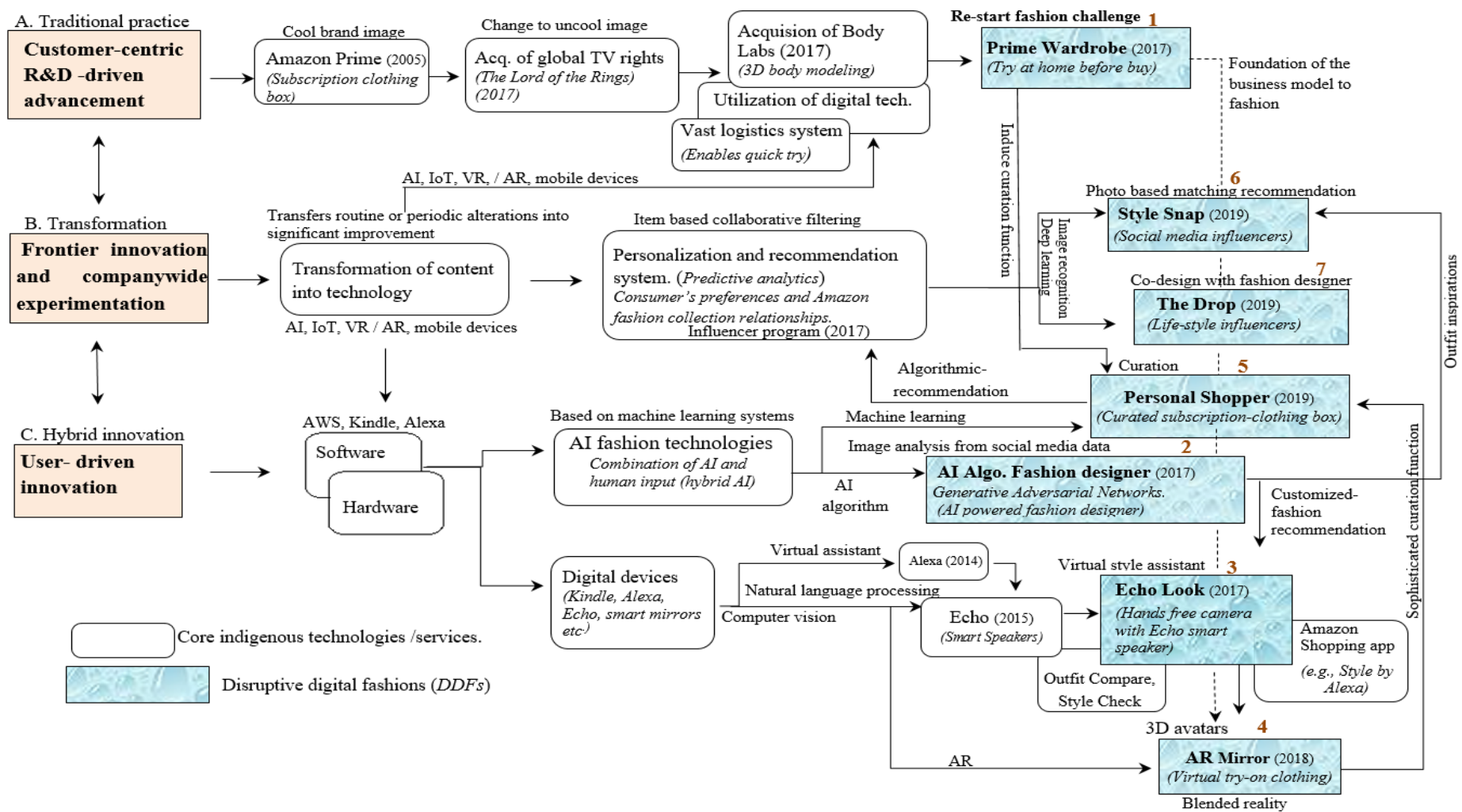
FIGURE 10.   Amazon's orchestration strategy in emerging disruptive digital fashion. Source: Articles II and V

Figure 10 represents Amazon's approach to digital fashion innovations, emphasizing how learning from past innovations contributes to new functionality development and innovations. Figure 10 illustrates how digital fashion innovations and contributing technologies contribute to the broad strategy, confirming that fashion innovations are technologically advanced and aligned with shifting consumer preferences. The flow of the figure, followed by feedback loops, indicates that Amazon's digital fashion business is dynamic and continuously evolving based on changing customer preferences and technological advancements.

This orchestration strategy is structured around three main pillars, as discussed above. First, in traditional practice, the customer-centric approach focuses on R&D in creating a trendy fashion brand image. In the past, Amazon failed several times to create an image of a trendy fashion brand. In creating a trendy image, foundational services such as Amazon Prime (2005) and the acquisition of TV rights for "The Lord of the Rings" and Body Labs (2017) played a significant role. These ventures acted as foundations for integrating digital technology into fashion lines. Second, the transformation involves shifting from traditional practices to experimentation with innovations. This involves the transformation of content into technology by using Industry 4.0 technologies, such as AI, IoT, AR, VR, social media, and mobile technologies. In this phase, Amazon converts routine or periodic alterations into significant improvements by transforming content via AI technologies and item-based collaborative filtering, leading to customized suggestions for every individual customer enabled by predictive analytics. Customization and personalization are carried out by machine learning that matches customers' preferences and Amazon's fashion collection system. Third, the user-driven innovation approach represents how Amazon incorporates user's preferences into the R&D process. It combines Amazon's core technologies, such as AWS and Alexa, with soft and hardware developments to create user-driven innovations. In this process, AI and machine learning contribute to developing ADF innovations that offer sophisticated services, such as smart mirrors, virtual assistants, and avatars.

By following the orchestration strategy, Amazon developed ADFs such as Prime Wardrobe (2017) AI Algo. Fashion Designer (2017), Eco Look (2017), AR Mirror (2018), Personal Shopper (2019), Style Snap (2019), and The Drop (2019). This shows that orchestration strategy and learning from past innovations contributed to AI-driven ADF's development, as illustrated in Table 2. The table presents a description of a series of seven ADFs and the ways Amazon has synchronized ADFs with AI technologies.

TABLE 2.   Learning orchestration of advanced digital fashion

Advanced Digital Fashion	Functionality	Implications from previous innovation	Acquired assets that propagated followers	Core function of Industry 4.0
1. Prime Wardrobe (2017)	Facilitated home-based trials of fashion products	Utilizing, 3D bodies scanning, integrating AI, IoT, VR/AR, and mobile technologies	Basis of the business model used to obtain customer data about their fashion preferences Done by online style preferences survey on Amazon.com	ML, IoT, data analytics, cloud computing
2. AI Algo. Fashion Designer (2017)	Introduces new designs by learning from fashion trends on the web	Pattern recognition, trend analysis, customers data, feedback loops, supply chain integration, and virtual prototyping	Capability of design generation without human supervision, alternative to human fashion designers	Big-data analytics, ML, DL, Generative Adversarial Networks, cloud computing.
3. Echo Look (2017)	Personalized fashion advice, virtual style comparisons, virtual outfit visualization	Alexa, virtual fitting rooms, mobile apps Outfit Compare (share photos), Style Check (second opinion)	Amplified AI algorithms in the fashion design suggesting personalized outfits Advanced Alexa skills in becoming a fashion advisor	Combination of ML, CV, SL, DL, big data analytics, AR/VR
4. AR Mirror (2018)	Virtual try-on and visualization of several virtual outfits on virtual bodies	CV-based Amazon's Body Labs and LAB 126 software, real-time image processing	Collection of customer's data including 3D visual measurements of body dimensions and curation based on software, human designers, and customer's preferences	CV, AR, VR, depth sensing camera, IoT, mobile app integration. cloud computing
5. Personal Shopper (2019)	Subscription model, personalized outfits are based on customers' preferences and Amazon's designers	Advanced form of Prime Wardrobe with curation function, integrated with feedback loops	Data driven insights, improved productivity with feedback loops, expanded customers reach and data monetization Reductions in online returns and minimizing wastage	ML, data analytics, big data, cloud computing, IoT integration.

TABLE 2 continues

Advanced Digital Fashion	Functionality	Implications from previous innovation	Acquired assets that propagated followers	Core function of Industry 4.0
6. Style Snap (2019)	Instead of text, customers are provided with matching outfits based on their uploaded photos	Influencer program Integrates traditional fast fashion with digital fashion and ADF technologies	Enables seamless switching In real time, customers upload their preferred images and receive recommendations in real time.	CV, DL, image recognition, NLP, cloud computing
7. The Drop (2019)	Allows limited time exclusive fashion shopping on platform based on influencer collaboration	Amazon's own influencers Program, Direct to consumer model,	With novel and limited quantities, it represents a new business model utilizing external innovation resources by co-designing with external designers. Supply chain optimization	ML, data analytics, personalized algorithms, personalization engines.

From Table 2, we see that the advancement of AI with its layered functionalities, such as machine learning, computer vision, statistical learning, and deep learning, along with technologies utilizing these functions as augmented reality and virtual reality, have significantly contributed to this orchestration. A series of seven ADFs enhance customers' experiences by providing customized solutions to every individual customer and establishing new business models in collaboration with external resources, such as designers and fashion influencers. This strategy aligns with the concept of neo-open innovation, a new approach to the emergence of innovation that fosters sustained growth by balancing the dilemma between R&D expansion and a decline in productivity by harnessing the vigor of soft innovation resources. For example, Style Snap and The Drop initiatives incorporate broad influencer channels, including entertainment, social media, blogs, videos, and email lists. The scope of stakeholders involved in ADFs is broader and more balanced than that of traditional stakeholders in the traditional fashion industry. This involvement of broad stakeholders provides Amazon with big data from external resources and familiarizes Amazon's fashion algorithms and internal designers with global trends. This process can be defined as a learning orchestration externality.

5 RESEARCH PHILOSOPHY AND METHODOLOGY

In conducting meaningful research, it is essential to comprehend the foundational characteristics that guide the examination process. Central to the foundations is understanding research philosophy, which is interlinked to research approaches. This chapter describes the essential concepts of the research philosophy and approaches used in this research. These common frameworks are interconnected, influence each other, and provide a lens through which reality can be understood.

5.1 Philosophical paradigm

The framework of scientific research can be broken down into the following main categories (Creswell et al., 2007; Lincoln et al., 1985, 1988; Tolk, 2012):

1. Ontology, representing what exists, beliefs, and assumptions about reality.
2. Epistemology, encompassing knowing the reality or reliable knowledge.
3. Methodology, representing the overall approach in conducting research and methods that follow the paradigms.

Paradigms encompassing worldviews are conceptual and practical tools for solving research problems. Each paradigm shapes the researchers' approach to completing the research endeavor. The philosophy of research represents a foundational framework representing the researcher's cognitive approach for conducting research, selecting research strategies, problem identification and solving, data collection and analysis leading to novel insights (Easterby-Smith et al., 2008; Marczyk et al., 2005), and the choice of methodology should be congruent with the philosophical position and the phenomenon being investigated (Zukauskas et al., 2018). Thus, researchers should establish the validity of research using certain paradigms (Myers et al., 2002) because choosing a research paradigm is not a random choice. It emerges from researchers' thinking processes and worldviews (Saunders et al., 2009). Given this

background, the coevolution between advanced technologies and the fashion industry must be founded on these principles. Based on the principles elucidated above, it is clear that philosophical paradigms contribute significantly to executing research endeavors. Several research philosophies, including positivism, interpretivism, constructivism, pragmatism, and realism, have been extensively examined by scholars (Bryman, 2016; Saunders et al., 2009; Zukauskas et al., 2018).

One of the classic and historically dominant paradigms is the positivist approach, driven by objectivist thinking, which believes that reality exists independently of the observer's perception and that objective methods (empirical and logical evidence) should be used in research. In social science, the positivist approach refers to quantitative research techniques because researchers must be detached from research; knowledge is based on the cause-and-effect approach, commitment to reductionism, and verificationism (Creswell, 2003: Easterby-Smith et al., 2008). By comparison, the post-positivism paradigm is more flexible than positivism. Post-positivism still inherits the boundaries of objective observation and acknowledges that absolute truth may remain abstract. It sees knowledge as a sequence of logical steps, and findings are based on objectivity, uniformity, and control (Creswell et al., 2011). However, in reaction to the positivist school of thought, there exists an alternative approach called social constructionism, which believes that reality is not objective and considers subjects social rather than individual, and interpretations of people can understand it. The research methods for social constructionism are primarily qualitative, such as observations, interviews, and textual analysis. This paradigm enables a researcher to become involved with the research process and focus on societal perspectives while not being limited to data gathering (Gergen, 2007, 2008; Holstein et al., 2013).

Nevertheless, the connection between positivists and social constructionism has been acknowledged (Martin, 2003). In bridging the gap between positivist and social constructivist paradigms, another paradigm is pragmatism (Creswell, 2007; Cresswell et al., 2011). In 1925, pragmatism was an alternative paradigm that centered on solving real-world problems while considering what works in a particular problem, not what might work (Creswell, 2003; Dewey, 1925). In addition to these paradigms, well-known research methodology scholars, mainly qualitative researchers such as Guba et al. (1994, 2005), have examined philosophical paradigms with their associated characteristics, including positivism, post-positivism, critical theories, constructivism, and participatory perspectives. This dissertation is anchored in the pragmatism paradigm because I, the author, seek a balance between objectivity and subjectivity. I follow pragmatism, which suggests what is functional, helpful, and practical. This dissertation is based on empirical research that integrates qualitative and quantitative research methods. Pragmatism gives the flexibility to select the most suitable research methods for elucidating the research problem.

5.2 Research design and strategies

Research paradigms are accepted models or patterns that influence researchers in elucidating research designs and relevant strategies (Kuhn, 1962; Morgan, 2007; Bunniss et al., 2010). The coevolution of fashion and advanced technology is a complex and multifaceted phenomenon. This dissertation seeks to understand how technology changes fashion and how fashion changes and advances technology lead to the emergence of new business models. The complexity of the topic requires a flexible paradigm in handling empirical and exploratory dimensions of inquiry. The nature of this dissertation's research questions, encompassing the coevolution of fashion and advanced technology, necessitates both qualitative and quantitative methodologies. For example, the analysis of Amazon's data-driven business model requires quantitative methodology, a more positivist approach leading to objective data analysis.

Conversely, the socio-economic, technological, and cultural dynamics impacting the fashion industry and advancements in the digital economy require a qualitative approach to gain in-depth insights. Thus, for a better understanding of the subject and insightful execution of research to meet goals, it is advisable to follow a research plan and appropriate methods. Research design and research plan are interchangeable; they serve as blueprints for data collection and treatment, conducting analysis, and making interpretations in a research process (Miller et al., 2002; Myers et al., 2013). Bryman (2016) analyzed research designs using several methodologies and suggested that well-established research designs contribute to informed data collection and analysis decisions.

Furthermore, an observation method was also applied to complement the qualitative and quantitative methods. It enables researchers to use their senses in data collection (Adler et al., 1994). Observation methods are suited to studying the evolving nature of retail services and experiences (Applebaum, 1951). Observations provide valuable insights by complementing other data collection techniques and offering a closer view of phenomena in natural settings (Baker, 2006).

A pragmatic stance does not rule out other methods and focuses on whether the research helps determine what a researcher wants and whether the findings are relative, not absolute. This dissertation has gained advantages from research approaches reflecting positivism and social constructionism, leading to a mixed methods research approach incorporating qualitative and quantitative research approaches (Morgan, 2007; Shakeel, 2019; Yvonne, 2010). Quantitative techniques refer to obtaining quantifiable values and incorporating analytical and mathematical approaches (Newman, 1998). Quantitative research deals with statistical data analysis, numerical analysis, and mathematical models to draw conclusions (Babbie, 2010; Greenspan, 2018). Qualitative research design corresponds to the positivist approach, which focuses on object reality (Rovai et al., 2014).

Morgan (2007) and Lincoln et al. (2011) stated that qualitative research gained acceptance among researchers because it shows how people understand things differently and produce new knowledge (epistemology), such as realism and social constructivism. The data collection in this technique involves observations, interviews, and active participation. Scholars have examined the limitations of both qualitative and quantitative techniques (Currie, 1968; Queirós et al., 2017). Thus, incorporating both qualitative and quantitative techniques has enhanced this dissertation by balancing objective and subjective viewpoints and values. The mixed methods case study approach was not intended to gain "more" but a comprehensive understanding of the coevolution of advanced technology and the fashion industry and how this coevolution has generated new perspectives of innovation. The qualitative dynamics of Amazon as a case study allowed for the in-depth exploration of complex aspects, such as the impact of digital innovations on advancing fashion innovations in the digital economy and the emergence of novel innovations such as ADFs, supra-omnichannel, and neo-luxury. These aspects are briefly explained through an empirical analysis. On the quantitative side, empirical data related to the growth trajectory of Amazon's R&D-driven business model, investments, and their correlation to growth and productivity are analyzed. How Amazon balances the dilemma of the two-faced nature of ICT is also empirically discussed.

Moreover, the mixed method case study approach has enabled answering the research questions of this dissertation (Guba et al., 2005). Based on the nature of this dissertation, a case study approach offers a focused and controlled examination and provides a comprehensive understanding of the emergence of a phenomenon. In the use of the case study method, patterns, connections, and underlying mechanisms can unfold (Woodside, 2010). According to Yin (2012, 2014), a case study empowers researchers to empirically examine a phenomenon in its real-life context when a researcher has limited control over the events. Researchers collect detailed information using a variety of data collection procedures and tools over a sustained period. A case study method is the best option for researchers when

1. the subject under examination yields significant insights leading to new perspectives, concepts, and theory development;
2. it involves unusual and extreme situations, such as the effects of medicines on patients,
3. new insights that were not envisioned previously.

Therefore, in alignment with Yin's (1984) invaluable guidance, Amazon was chosen as the case study. This dissertation has examined Amazon's R&D-driven business model because Amazon has an influential position as a technology giant. The subject itself indicates that the case study is central to this dissertation. Moreover, using the case study approach has facilitated the introduction of novel concepts and perspectives that might not have been investigated before, effectively aligning with Yin's suggestions on the capacity of the case study approach. In line with Yin's guidance, new perspectives such as stakeholder capitalization and a new stream of digitalization in Article I, concepts of ADFs

and learning orchestration in Article II, supra-omnichannel and cloud-based fashion platform in Article III, neo-luxury and generative design-driven innovation in Article IV, and digital solutions beyond e-commerce toward metaverse society in Article V.

5.3   Techno-economic analysis through mixed methods

This dissertation consists of five journal articles, uses the Amazon business model as a case study, and employs mixed methods, that is, qualitative, and quantitative methodologies followed by concepts of techno-economic analysis. Articles I, II, and V are based on mixed methods but more on the qualitative side, and Articles III and IV are also based on mixed methods but lean more on the quantitative side. All five articles incorporated the concepts of techno-economic analysis.

Articles I and II use mixed methods with a predominant qualitative approach. They use the concepts of techno-economics analysis. These approaches are used to explore the dynamic relationships between the fashion industry, digital solutions, stakeholder capitalization, and influential factors, such as socio-economic and cultural dynamics. With these methods, this study contributes to deepening our understanding of how the fashion industry and digital solutions can co-evolve while considering shifts in people's preferences from economic functionality to supra-functionality beyond economic value. The articles analyze concepts, theories, and relationships among contributing factors, such as the role of AI, R&D, and SIRs in the fashion industry transformation. These articles elucidate in-depth analyses using techno-economic analysis concepts and propose a framework that represents the emergence of ADFs followed by a learning orchestration strategy. The qualitative approach provided a novel and comprehensive understanding of the concept of ADFs. Article V qualitatively reviews the preceding innovations and suggests their contribution to new business models beyond e-commerce. This suggestion is based on the conceptual framework in the original article.

Articles III and IV are based on mixed methods but dominated by quantitative approaches. Article III employs logistic growth functions and carries out statistical tests. Both simple logistic growth (SLG) and logistic growth within a dynamic carrying capacity (LGDCC) function are used. The backward elimination method was used with a 5% criterion threshold. The quantitative analysis used in Article III indicates that Amazon has been increasing investments in R&D from 2014 to 2019; this has resulted in significant growth in the fashion business; without AI integration, this growth would have been less. This indicates that Amazon's success in fashion is primarily due to ADFs.

The figures are at a significance level of 1% regarding validity and reliability. This indicates that the results are reliable, and there is a mere 1% chance that the findings are based on randomness. It also indicates that the findings are generalizable.

The following is a noteworthy mathematical model for techno-economic analysis in Article III, which analyzes Amazon's AI-driven fashion trajectory. ICT, shaped by network externalities, amends the correlation between innovations and institutional systems, introducing new perspectives of innovation that catalyze rapid growth. Schelling (1998) highlighted a wide range of logistically evolving and disusing social mechanisms inspired by these interactions. The progress of digital innovation is grounded in the Internet, and AI enhances these interactions and accelerates ICT's logistic growth, represented by a sigmoid curve (Watanabe et al., 2004). The logistic growth trajectory of Amazon's AI-powered digital fashion initiative and its growth trajectory, proxied by apparel sales share in the US, can be depicted by the epidemic function in Eq. 1:

$$\frac{dS}{dt} = aS\left(1 - \frac{S}{N}\right). \tag{1}$$

This leads to an SLG function, as shown in Eq. 2:

$$\text{SLG} = S(t) = \frac{N}{1 + be^{-at}}, \tag{2}$$

where t is time, N is carrying capacity, a is velocity of diffusion, and b is a coefficient indicating the initial level of diffusion.

As far as the development trajectory depends on the SLG trajectory, its digital value, $S(t)$, saturates with the fixed upper limit N. However, once the trajectory shifts to LGDCC, its digital value, $S(t)$, can continue to increase, as it creates a new carrying capacity during the process of development.

In particular, innovation that creates new carrying capacity $N(t)$ during the diffusion process, Eq. 1, is developed as follows:

$$\frac{dS(t)}{dt} = aS(t)\left(1 - \frac{S(t)}{N(t)}\right). \tag{3}$$

Eq. 3 develops the following LGDCC function:

$$S(t) = \frac{N_k}{1 + be^{-aR} + \frac{b_k}{1 - a_k/a}e^{-a_kR}}, \tag{4}$$

where N_k is ultimate carrying capacity and a, b, a_k, and b_k are coefficients. Eq. 4 incorporates a self-propagating function as carrying capacity increases corresponding to $S(t)$ increase (Watanabe et al., 2004), yielding Eq. 5:

$$\Delta S(t) = \frac{dS(t)}{dt}. \tag{5}$$

The dynamic carrying capacity in this LGDCC is depicted as follows:

$$N(t) = S(t)\left(\frac{1}{1 - \frac{1}{a}\cdot\frac{\Delta S(t)}{S(t)}}\right).$$

The sources for this part are Article III, Watanabe et al. (2004), and Schelling (1998).

Similarly, Article IV uses mixed methods with a predominant quantitative approach. The biological concepts of homeostasis and resonance are applied to understand Amazon's market behavior and how Amazon maintains a balance between apparel sales growth and online sales. Its relative apparel intensity increased significantly between 2014-2016. The quantitative findings indicate a significant correlation between investments in R&D and Amazon's market share in apparel. The findings show that Amazon maintains consistent relative apparel intensity (RAI), suggesting its capacity to adjust its business models in response to external factors and sustained growth.

Next, we discuss the mathematical model reflecting homeostasis management used in Article IV. The RAI can be depicted as follows:

$$\eta = \frac{A_{Am}/A_U}{O_{Am}/O_U} \equiv \frac{ASS}{OSS},$$ (6)

where A_{Am} is Amazon apparel sales, A_U is US apparel sales, O_{Am} is Amazon online sales, and O_U is US online sales. ASS stands for apparel sales share, and OSS stands for online sales share.

Let A_1 be the first-party seller's sales share and A_3 the third-party seller's sales share. Then,

$$ASS = A_1 + A_3.$$ (7)

Third-party sellers' sales share gives

$$\varphi(t) = \varphi + \varphi^{'}(t) = A_3/A_1 \ll 1,$$ (8)

where φ is the constant rate over the period and $\varphi^{'}(t)$ is fluctuating rate depending on time. Although a small ratio, a certain level of A_3 is maintained by fluctuating within a certain range:

$$A_3 = \varphi(t)A_1.$$

Since revenue (sales) growth depends on a rapid increase in A_1,

$$\frac{\Delta A_3}{A_3} = \frac{\Delta\varphi(t)}{\varphi(t)} + \frac{\Delta A_1}{A_1} \leq \frac{\Delta A_1}{A_1}, \quad \frac{\Delta\varphi(t)}{\varphi(t)} = \frac{\Delta\varphi + \Delta\varphi'(t)}{\varphi(t)} = \frac{\Delta\varphi'(t)}{\varphi(t)} \leq 0.$$

To maintain A_3,

$$\frac{\Delta\varphi(t)}{\varphi(t)} = \frac{\Delta\varphi'(t)}{\varphi(t)} \geq 0.$$

Therefore, $\Delta\varphi'(t) \approx 0$. This can be satisfied by a fluctuation converge

$$\sum \varphi'(t) = 0$$ (9)

provided that A_1 depends on OSS with the ratio $\pi(t)$:

$$A_1 = \pi(t)OSS$$ (10)
$$ASS = (1 + \varphi(t))A_1 = (1 + \varphi(t))\pi(t)OSS$$ (11)
$$\eta = ASS/OSS = (1 + \varphi(t))\pi(t).$$

Since $\varphi(t) \ll 1$,

$$\ln \eta = \ln\big(1 + \varphi(t)\big) + \ln \pi(t) \approx \varphi(t) + \ln \pi(t),$$
$$\frac{\Delta\eta}{\eta} \approx \Delta\varphi(t) + \frac{\Delta\pi(t)}{\pi(t)} = \Delta\varphi'(t) + \frac{\Delta\pi(t)}{\pi(t)} \qquad (12)$$

Given homeostasis management to

- minimize the fluctuation rate of third-party sellers' sales share ($\sum \varphi'(t) = 0$) and
- maintain the dependence of first-party sellers' sales on online sales ($A_1/\mathrm{OSS} = \pi(t)$) stable ($\Delta\pi/\pi \approx 0$),

homeostasis management can be expected as $\Delta\eta/\eta \approx 0$. Since $\Delta\pi/\pi \approx 0$ (see Fig. 11 and Article IV), under condition $\sum \varphi'(t) = 0$, $\Delta\eta/\eta \approx 0$, this means homeostasis.
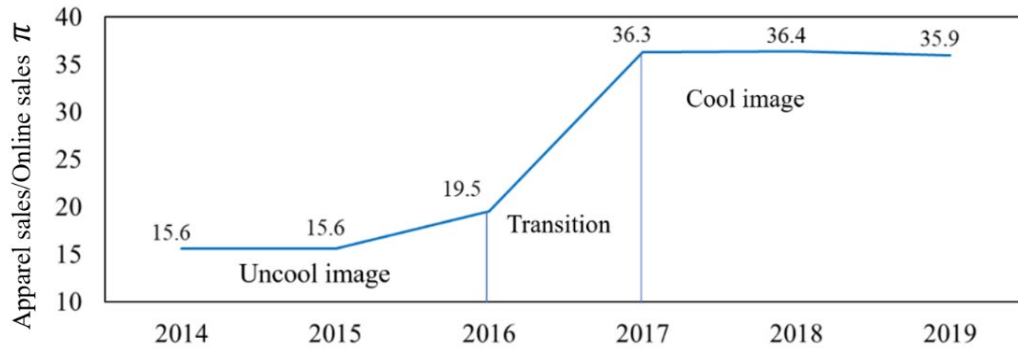
FIGURE 11.   Amazon's relative apparel intensity beyond its cool image; Source: Article IV

The model for the breakthrough of the Internet dilemma describes the relationship between luxury brands' innovation strategies and advanced digital fashion (ADFs) in a non-contact society. This model suggests that luxury brands can overcome the 'Internet dilemma' — the challenge of maintaining exclusivity, craftsmanship, and customer experience online — by co-evolving with ADFs. In this context, the 'breakthrough of the Internet dilemma' represents a strategic endeavor where luxury brands successfully integrate Internet sales while maintaining brand heritage. This co-evolution is described as leading to an increase in Relative Apparel Intensity (RAI), which is a metric signifying the proportion of online sales to wholesale. The model suggests that in a non-contact society, there's a decline in apparel intensity through traditional channels (AU/WU) and an increase in online sales intensity (OU/WU), both of which improve RAI. Higher RAI, in turn, correlates with increased sales and consequently boosts Research and Development (R&D), fostering further innovation and overcoming the Internet dilemma. This cycle emphasizes the importance of neo-luxury for sustainable growth in markets increasingly shifting towards online, non-contact interactions, as illustrated in Fig. 12.

$$R\&D \leftarrow Sales \leftarrow \eta \uparrow = \frac{\dfrac{L_{Am}}{O_{Am}} \times \dfrac{A_{Am}}{L_{Am}}}{\dfrac{A_U}{W_U} \downarrow} \times \frac{O_U}{W_U} \uparrow$$
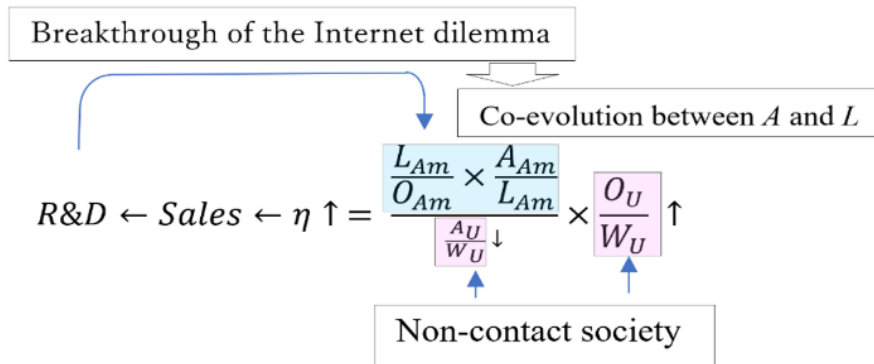
η: Relative apparel intensity; L_{Am}: Amazon luxury sales; O_{Am}: Amazon online sales; A_{Am}: Amazon apparel sales; O_U: US online sales; W_U: US whole sales.

FIGURE 12.   Dynamism in harnessing co-evolutionary relationships between advanced digital fashions and the development of luxury brands. Source: Article IV

6 OVERVIEW OF INCLUDED ARTICLES

This dissertation contains five scientific journal articles on the digital transformation of the fashion industry. These five articles were developed in three phases, as discussed earlier. Phase 1 includes Articles I and II, which explain the factors accelerating digital solutions and how Amazon orchestrates digital fashion technologies. Phase 2 includes Articles III and IV, which provide an evolutionary analysis of emerging AI fashion technologies leading to new business model development. Phase 3 includes Article V, which suggests new business models beyond traditional e-commerce. This chapter provides a brief overview of the articles.

6.1 Article I: Fashion-driven textiles as a crystal of a new stream for stakeholder capitalism – Amazon's endeavor

This article investigates the factors contributing to the digital transformation of the fashion industry. The fashion industry reflects innovations in the socio-economic and cultural aspects of society. People are more aware, and their preferences are shifting from economic functionality to supra-functionality beyond economic value. The present digital economy has triggered significant changes in the fashion industry. It demonstrates how changes in society influence fashion trends and how the fashion industry contributes to these trends in the digital economy. Therefore, the objective is to investigate the relationship between the fashion industry and computing technologies while focusing on the impact of digital solutions, particularly Amazon's R&D-driven disruptive business model. There is a lack of empirical studies in the digital fashion domain that support claims made about the implications of digital solutions in the fashion industry. Several studies have analyzed different features of the fashion industry and examined Amazon's unique R&D system, including its technology, strategies, and financial management systems. However, a significant research gap exists in the context of the coevolutionary dynamism of advancements in the

fashion industry and Amazon's R&D system and the consequent developments in digital solutions and approaches that considers stakeholder capitalization. Moreover, the authors investigated the way digital innovations can enable a new stream of sharing and a circular economy.

The objective of the research, its exploratory nature, and its motivation to study the interplay between the fashion industry and digital solutions required an in-depth qualitative case study approach. The secondary data used in this study comprise academic literature and industry reports, particularly Amazon's official documents, such as annual reports, financial statements, and letters to stakeholders. This paper incorporates data triangulation to gain accuracy and a detailed understanding of the given phenomenon.

The market size of the global fashion industry experienced significant growth, rising from $1.05 trillion (2011), $1.25 trillion (2015), $1.4 trillion (2017), and $1.65 trillion (2020). The USA and the EU contributed 40% of the combined figure. Notably, the growth of the apparel industry has been faster than the growth of the global economy. Between 2011 and 2015, the global GDP grew on average by 2.7%, and the apparel growth rate was 4.70% during the same period. Fast fashion sector experienced an even higher surge with market share growth of 10%. The GDP elasticity for fashion ε_{FG} (1% increase in GDP increases ε_{FG}% increase in fashion) is more than two times higher than the GDP elasticity for textiles and apparel.

This study identifies factors influencing the digital transformation of the fashion industry. These factors are categorized into three groups: company-specific, technology evolution, and policy. At the company level, it was demonstrated that the incorporation of SIRs into an R&D-driven business model, a shift in people's preferences, and stakeholders' concerns play vital roles in driving the transformation of the fashion industry. For example, the study highlights the relative significance of coevolution between R&D transformation acknowledging the challenges of its growth and productivity decline, and digital solutions of the fashion industry that correspond to a shift in people's preferences for supra-functionality. Amazon has introduced a new concept of R&D that successfully balances growth and productivity through SIR incorporation. At the technology level, advancements in the fashion industry by orchestrating shifts toward digital, sharing, and circular economies should be utilized in accelerating the digital transformation of the fashion industry. At the policy level, the involvement of stakeholders and business leaders could accelerate financing in R&D. Although this study provides valuable suggestions for stakeholders' involvement in coevolution, as mentioned earlier, its applications are limited to specific contexts. This understanding should be expanded on a broader level.

6.2 Article II: Amazon's initiative transforming a non-contact society – Digital disruption leads the way to stakeholder capitalization.

In light of the socioeconomic changes that emerged during and after the COVID-19 pandemic, companies are exploring new frontiers beyond their traditional models to adapt to the rise of a non-contact society. By utilizing its novel innovation assets, Amazon has taken ambitious steps in this direction. This article focuses on Amazon's success in developing new ADFs through AI-oriented R&D and how its R&D system and financing approach transform routine and periodic alterations into significant improvements. ADFs are the authors' elaboration and refer to a new fast fashion business model that leverages digital innovation assets and the learning effects of preceding development. The noteworthy idea we discussed is coevolution, which represents different technologies working together. In this regard, this study conducts an empirical coevolutionary analysis of Amazon's ADF development trajectory and the fashion industry's advancements, with particular attention paid to the role of AI advancement.

This article begins by investigating Amazon's historical failures in the digital fashion domain. It explores the role of AI and institutional systems in facilitating learning orchestration externalities in providing digital solutions in a non-contact society. This article delves into Amazon's learning orchestrating externality strategy in AI-driven innovations, particularly in developing a series of seven ADFs. ADFs include Prime Wardrobe and AI Algo. Fashion designer, Echo Look, AR mirror, Personal Shopper, Style Snap, and The Drop. The functionality and effects of the learning orchestration externalities of these ADFs are briefly discussed here, because these ADFs act as primary contributors to the next phase of the present research. These ADFs have strengthened Amazon's omnichannel approach and leveraged innovative assets.

Prime Wardrobe technology allows people to try at-home fashion products before they buy, leveraging curation functionality and advanced digital technologies in using customer data and machine learning algorithms to offer customization. AI Algo. Fashion designers generate new designs using machine learning and deep learning-based generative adversarial networks. By continuously learning from the Internet, customers' data, and trendy styles, it stays up to date. Echo Look technology contains a depth-sensing camera that provides virtual try-on features, leveraging computer vision (CV) and AR to superimpose virtual clothing. AR Mirror technology provides real-time virtual fashion visualization. It enables real-time customization. Personal Shopper is a subscription-based fashion service that utilizes AI technology. Style Snap technology uses visual inputs to identify fashion trends from the Amazon catalog. It is based on deep learning and computer vision technologies. The Drop is a limited-time fashion service that incorporates social media fashion influencers.

This study suggests company-specific, technology, and policy-related implications. At the company level, the findings show that Amazon's fashion empire is based on AI-driven R&D. AI has enabled it to create sophisticated fashion algorithms that advance curation functions and generate personalized recommendations. At the technology level, the algorithms should be continuously trained on new data on changing customers' preferences. At the policy level, Amazon collects large amounts of data from its products and services. Data privacy and security should be prioritized. The ADF model embraces neo-open innovation, acts as an SIR, and contributes significantly to achieving a sustainable business model. The secondary data used in this study comprise news releases, academic literature, and industry reports, notably Amazon's official documents, such as annual reports, financial statements, and letters to stakeholders. This paper incorporates data triangulation to gain accuracy and a detailed understanding of the phenomenon.

6.3 Article III: Amazon's new supra-omnichannel – Realizing growing seamless switching for apparel during COVID-19

The crux of this paper lies in understanding the synchronization of digital fashion technologies, the concept of coevolution, and dual coevolution. It discusses the way digital fashion technologies work together and create new platforms. A conceptual framework represents this interplay of technologies. Recently, the fashion industry has been at the forefront of digital transformation. Even before COVID-19, the fashion industry was integrating digital technologies.

However, this paper suggests how Amazon turned the COVID-19 crisis into a springboard for new innovations. Amazon's digital fashion solutions leverage AWS, AI, and big data to discover new frontiers in the fashion industry beyond contemporary models. Through empirical analysis of the development trajectories of preceding fashion innovations such as ADFs and Luxury Stores—a digital platform for luxury brands—this paper suggests a solution to solving the historic "Internet dilemma," representing the challenges that luxury brands face in leveraging digital technologies. The Luxury Stores platform addresses the reluctance of luxury brands through novel ways and incorporates mobile apps and websites, AR and VR technologies, View in 360, and recommendation engines. The empirical analysis also considered the implications of patents on ODM technology.

To address the Internet dilemma and challenges that emerged during COVID-19, our analysis suggests conceptual frameworks, such as the synchronization of ADFs, patented ODM, and luxury brands leveraging Luxury Stores. The coevolution of these innovations reveals the development of a cloud-based fashion platform that facilitates the on-demand customization of fashion products through seamless switching. The big data acquired from customers, manufacturers, stakeholders, and social networks obtained for on-demand

customization further expands and enhances AWS functionalities that cater to various cloud computing needs. This coevolution drives the progress of cloud-based fashion platforms, creating a virtuous cycle of mutual advancement. As a result, this virtuous cycle gives rise to the emergence of a dual coevolution among ADFs, Luxury Stores, ODM, and cloud-based fashion platforms, ultimately leading to a supra-omnichannel approach. The supra-omnichannel approach accelerates seamless switching and suggests new frontiers of innovation beyond traditional models. Several studies suggest the strategic implementation of an omnichannel approach, but no one has suggested any concrete example that satisfies the unique demands of the fashion industry. Therefore, a framework for the supra-omnichannel is provided.

Indeed, this study has limitations. Its focus is on analyzing Amazon's business model and fashion initiatives. Further, limited data are available for numerical analysis. Data triangulation is used to incorporate rich evidence. The secondary data used in this study are obtained from news releases, academic literature, industry reports, and particularly Amazon's official documents, such as annual reports, financial statements, and letters to stakeholders. These issues may have led to the building of a narrow perspective. For the fashion industry, the findings of this study may act as a starting point in understanding the development of new business models with the interplay of technologies in non-contact society that emerged during and after the COVID-19 pandemic.

6.4 Article IV: A new perspective of innovation toward a non-contact society – Amazon's initiative in pioneering growing seamless switching

This paper provides a brief understanding of Amazon's R&D system, encompassing technology and content development, yielding insights that contribute to the development of new business models in a non-contact society. It explores how emerging economic crises during and after COVID-19 can be converted into springboards for new technological innovations.

In response to the historic Internet dilemma of luxury fashion brands, this study examines unforeseen shifts in the fashion industry, including a decline in apparel demand and an increased dependence of luxury fashion brands on e-commerce. It highlights the effective use of the learning orchestration externality strategy, which catalyzed the development of AI-driven ADFs. ADFs and luxury brands share a coevolutionary trajectory, a solution to the Internet dilemma of luxury brands. This coevolution aligns with the cultural transformation toward a newfound era of meaning. Here, meaning is a significant driver of design-driven innovations, eventually forming a self-propagating generative function.

Moreover, the paper explores generative innovations and suggests the significance of design-driven innovations, speculative design and pppp (possible, plausible, probable, and preferable features), and generative design-driven

innovations. The focus of design-driven innovation revolves around the orchestrated delivery of novel meanings to customers that were never envisioned before. Speculative design and pppp empower the discovery of future scenarios and finding desired ones that align with shifts in people's preferences in a non-contact society. The iterative process of generative design exploration further advances the process of idea generation, prototyping, and identification of new solutions. The emergence of generative design-driven innovation is based on the coevolution of design-driven innovation and generative design exploration. This interaction sets generative design-driven innovation as a self-propagating process.

The technology cornerstone, AWS, is an innovative cloud computing and data storage infrastructure endowed with generative function. This generative function leads to the development of a cloud-based fashion platform. A coevolutionary relationship exists among the self-propagating generative function, AWS, and neo-luxury. This coevolution results in an increase in seamless switching. Hence, a new perspective on innovation can be explored.

Moreover, this study suggests that R&D is considered Amazon's culture that promotes continuous experimentation, leading to the development of a participatory architecture that harnesses the power of its users. This gives rise to user-driven innovations that facilitate further advancements in ICT. Such advancements contribute to the co-emergence of soft innovation resources. Ultimately, soft innovation resources activate self-propagating functions. It suggests how the design-driven innovation approach and the learning effects of preceding innovations have enabled it to become the world's top R&D company. By incorporating changing customers' preferences toward supra-functionality and the effects of COVID-19, Amazon's approach transforms routine and periodic alterations (non-R&D oriented) into significant improvements (R&D oriented) during the R&D process.

The study uses an interdisciplinary research methodology to merge the principles of homeostasis and resonance with the techno-economic analysis approach. Data triangulation is used to incorporate rich evidence. The secondary data used in this study are obtained from news releases, academic literature, industry reports, and particularly Amazon's official documents, such as annual reports, financial statements, and letters to stakeholders.

6.5   Article V: A new perspective on the textile and apparel industry in the digital transformation era

Building upon the findings from the preceding articles, this literature survey explores the growing ecosystem of Amazon's fashion technologies and the catalytic role played by AWS in digital fashion advancements. Central to our investigation is the significant role of AI technologies that have orchestrated the trajectory of the fashion industry toward digital transformation. This research

suggests a framework in which digital fashion technologies contribute to the development of new business models beyond e-commerce in a non-contact society. The required technologies that enable the metaverse are under development, and the number of studies in the digital fashion context is very limited. Against this premise, theoretical and practical frameworks are provided for transcending the boundaries of traditional e-commerce beyond e-commerce and ultimately leading to a metaverse society. This study suggests that traditional e-commerce as well as live commerce is based on commercial business activities, whereas the metaverse that emerged from gaming provides a broad spectrum of experiences, such as social interactions, entertainment, and education.

The enabling technologies encompass a series of seven ADFs representing virtual clothing, a paradigm of ODM, and a new concept of neo-luxury in the development of a cloud-based fashion platform. Driven by a learning orchestration strategy, this platform solves the Internet dilemma and integrates all the stakeholders and their activities in real time. The platform resonates with the learning effects of preceding innovations and provides a holistic solution. Based on these innovations, our analysis explores the trajectory beyond e-commerce.

A growing number of academic debates suggest that the metaverse will have a profound impact on the fashion industry. However, there is a significant gap in explaining how digital fashion technologies co-exist and contribute to metaverse-based fashion advancements. In this context, a series of ADFs have the potential to be extended in the metaverse, as they blend seamlessly physical and cyber elements of fashion, reshaping people's fashion choices and their interaction with designers. ODM and neo-luxury can offer on-demand personalization by keeping a sense of individuality in the metaverse. Cloud-based fashion platforms can provide real-time immersive experiences by connecting stakeholders. Design-driven innovations integrate aesthetics with technology in the metaverse.

7   SUMMARY OF RESULTS

This chapter provides the results of the articles included in this thesis.

7.1   Results of Article I

Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2020). Fashion-driven textiles as a crystal of new stream for stakeholder capitalism: Amazon's endeavor. *International Journal of Managing Information Technology*, *12*(4), 19–42.

Objectives

Understanding the dilemma of expansion in R&D and decline in productivity, the coevolutionary relationship between advancements in R&D and digital innovations in the fashion industry in the context of digital transformation.

Results

Empirical analysis suggests that Amazon has successfully constructed an R&D-driven ecosystem business model that balances R&D expansion and a potential decline in productivity. At the core of this dynamism is a virtuous cycle containing innovations and growth in ICT, user-driven innovations, soft innovation resources, and the emergence of self-propagating functions that contribute to functionality development.

The authors demonstrated that from 2011 to 2015, the global apparel market experienced a significant 4.70% increase compared to the worldwide GDP's 2.70% growth. During this period, fast fashion experienced a notable 10.0% increase in market share. Moreover, the process of functionality development occurs within ICT's self-propagating cycle. This dynamism satisfies the shift in people's preferences from economic functionality to supra-functionality beyond economic value. Learning from Amazon's success, the fashion industry can harness this novel virtuous cycle for new innovations in the digital economy, leading to coevolution between R&D investments and digital fashion innovations. The

coevolutionary relationship between Amazon's soft innovation resources and technological advancements in the fashion industry can provide promising solutions for the digital and sustainable transformation of the fashion industry.

The authors discovered that the emergence of a non-contact society accelerated the use of digital technologies. This drew more users and institutions, enabling a cycle in which the technology is improved and more users want to use it. This, in turn, triggers the emergence of new functionalities. To further advance digital fashion innovations, the fashion industry should incorporate circular and sharing economy models. This trajectory can also enable stakeholders to make higher R&D investments.

Author contribution

Article I was supervised by Professor C. Watanabe, and the study was primarily conceptualized by Waleed Akhtar in collaboration with the supervisors. The methodology was co-developed, led by Professor C. Watanabe, and in collaboration with Waleed Akhtar. Data collection and analysis were initiated by Waleed Akhtar and enriched by insightful comments from Professor Y. Tou. The writing and editing of the manuscript were initiated by Professor C. Watanabe and co-edited by Waleed Akhtar. The formal analysis was conducted mainly by Waleed Akhtar. An investigation into the topic was carried out by Waleed Akhtar, with valuable inputs from Professor P. Neittaanmäki. The visualization of the data and results was conceptualized by Waleed Akhtar, with additional contributions from Professor C. Watanabe. Project administration was jointly managed by Professor P. Neittaanmäki and Professor Chihiro Watanabe, and Waleed Akhtar oversaw the revisions, editing, and approval processes.

7.2 Results of Article II

Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2021). Amazon's initiative transforming a non-contact society: Digital disruption leads the way to stakeholder capitalization. *Technology in Society*, *65*, 101596.

Objectives

Exploring digital solutions in fashion industry through empirical coevolutionary analysis of the development trajectories of ADFs. The role of AI, learning orchestration externalities strategy, post-COVID-19 society, and new business models are investigated.

Results

This study examines Amazon's development of digital fashion solutions, ranging from failure to success. Empirical analysis suggests that by deploying a learning orchestration externality strategy, Amazon has transformed its business model from network externality to big data externality in the contemporary digital economy. A noteworthy finding is the integration of hierarchical AI

functionalities that capture customer data and evolve with changing customers' preferences. Hierarchical AI functionalities and soft innovation resources contributed to the development of a series of seven ADFs. Every ADF incorporates unique AI functions and tools, from machine learning to the incorporation of social media influencers, reflecting an omnichannel approach. Amazon AI-driven R&D facilitates digital fashion solutions and consistent algorithm training in line with customers' preferences. Powered by AWS and AI, ADF technologies seek higher functionality development through internal R&D, external market learning from external designers, and harnessing the vigor of SIRs. This synergy leads to neo-open innovation, accelerating significant improvements in technology development and its diffusion. However, the Drop initiative attracts broad stakeholders.

Author contribution

In Article II, Professor C. Watanabe provided supervision. The conceptual foundation was jointly established by Waleed Akhtar and Professor C. Watanabe, who contributed equally. Similarly, the methodology was collaboratively developed with Professor C. Watanabe and Waleed Akhtar. Waleed Akhtar played the primary role in data collection and analysis. He led the writing and literature review. Waleed Akhtar was at the forefront of the formal analysis, while Professor Y. Tou enriched it with insightful comments. The investigation was primarily led by Waleed Akhtar and complemented by the valuable insights of Professor Pekka Neittaanmäki. Waleed Akhtar primarily visualized the data and results. The project administration was jointly managed by Professor P. Neittaanmäki and Professor Chihiro Watanabe. All revisions, final editing, and approval processes were overseen and executed by Waleed Akhtar.

7.3   Results of Article III

Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2021). Amazon's new supra-omnichannel: Realizing growing seamless switching for apparel during COVID-19. *Technology in Society*, *66*, 101645.

Objectives

Techno-economic analysis, empirical analysis of Amazon fashion business, supra-omnichannel approach, exploring cloud-based fashion platforms, addressing Internet dilemma.

Results

Empirical analysis demonstrates the impact of ADFs on apparel sales share in the USA between 2014 and 2019. This evaluation is based on two trajectories: sales without ADFs (A) and sales with ADFs (B). In this case, the authors used the logistics growth function to model these trajectories, such as simple logistic growth (SLG) and logistic growth within dynamic carrying capacity (LGDCC).

SLG incorporates dynamic carrying capacity $N(t)$, suggesting that growth will stabilize. However, LGDCC introduces a new carrying capacity during diffusion. It maintains sustainable growth based on self-propagation. The results indicate that without ADFs, sales share would stabilize by 5% in 2019. The share increased in 2019 by 9.5% with the incorporation of ADFs (B). LGDCC reflects growth due to the incorporation of ADFs. Amazon's increase in the market share of the apparel market is due to investments in R&D, especially in AWS, AI, and AR/VR.

The incorporation of ODM is one of the solutions to resolving the Internet dilemma of luxury brands in a non-contact society. The empirical analysis suggests the development of a cloud-based fashion platform that facilitates the combination of all stakeholders in the value chain. The fashion platform enhances AWS's functionality, further improving its capabilities. The coevolution between ODM, luxury brands, and ADFs advances a dual coevolution, leading to a supra-omnichannel approach. The supra-omnichannel integrates multiple technologies and functionalities to redefine how the fashion industry approaches the digital era during and after the COVID-19 pandemic.

Author contribution

In Article III, Professor C. Watanabe supervised, while Waleed Akhtar played a primary role in conceptualization alongside the supervisors. Professor C. Watanabe equally crafted methodological aspects with Waleed Akhtar. Waleed Akhtar led the data collection and analysis, receiving input from Professor Y. Tou. Waleed Akhtar led the writing and literature review processes with Professor C. Watanabe's insights. For formal analysis, Waleed Akhtar took charge, with added insights from Professor Y. Tou. Professor C. Watanabe took the lead role in numerical analysis, with contributions from Waleed Akhtar. The investigation saw Waleed Akhtar's proactive involvement, complemented by Professor Pekka Neittaanmäki comments. Visualization was predominantly Waleed Akhtar's endeavor, enriched by Professor C. Watanabe's insights. Professors P. Neittaanmäki and C. Watanabe managed the project administration, and Waleed Akhtar led all revisions, final editing, and approval processes.

7.4   Results of Article IV

Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P. (2022). A new perspective of innovation toward a non-contact society: Amazon's initiative in pioneering growing seamless switching. *Technology in Society*, *69*, 101953.

Objectives
Techno-economic analysis examining Amazon R&D dynamism, coevolution, homeostasis, resonance strategy, and design-driven innovations.

Results

A direct and more than proportional relationship is found between Amazon's R&D initiatives and AWS growth from 2008 to 2020. Regression analysis reveals that a 1% increase in R&D is associated with a 1.44% upsurge in AWS. At the 1% level, both coefficients are statistically significant. Collectively, R&D is a major force behind AWS's growth trajectory. Moreover, a significant correlation reflecting Amazon's focus on innovations is observed between R&D investments and Amazon's market share in apparel from 2014 to 2019. As COVID-19 has affected consumer behavior, there has been a significant decline in the demand for apparel and other non-essential items. In response to the impact of COVID-19 on consumer behavior, the concept of homeostasis is applied to strike a balance between apparel sales growth and online sales. The authors observe that AI-driven ADFs contributed to adapting to external challenges and improved sales.

Numerical analysis indicates a significant increase in Amazon's relative apparel intensity (RAI) between 2014–2016 due to the incorporation of AI-powered ADFs. The consistency of RAI is observed from 2017, which indicates that Amazon has achieved a balance between apparel sales growth and online sales, reflecting strategic initiative rather than reaction to market dynamics. For example, one of Amazon's strategies is to focus on high-value products such as ADFs along with diverse fashion products. Stability in RAI is important for this strategy. The balance in RAI reflects the biological concept of homeostasis. The stable RAI suggests Amazon's ability to adapt to market shifts. An assessment of the coevolution between ADFs and neo-luxury shows that COVID-19 triggered this coevolution, reflecting people's shift toward meaning rather than commodity. Meaning is central to design-driven innovations. With its generative function, AWS enables the development of a cloud-based fashion platform.

Furthermore, this study leads the authors toward a new challenge of revealing the inside of the black box of Amazon's business model, where a majority of the information remains shielded from the public. Therefore, multiple methodologies that incorporate the concepts of homeostasis and resonance into techno-economic analysis are applied to understand the balance achieved by Amazon between apparel sales and online sales.

Author contribution

In Article IV, Professor C. Watanabe was in charge of supervision. Waleed Akhtar contributed primarily to conceptualization, with insights from Professor C. Watanabe. Professor C. Watanabe initiated the methodology and numerical analysis with Waleed Akhtar, who collected most of the data and contributed to the analysis with insights from Professor Y. Tou. Waleed Akhtar primarily contributed to writing and literature reviews. During the investigation, Professor Pekka Neittaanmäki gave essential comments. Visualization was mainly Waleed Akhtar's task, with guidance from Professor C. Watanabe. Professors P. Neittaanmäki and C. Watanabe managed the project, and Waleed Akhtar handled the revisions, final editing, and approval processes.

7.5 Results of Article V

Akhtar, W., Watanabe, C., Tou, Y., & Neittaanmäki, P. (2022). A new perspective on the textile and apparel industry in the digital transformation era. Textiles, 2(4), 633–656.

Objectives

Literature survey to find new business models beyond traditional e-commerce in the metaverse society.

Results

New fashion innovations during COVID-19 surpassed traditional e-commerce boundaries, blending fashion, technology, entertainment, and sustainability. Leveraging the potential of high-performance computing through Amazon Bracket (quantum), the Amazon Aware initiative has the potential to improve the efficiency of supply chain analytics, carbon footprint assessments, and the optimization of circular and sharing economy models. For Amazon Style, representing ODM, real-time data analytics and forecasting are crucial; quantum computing can analyze vast amounts of data quickly and transform predictive algorithms. Quantum algorithms can generate instant designs for Luxury Stores' initiatives. Employing the Amazon Bracket on Making the Cut can improve user engagement with real-time feedback. As these initiatives interact and overlap, they resonate with the principles of the metaverse. This is because users can actively engage in real-time co-creation, personalization, and immersive entertainment, representing the dynamic interactivity central to the metaverse.

Author contribution

In Article V, Professor C. Watanabe supervised, while Waleed Akhtar and Professor C. Watanabe jointly conceptualized the work. Waleed Akhtar led the methodology, data collection, analysis, writing, editing, formal analysis, and visualization. Professor Pekka Neittaanmäki offered comments on the investigation. Professors P. Neittaanmäki and C. Watanabe handled project management, and Waleed Akhtar managed revisions, final editing, and approval processes.

8 CONCLUSION

Fashion reflects economic, cultural, and technological shifts in our society. As people become more aware of the structural problems associated with the traditional fashion industry, such as its impact on the environment and its slow responsiveness to evolving peoples' preferences, there is a growing demand for structural changes. This has led to a transformation in the industry, with digital solutions being developed to address these issues, making fashion synchronize with people's rapidly changing demands. The emergence of a non-contact society during and after the COVID-19 pandemic emphasized these challenges, accelerating the timely development of digital solutions. Moreover, the United Nations Sustainable Development Goals (SDG) are relevant to the fashion sector. In particular, SDG 9 indicates that traditional industries should integrate advanced technologies to develop intelligent and resilient infrastructure, accelerate innovations, and promote sustainable industrialization. The significant difference between traditional fast fashion and digital fashion is that the latter is data-driven, based on advanced technologies, incorporates shifts in customers' preferences on an individual level, is collaborative, functions in a non-contact society, and is environmentally sustainable. This research examines the coevolution of advanced digital technologies and the fashion industry to explore new business models. In doing so, Amazon's AI-driven R&D business model was studied as a case study. This coevolutionary dynamism was addressed in the five included articles.

8.1 Theoretical implications

In the dynamic digital economy, the technology and fashion industry's coevolution is accelerating transformative innovations, transcending previous industrial revolutions to Industry 4.0. This shift reshapes traditional industry norms and sparks discussions about the dichotomy between modern and traditional industries (Berg, 1992).

The evolution of the digital economy is reshaping the concepts of growth and productivity. ICT-advanced countries are often trapped in the dilemma of the productivity paradox, in which higher inputs result in lower outputs. Similarly, R&D-intensive firms often confront the two-faced nature of ICT—that is, higher investment in ICT results in declining productivity. This unexpected situation has been observed in various advanced economies, where increasing digital technology investments only sometimes increases productivity. The first research analyzes the coevolution between R&D transformation, highlighting the dilemma between its growth and decline in productivity and the significance of digital solutions to the fashion industry. This suggests that this paradox can be balanced by harnessing the vigor of SIRs, which lead to neo-open innovation (Stoneman, 2010; Tou et al., 2018). Neo-open innovation fosters a culture of innovation, improves knowledge management, and leverages external innovation resources (Articles I and II).

Article II fixes the problem by introducing an AI-driven digital solution named ADF. ADF emerged while using the learning orchestration externality approach. With aesthetic, functional, and technological appeals (Cappetta et al., 2006; Swan et al., 2011), ADFs act as SIRs, representing a new business model corresponding to neo-open innovation that balances the dilemma of expansion in R&D and decline in productivity (Articles II, III, and V). This dynamism suggests how industries and economies, on a broader level, harness the potential of SIRs or soft innovations for growth by avoiding the ICT dilemma.

Amazon's customer-centric R&D culture, integrated with innovative AI-driven strategies, harnesses the power of consumers' behaviors and thoughts across multiple hierarchical levels through the assimilation of preceding innovations. This dynamic approach enables the seamless orchestration of continuous learning through evolving ADFs. This enables Amazon to keep learning and improving its products and services (Articles II and IV).

The new concept, ADFs, encompasses online and offline shopping experiences and is built upon AI, AR, VR, and CV technologies. These technologies enable the fusing of the net and the real. When applied to shopping, these technologies contribute to omnichannels, which means seamless switching with a unified experience (Verhoef et al., 2015). Fashion retailers' challenging task is to maintain customer experience over single, multi, and omnichannels (Article IV). This experience should be consistent and unique and should maintain the brand's value. However, luxury brands confront the Internet dilemma and prefer physical presence over digitalization (Aiolfi et al., 2019; Kapferer, 2015; Kapferer, 2017). This reflects their structural impediment to omnichannel dependence. Moreover, the challenges faced by contemporary omnichannels are multifaced, encompassing digitalization, operational, and brand value (Aiolfi et al., 2019; Bijmolt et al., 2021; Cui et al., 2021; Leeflang et al., 2014). This necessitates digital solutions in which a complete and undisrupted customer experience can be provided without compromising the brand's unique values. Articles III and IV, with a supra-omnichannel approach and neo-luxury concepts, fix this problem.

The third research study introduces the novel concept of a data-driven, cloud-based fashion platform arising from the synchronization of ADFs, luxury brands, and ODM. ODM reflects the development of a supra-omnichannel while incorporating the concept of dual coevolution. The supra-omnichannel approach is a practical example of an omnichannel implementation that needs to be included in fashion. This approach fills the research gap by considering the unique demands of the fashion industry in providing a holistic and unified customer experience (Articles III and IV).

The increase in seamless switching due to rapid advancements in the digital economy and the paradigm shift in people's preferences toward supra-functionality has prompted companies to embrace a more user-centric approach. This transformation has led companies to embrace omnichannel alternatives. However, contemporary omnichannels confront implementation challenges (Simone et al., 2018). In response to omnichannel challenges, a new concept of supra-omnichannel provides a more holistic customer experience by transcending the traditional omnichannel approach. Supra-omnichannel, with enhanced integration and synchronization, provides a holistic customer experience, optimized, and flexible supply chain, scalable solutions that correspond to changing people's preferences, and advanced personalization through ODM. The interconnected evolution of ADFs, luxury brands, and ODM within the supra-omnichannel framework facilitates collaborative synergies and new innovations. This dynamism overcomes the limitations of traditional approaches (Article III).

Studies advocating that luxury brands should not be sold online have created an Internet dilemma. Contrary to these studies, a new concept, neo-luxury, has been proposed that offers a novel digital solution (Canvas, 2022). AWS, a generative function, integrates stakeholders into a cloud-based fashion platform. Building on the coevolution of AWS, ADFs, and ODM, a new concept of neo-luxury is suggested. Neo-luxury has the potential to solve the historic Internet dilemma of luxury brands. Neo-luxury removes offline and online boundaries that prevent seamless switching (Brynjolfsson et al., 2013; Rigby, 2011). Amazon has introduced a new storefront for luxury brands, Luxury Stores, which offers physical store-like features (Articles III and IV).

As a multisided platform, Amazon seamlessly integrates fashion and luxury brands with third-party sellers in the marketplace. It allows sellers to make independent pricing decisions and to continuously introduce their fashion lines, enhancing users' experiences and satisfaction in the fashion segment. However, its dual role as marketplace owner and seller creates platform governance complexities (Teh, 2022). When platforms offer their products alongside those of third-party sellers, they might show their items more prominently, impacting the visibility of other sellers.

The collection of big data from cloud-based fashion platforms and the supra-omnichannel approach enrich and expand AWS functionalities. This advanced AWS, in turn, accelerates coevolution among ADFs, ODM, and luxury

brands, reshaping the digital fashion industry through advanced solutions and logistics (Article V).

Amazon has built influence over customers and sellers, which facilitates the development of an exceptionally advanced cash conversion cycle and enables the implementation of dynamic pricing, contributing to more interactions with customers and increasing free cash flow. Amazon has institutionalized R&D and experimentation as the company's culture, aiming to develop customer obsession in buying decisions. This strategy has enabled Amazon to develop a system for participation, leveraging digital technologies and user-driven innovations. These innovations accelerated advancements in ICT, which enabled the development of soft innovation resources in the marketplace. This dynamism activates a self-propagating function that induces functionality development, leading to supra-functionality beyond economic value, which satisfies shifts in people's preferences.

Amazon's R&D system converts routine or periodic alterations into notably advanced improvements during the R&D process by incorporating external innovation resources. Amazon transforms "content" centered around routine and periodic changes into "technology," which leads to substantial improvements. This system relies on a chain of networks, a big data collection system, and a participation architecture. Amazon's sophisticated management systems, driven by customer-centric leadership from CEOs and contributions from innovative workers, have operated effectively, ensuring responsiveness and adaptability to disruptive business changes and the evolution of market demands.

8.2   Practical and policy implications

The COVID-19 pandemic has enabled businesses to rethink and reshape their business models globally. The emergence of a "new normal" characterized by a non-contact society and shifting consumer preferences has accelerated innovations in the fashion domain. This transition suggests the significance of exploring digital solutions to create synergy among fashion, technology, entertainment, and sustainability, going beyond the traditional limitations of e-commerce. For example, high-performance computing, such as quantum computing with Amazon Bracket, can advance supply chain analytics and users' engagement with real-time feedback and improve the effectiveness of circular and sharing economy models. Technology is essential not only to satisfy the evolving demands of a non-contact society but also as a strategic move to adopt innovations such as online fashion shows, metaverse, see now buy now, ODM, and to refine digital platforms. This leads to more personalized experiences and addresses the growing consumer demand in the evolving digital fashion world. Organizations should develop a long-term vision for a post-pandemic non-contact society that highlights resilience, adaptability, and non-contact solutions.

Practical applications of coevolution imply the incorporation of strategies that reconcile the dichotomy between higher R&D investments and declining productivity. A convincing example of successfully balancing this dilemma is Amazon, which has managed to improve its productivity and growth through heavy investments in AI-driven R&D, representing the practical implementation of coevolutionary dynamism.

Amazon's digital fashion trajectory illustrates the immense potential for adapting AI-driven technologies and mechanisms to cultivate an ecosystem for new innovations. Integrating hierarchical AI functionalities is crucial because it enables companies to align with changing peoples' preferences, fostering user-driven innovations and development. For the fashion industry, AI and learning orchestration strategy is important because it enables the creation of ADFs, supra-omnichannels and the implementation of unique AI functions and tools. Luxury brands and traditional industries should seek active collaboration with technology companies, such as Amazon's innovative platform, to enhance digital expertise in the neo-luxury conundrum. Powered by AWS's generative function, AI and machine learning should be implemented in designing and prototyping, reducing errors, and enhancing design-driven innovations. Amazon's AI algorithm fashion designer and Alexa are trained to be fashion designers, and they are expected to assist human designers in fashion co-creation.

The fashion industry is undergoing a transformation driven by shifts in consumers' preferences, growing consumer awareness of sustainability, and the rapid pace of digitalization. To ensure positive results from this transformation, it is important to implement a comprehensive framework of policies and regulations complemented by industry-driven initiatives. This combined effort can lead the fashion industry toward growth, as well as protect the rights of designers and consumers. Both government and industry should encourage collaboration and knowledge sharing between technology companies (e.g., Amazon) and traditional industries (e.g., fashion) to advance coevolution further and drive innovations, thereby satisfying consumers' preferences on an individual level. Companies should prioritize applying homeostasis and resonance concepts to innovation management strategies.

In the era of emerging Society 5.0, characterized by the seamless fusing of digital and physical realms and driven by advancements in interconnected technologies, opportunities arise in creating a human-centered society (Salgues, 2018). In this paradigm, AI-driven digital fashion technologies, as explored in this dissertation, are not merely digital innovations in fashion; they are important components that bridge the fashion industry with the demand of Society 5.0. Amazon's endeavors in digital fashion are examples of how digital transformation can reshape the industry. It is important that institutions and policy makers thoughtfully address the rapidly evolving digital fashion industry, which is ready to play a significant role in shaping sustainable and advanced Society 5.0. Endorsing neo-open innovations by harnessing the vigor of SIRs and user-driven innovations stimulating co-creation. This may result in improved productivity and limited dependence on traditional fast fashion practices.

8.3 Limitations and future research

Acknowledging research limitations is fundamental for transparency, advancing a vigorous foundation for future research, and a comprehensive understanding of the coevolutionary dynamism of advanced technology and fashion. This dissertation presents insightful perspectives on the digital transformation in the fashion industry, focusing on developments in digital fashion innovations. It uses Amazon as a case study within the broader context of technology giants like GAFAM (Google, Apple, Facebook, Amazon, and Microsoft). Amazon's choice was driven by its leadership in fashion technology solutions and its pioneering role in AI-driven innovations. However, an inherent limitation of this focus is the potential need for more generalizability of the findings. The practices and strategies of Amazon, as a part of the GAFAM group, may not be representative of the entire technology sector or the diverse approaches within the fashion industry. Moreover, technology giants such as Amazon have strict policies regarding information sharing and internal operations. However, this study relies on empirical data sourced from Amazon's activities, potentially limiting the depth and generalizability of the findings. The limited sample size, mainly centered on Amazon and the limited number of luxury brands that joined the Amazon platform, may raise concerns about applying the results to the broader digital fashion domain. Using indirect evidence and analogical approaches may introduce subjectivity, emphasizing more primary data.

This study lays the foundation for further research into how digital fashion and technology advancement can reshape the fashion industry, fostering innovation, sustainability, and growth in the post-pandemic world. Future research should expand beyond Amazon and consider a broader range of companies and domains. Furthermore, new investigations should consider extended timeframes and use primary data. On the premise of high-performance computing, future research should explore new business models beyond e-commerce, for instance, metaverse fashion. Algorithmic designs are on the rise that create new styles without human supervision. More research is needed to understand how AI interfaces with human designers' creativity.

YHTEENVETO (SUMMARY IN FINNISH)

Tämä väitöskirja esittää kattavan empiirisen analyysin teknologian ja muodin yhteiskehityksestä keskittyen erityisesti muotiteollisuuden digitaaliseen muutokseen. Keskeinen näkökohta tässä tutkimuksessa on analysoida Amazonin muuttavaa roolia tällä alalla. Yhtiö on siirtynyt sähköisen kaupankäynnin johtajanasemasta edelläkävijäksi teknologian ja muodin yhdistämisessä. Amazonin kasvutarinaa tutkitaan empiirisesti, jotta voidaan osoittaa, että tutkimus- ja kehitysinvestoinnit, innovatiiviset tekoälyalgoritmit ja tehokkaat pilvipohjaiset ratkaisut ovat muokanneet muotialaa merkittävästi. Amazonin tapaustutkimus valottaa sitä, millä tavoin teknologiset edistysaskeleet voivat toimia katalysaattoreina muodin kehittymiselle.

Tämä tutkimus haastaa perinteisen teknologian ja muodin erottamisen ehdottaessaan yhteiskehitysmallia, jossa kumpikin alue vaikuttaa toisiinsa ja edistää toisiaan. Yhteiskehitystä havainnollistaa kehittyneen digitaalisen muodin syntyminen, joka tarkoittaa merkittävää harppausta muoti-innovaatioissa. Kehittynyt digitaalinen muoti, joka on syntynyt Amazonin strategisesta tekoälyn ja suurdatan hyödyntämisestä, merkitsee poikkeamista perinteisistä muotinormeista yhdistäessään esteettisen vetovoiman datavetoiseen tehokkuuteen. Väitöskirjassa pohditaan kehittyneen digitaalisen muodin roolia muoti-innovaatioiden tuottavuusparadoksin ratkaisemisessa ja sitä korostetaan olennaisena pehmeänä innovaatioresurssina sekä katalysaattorina muotisektorin uusavoimille innovaatioille.

Tutkimuksessa korostuu erityisesti tekoälyn muutosvaikutus muotialaan. Tekoälyn monipuolinen rooli käsittää muun muassa suunnitteluprosessien parantamisen, kuluttajakokemusten personoinnin, toimitusketjujen optimoinnin ja tilauksesta tapahtuvan valmistuksen mahdollistamisen. Väitöskirja tarjoaa yksityiskohtaisen analyysin Amazonin hierarkkisista tekoälytoiminnoista, jotka ovat mukautuvia ja kehittyvät kuluttajien muuttuvien mieltymysten mukaan. Tällainen tekoälykeskeinen lähestymistapa on ollut ratkaisevan tärkeä seitsemän erillisen kehittyneen digitaalisen muodin sarjan kehittämisessä. Niistä jokaisessa on ainutlaatuisia tekoälyominaisuuksia ja -työkaluja edistyneistä koneoppimisalgoritmeista sosiaalisen median vaikuttajien integrointiin ja kaikki huipentuu kattavaan omnikanavaiseen (kanavasta riippumattomaan) lähestymistapaan.

Samanaikaisesti väitöskirjassa tutkitaan syvällisesti yliomnikanavaisen lähestymistavan käsitettä. Tämä lähestymistapa merkitsee paradigman muutosta siinä, miten muotibrändit ovat vuorovaikutuksessa kuluttajien kanssa ja hallinnoivat toimintojaan ylittäen perinteiset mallit yhdistäessään saumattomasti digitaalisia ja fyysisiä kokemuksia. Tutkimuksessa tarkastellaan Amazonin pilvipohjaista muotialustaa tämän lähestymistavan ilmentymänä ja havainnollistetaan sen tarjoamaa yhtenäistä kokemusta, joka yhdistää tehokkaasti kaikki arvoketjun sidosryhmät. Tämä alusta tunnetaan asiakaspolun virtaviivaistamisesta ja merkittävistä haasteista, joita luksusbrändit kohtaavat Internet-aikakaudella erityisesti tilausvalmistuksessa.

Väitöskirjassa esitellään uusluksuskonsepti. Se haastaa perinteisen näkemyksen, jonka mukaan luksusbrändien tulisi välttää online-läsnäoloa. Digitaalisen muutoksen ja kontaktittoman vuorovaikutuksen aikakaudella kuluttajien mieltymykset siirtyvät kohti henkilökohtaisia ja merkityksellisiä kokemuksia, jotka ulottuvat perinteisten luksustavaroiden ulkopuolelle. Tutkimuksessa tarkastellaan digitaalisten teknologioiden, erityisesti tekoälyn ja kyberfyysisten järjestelmien soveltamista näiden henkilökohtaisten, digitaalisesti tehostettujen, kontaktittoman yhteiskunnan mieltymysten mukaisten muotikokemusten luomiseen.

Lopuksi pohditaan metaversumimaisen yhteiskunnan mahdollista syntyä uskaltautuen nykyisten digitaalisten ratkaisujen ulkopuolelle. Väitöskirjassa esitellään uusia liiketoimintamalleja, joissa yhdistyvät muoti, teknologia, viihde ja kestävä kehitys. Amazon Bracketin (Quantum) kaltaisista teknologioista keskustellaan tuoden esiin niiden potentiaali mullistaa toimitusketjun analytiikka, hiilijalanjälkiarvioinnit sekä kierto- ja jakamistalouden mallien optimointi. Tutkimuksessa ehdotetaan, että nämä aloitteet voisivat edistää reaaliaikaista käyttäjien sitoutumista muodin yhteisluomiseen, mikä resonoi metaversumi-konseptin ytimessä olevan dynaamisen interaktiivisuuden kanssa.

Väitöskirjassa esitetään, että muotiteollisuuden digitaalinen muutos, josta esimerkkinä ovat Amazonin strategiset innovaatiot, tarjoaa syvällisen ymmärryksen teknologian ja muodin monimutkaisesta suhteesta. Tätä yhteiskehitystä ei kuvata lineaarisena etenemisenä vaan monitahoisena prosessina, jolla on merkittäviä vaikutuksia muotiteollisuuteen, laajempiin teollisiin sovelluksiin ja päätöksentekoon digitaalisella aikakaudella. Yliomnikanavaisen lähestymistavan integrointia tekoälyyn perustuvaan kehittyneeseen digitaaliseen muotiin korostetaan kriittisenä strategiana kontaktittoman yhteiskunnan asettamiin haasteisiin vastaamisessa, mikä on erityisen tärkeää COVID-19-pandemian yhteydessä. Näitä edistyneitä digitaalisia ratkaisuja ei esitetä vain väliaikaisena vastauksena pandemiaan vaan indikaattoreina muotiteollisuuden perustavanlaatuisesta muutoksesta, mikä tasoittaa tietä toisiinsa yhdistetymmälle, kestävämmälle ja innovatiivisemmalle tulevaisuudelle.

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ORIGINAL PAPERS

I

FASHION-DRIVEN TEXTILES AS A CRYSTAL OF NEW STREAM FOR STAKEHOLDER CAPITALISM: AMAZON'S ENDEAVOR

by

Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P., 2020

Fashion-Driven Textiles as a Crystal of a new Stream for Stakeholder Capitalism – Amazon's Endeavor

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ABSTRACT

Fashion reflects changes in socio-economic and cultural life which, in turn, changes fashion, and apparel boosts such change. Thus, in response to a shift in people's preferences from economic functionality to supra-functionality beyond an economic value, the fashion industry has been gaining momentum worldwide.

In the digital economy, the fashion industry is in the midst of global dynamic change stimulating volatility, velocity, variety and dynamism, which necessitate a digital solution.

Digital business leader Amazon has succeeded in constructing an R&D-driven disruptive businesss model. This can be attributed to a virtuous cycle among user-driven innovation, advancement of the Internet, co-emergence of soft innovation resources, and activation of a self-propagating function leading to supra-functionality satisfying user preferences.

Given a timely digital solution, the fashion industry reinforces this cycle which, in turn, advances the solution. Thus, broad stakeholder involvement betting on a higher level of R&D expecting the future prospects of the industry can be expected.

Based on a co-evolution analysis of the development trajectories of Amazon and the fashion industry, an insightful suggestion paving the way to stakeholder capitalism, essential for global business leaders, is thus provided.

KEYWORDS

Fashion, Fashion-driven textiles, Apparel, Amazon, Stakeholder capitalism

1. INTRODUCTION

Fashion reflects the change in aesthetic, economic, political, cultural, and social life[1]. These changes, in turn, change fashion, and apparel boosts this change [2]. Thus, in response to a shift in people's preferences from economic functionality to supra-functionality beyond economic value encompassing socio-cultural, aspirational, tribal, and emotional values[3, 4, 5], the fashion industry has been gaining momentum worldwide[6].

Under the digital economy, contemporary fashion industry is in the midst of global dynamic change[7, 8] urging it volatility, velocity, variety, complexity and dynamism[9, 10], which necessitate digital solution.

Digital business leader Amazon has succeeded in constructing a sophisticated R&D-driven disruptive business model transforming its core investment, R&D into a new concept of R&D [11, 12]. This success can be attributed to a virtuous cycle among user-driven innovation, advancement of the Internet, co-emergence of soft innovation resources, and activation of a self-propagating function that induced functionality development, leading to supra-functionality beyond an economic value that satisfies a shift in users' preferences [13].

Given a timely digital solution, fashion industry could reinforce this cycle [14] which, in turn, advances the solution leading to co-evolution between them. Thus, broad stake holder involvement betting on a higher R&D with the expectation of the future prospects of the industry as well as the company can be expected [15].

To date, while many studies have analyzed the identical features of fashion and the fashion industry (e.g., [16, 17, 18, 19, 20]), and also Amazon's R&D system from the viewpoints of technology operation strategy as well as financial management system (e.g., [21, [22], [11], [12]), no one has analyzed their co-evolutionary advancement leading to further advancement of digital solution of the fashion industry and Amazon's R&D-driven customer centric virtuous cycle toward stakeholder capitalism.

Given the increasing significance of stakeholder capitalism corresponding to a shift in people's preferences from economic functionality to supra-functionality beyond economic value, and Amazon's notable endeavor toward this direction, on the basis of an empirical analysis of the co-evolutionary development trajectories of Amazon and the fashion industry, an insightful suggestion toward stakeholder capitalism is attempted to explore.

Amazon has been endeavoring to frontier innovation and companywide experimentation, thereby develops its growing empire and subsequent big data collection system enabling it harnessing the power of users which function as a virtuous cycle leading to the transformation of "routine or periodic alterations" into "significant improvement" during R&D process.

This has been enabled by fusing unique R&D system and a sophisticated financing system centered on cash conversion cycle (CCC) driven free cash flow management.
With this orchestration it leverages the expectations of a wide range of stakeholders by providing supra-functionality and thereby takes the initiative of stakeholder capitalism in which stakeholders bet on Amazon's prospecting future through its aggressive R&D.

Co-evolution between these endeavors and fast fashion advancement in the new stream of the economies as digital, circular and sharing economies provides insightful suggestion particularly to institutional innovation and also to fashion-driven textiles toward stakeholder capitalism.

Organization of this paper is as follows: Section 2 over reviews fashion as a reflection and changer of social life. New stream of the digital economy impacting on the fashion industry is examined in Section 3. Section 4 analyzes Amazon's endeavor toward stakeholder capitalization. Section 5 summarizes the noteworthy findings, policy suggestions, and future research.

2. FASHION AS A REFLECTION AND CHANGER OF SOCIAL LIFE

2.1. Fashion and the Fashion Industry

Fashion is a popular aesthetic expression at a certain time and in a certain context, especially in clothing, footwear, lifestyle, accessories, makeup, hairstyle and body proportions [20]. This is critical for the textile industry and it is best defined simply as the style or styles of clothing and accessories worn at any given time by groups of people.

The fashion industry forms part of a larger social and cultural phenomenon known as the "fashion system," a concept that embraces not only the business of fashion but also the art of fashion, and not only production but also consumption. It encompasses the design, manufacturing, distribution, marketing, retailing, advertising, and promotion of all types of apparel which triggers the downstream of textile industry [1] as illustrated in Fig. 1.
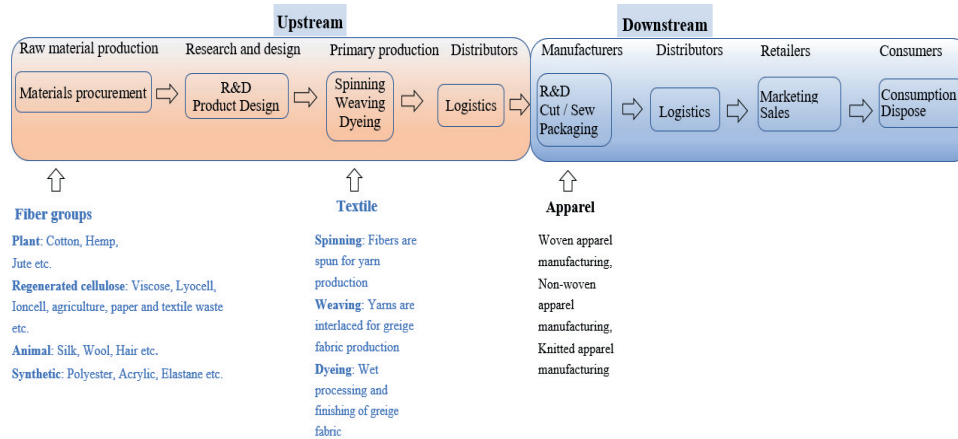

Figure 1. Value chain structure of the textile industry.

Source: Authors.

The fashion industry consists of four levels: the production of raw materials, principally fibers and textiles but also leather and fur; the production of fashion goods by designers, manufacturers, contractors, and others; retail sales; and various forms of advertising and promotion. These levels consist of many separate but interdependent sectors, all of which are devoted to the goal of satisfying consumer demand for apparel under conditions that enable participants in the industry to operate at a profit[17].

2.2. Chronology of the Fashion Industry

The fashion industry is a product of the modern age. Prior to the mid. 19th century, virtually all clothing was handmade for individuals, either as home production or on order from dressmakers and tailors. By the beginning of the 20th century, with the rise of new technologies such as the sewing machine, the rise of global capitalism and the development of the factory system of production, and the proliferation of retail outlets such as department stores, clothing had increasingly come to be mass-produced in standard sizes and sold at fixed prices. Although the fashion industry developed first in Europe and the US, today it is an international and highly globalized industry, with clothing often designed in one country, manufactured in another, and sold in a third. For example, a US fashion company might source fabric in China and have the clothes manufactured in Vietnam, finished in Italy, and shipped to a warehouse in the US for distribution to retail outlets internationally [17].

While the fashion industry has long been one of the largest employers in the US, and it remains so in the 21st century, employment declined considerably as production increasingly moved overseas, especially to China. Notwithstanding such employment shift, it not only accounts for a significant share of world economic output, but also, 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 Figs. 2 and 3[5], has gaining momentum worldwide [6].
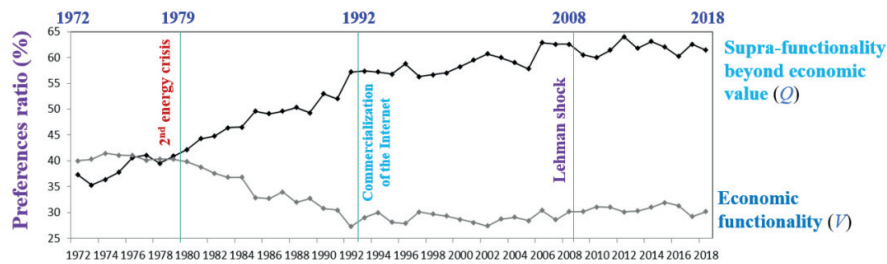
Figure2. Trend in the shift of people's preferences in Japan (1972-2018).

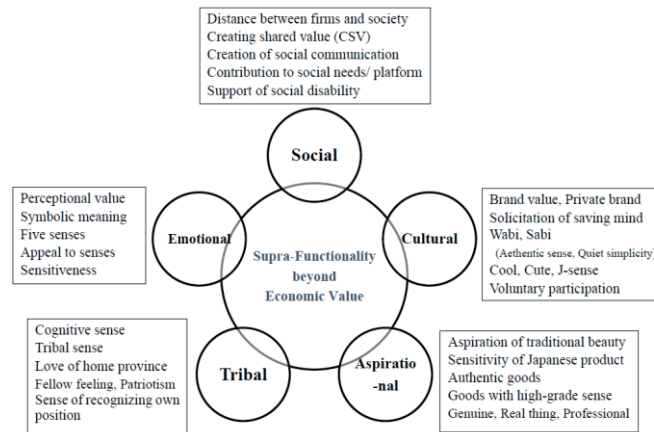Source: National Survey of Lifestyle Preferences [23].

Figure3. Concept of supra-function beyond economic value.

Original sources: [3, 4, 5].

Global market size of the apparel industry demonstrated sustainable increase from US$ 1.05 tril. in 2011, 1.25 tril. in 2015, 1.40 tril. in 2017, and 1.65 tril. (40 % are shared by EU and the US)in 2020. Apparel market grew faster than the global economy as, contrary to the average growth rate of 2.70% in global GDP from 2011 to 2015, global apparel market increased 4.70% in the same period. Fast fashion demonstrated much higher increase as 10.0% in this period as demonstrated in **Fig. 4**.GDP elasticity to fashion ε_{FG}(1% increase in GDP increases ε_{FG}% increase in fashion) is more than twice of GDP elasticity to apparel as demonstrated in the right hand of Fig.

Elasticity of GDP to apparel $\quad \varepsilon_{AG} = \dfrac{4.7}{2.7} = 1.7$

Elasticity of GDP to fashion $\quad \varepsilon_{FG} = \dfrac{10.0}{2.7} = 3.7$

$\qquad\qquad\qquad\qquad\qquad \varepsilon_{FA} = \dfrac{10.0}{4.7} = 2.1$

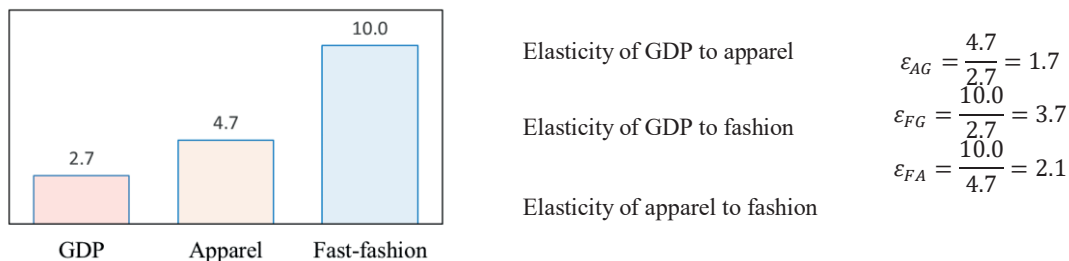Elasticity of apparel to fashion

Figure 4. Comparison of average growth rate of global GDP, total apparel and fast-fashion (2011-2015) - %$p.a.$.Source: Authors.

2.3. Contemporary Features of the Fashion Industry in the Digital Economy

Fashion reflects the change in aesthetic, economic, political, cultural, and social life. Social life changes fashion and apparel boosts this change [2]. Individuals and society use fashion to communicate their taste and lifestyle. The common tastes and lifestyle of society collectively form andrepresent the taste and lifestyle of that society[1]. Those new emerging lifestyles are interpreted by fashion designersinto fashion concepts and then translated into fashion commodities [24].

The fundamental impediment ofthe fashion industry is that the time it takes to source materials, convert them intoproducts and move them into the marketplace is invariably longer than the time the customer is prepared to wait.

Contemporary fashion industry has become extremely global and dynamic, in addition, quickly changing, trendy, and inexpensive but luxurious. These trends have transformed the industry into fast fashion. The primary requirement of fast fashion is to quickly produce a product in a cost-efficient manner to respond to fast-changing consumer tastes in as near real time as possible.

The importance of time as a competitive weapon has been recognized in this fashion. The ability to be able to meet the demands of customers for ever-shorter delivery times and to ensure that supply can be synchronized to meet the peaks and troughs of demand is thus critical. Consequently, key features of the fashion industry in the digital economy centered on fast fashion can be identified as volatility, velocity, variety, complexity and dynamismas illustrated in
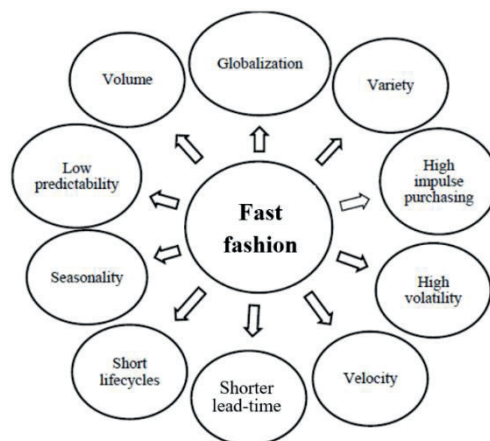

Figure 5. Key features of the fashion industry in the digital economy.

Source: Authors' elaboration based on[1].

With such features, fashion supply systems in the fashion industry as fast-moving, trend-driven business are characterized by three critical lead-times: time-to-market, time-to-serve, and time-to-react. All these requirements for shorter lead-time stress the importance of agility in fashion supply networks.

Adoption and implementation of lean manufacturing system as just-in-time, agile supply chains, and quick response are expected to reduce the processes involved in the buying cycle, and also lead-times for new fashion product into stores.

Advancement of the digital economy accelerates these demands. At the same time, it provides the fashion industry new solution, digital solution. In addition, this advancement emerges new

environments, shifting to sharing economy and circular economy which urges the fashion industry change to disruptive business model.

3. NEW STREAM OF THE DIGITAL ECONOMY IMPACTING ON THE FASHION INDUSTRY

3.1. Digital Solution to the Historical Demand of the Fashion Industry

Confronting Such Historical demand as fast fashion, technological breakthrough, particularly digital solution utilizing the dramatic advancement of the digital innovation, is highly anticipated. Noteworthy endeavors in the forefront of the fashion industry include:

(i) **Wearable technology** including smart fabrics that enhance wearer comfort by changing color or texture based on environmental changes.

(ii) **3D printing technology** that has influenced prominent designers, and will become more accessible to designers and eventually consumers, which could potentially shape the fashion industry entirely.

(iii) **Advancement of ICT centered on the Internet** such as online retailers and social media platforms have given way for trends to be identified, marketed and sold immediately. Styles and trends are easily conveyed online to attract the trendsetters. Posts on Instagram or Facebook can easily increase awareness about new trends in fashion, which subsequently may create high demand for specific items or brands.

(iv) **Machine vision technology** has been developed to track how fashions spread through society thereby the fashion industry can now see the direct correlation on how fashion shows influence street-chic outfits.

(v) **Internet of things (IoT)** improves customer experiences and apparel items will have digital capabilities that open communication between retailer and customer. Apparelinteracts with customer to collect data that helps retailers understand needs and concerns, and implement it to create a more personalized experience.

(vi) **Artificial intelligence (AI)** enables retailers collect, organize, analyze, and sort data into relevant categories, that can then be used to predict and understand what their customers are looking for.

(vii) **Mobile commerce** enables customers enjoy a seamless mobile-friendly shopping experience by clicking on the item they like and be redirected to the product page – effectively reducing search time. Businesses can provide their customers with a simple way to discover products and shop, all through their handy smartphones.

(viii) **Virtual reality (VR)/augmented reality (AR)** merge the physical and online worlds of retail. They enable shoppers to try outfits on an avatar, customized to the correct measurements, before purchasing an item. These platforms, change the online shopping experience for the better, as avatars and virtual platforms engage and retain the customers for longer.

(ix) **Next generation technology** for wood-based fibers are expected to solve future challenges such as cellulose gap, solutions to complex raw material needs, recycling solutions, and use renewable resource-based feed stocks [25, 26].

Thus, digitalization has completely evolved the fashion industry. With the introduction of new technologies such as AI, IoT, VR/AR, and mobile customers can expect to receive a more personalized experience that caters to all their needs and concerns[27].At the same time, these digital innovations provide digital solution to the fundamental impediment of the fashion industry, takes time in its complicated supply chain system (Fig. 1). Thus, digital solution enables the fashion industry transforming into new features in the digital economy as illustrated in Fig. 5.

3.2. Shifting to Sharing Economy

Cohen et al.[28] reminded that some altogether new and different business has emerged in the first decade of this century. These developments have started to challenge traditional thinking about how resources can and should be offered and consumed. This way of thinking supports the arguments that incremental improvements in our existing production and consumption systems are insufficient to transform our global economy toward sustainability [29, 30].From these, a new business model inevitably emerges toward the shared economy. Cohen et al.[28] pointed out that shared mobility solutions as reviewed earlier can be attributed to multiple agents, including public and private providers, seek to develop business models which address deficiencies in public infrastructure and public transit systems, historically the exclusive purview of local and regional governments. They also warned that the common interest in sustainability among these different types of agents does not always lead to harmony, instead giving rise to agency conflicts that can reduce the positive sustainability impact of their individual and collective initiatives.

The emergence of the sharing economy and its rapid shift accelerated by the digital economy have provided significant impacts on fashion leading to the shift to new ownership models driven by growing consumer desire for variety, sustainability and affordability. In recognition of this consumer shift, start-ups will not be the only players making their mark in these segments, established fashion brands will accelerate the pace with which they embrace new ownership models to further their relevance to consumers. Consumers are choosing to rent rather than own goods outright. This trend is partly driven by the young generation's hunger for newness, while embracing sustainability. Consequently, the lifespan of fashion products is being stretched as pre-owned, refurbished, repaired and rental business models continue to evolve. Across many categories consumers have demonstrated an appetite to shift away from traditional ownership to newer ways in which to access product. they are now wading into the pre-owned and rental markets. Additionally, because of the circular nature of this partnership, it bolsters the corporate and social responsibility of the fashion brand[6].

Thus, this shift corresponds to increasing concern to shift to circular economy and accelerated by the advancement of the digital economy.

3.3. Circular Economy and Circular Fashion

Given the increasing dependence on fashion-driven textiles, global consequences of environmental concerns and subsequent shifting trend from fossil economy to circular economy inevitably boosts circular fashion as illustrated in Fig. 6.

The world is already using approximately 1.6 planet's worth of resources every year. By 2030, the global middle class is expected to have increased to 5 billion people and the consumption of textiles and shoes by 65% compared to 2015. Clearly, there is an urgent opportunity to shift from "take-make-waste" production and consumption models to a new model called as "circular fashion" where resource loops are tightened and valuable materials are recovered [31].

Contrary to current fossil economy where manufacturers extract resources from the earth to make products that will soon be discarded in landfills, circular fashion requires the production of goods

and services operates like systems in nature, where the waste and demise of a substance becomes the food and source of growth for something new as illustrated in Fig. 6.

Shift of people's preferences to supra-functionality beyond economic value and also sharing economy correspond to this requirement in circular fashion. Advancement of ICT centered on the Internet driven digital innovation enables to accomplish this requirement by constructing platform ecosystem: all stakeholders (company, employee, user and government) challenge together for social demand. This accelerate new endeavor toward wood-based textile fibers.
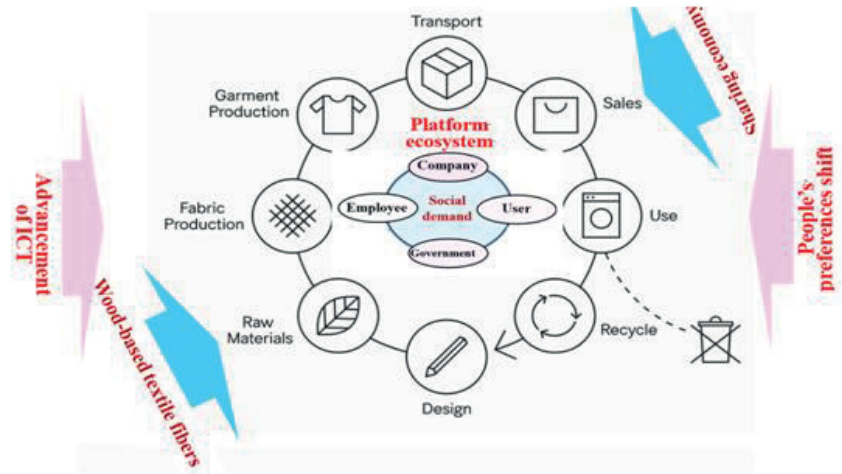

Figure 6. New stream of circular models in the fashion industry.

Source: Authors' elaboration based on [31].

4. AMAZON'S ENDEAVOR

4.1. Amazon as an R&D-Driven Customer Centric Company

4.1.1. Transformation of R&D into Neo Open Innovation

Contrary to the decisive role of R&D in the digital economy, the dilemma of its expansion and productivity decline has become a worldwide concern, which most digital economies are now confronting [32]. This dilemma can be attributed to the two-faced nature of ICT that ICT prices decrease as digital contents increase due to unique nature of ICT as freebies, easy replication and mass standardization [5, 33].

Notwithstanding such a dilemma, Amazon demonstrated a conspicuous increase in its R&D and became the world's top R&D firm in 2017 with a skyrocketing increase in its market capitalization, making it close to being the world's biggest company, as demonstrated in Figs.7 and 8.

[1]Given the profit maximum behavior in the competitive market, ICT prices are equivalent to marginal productivity of ICT
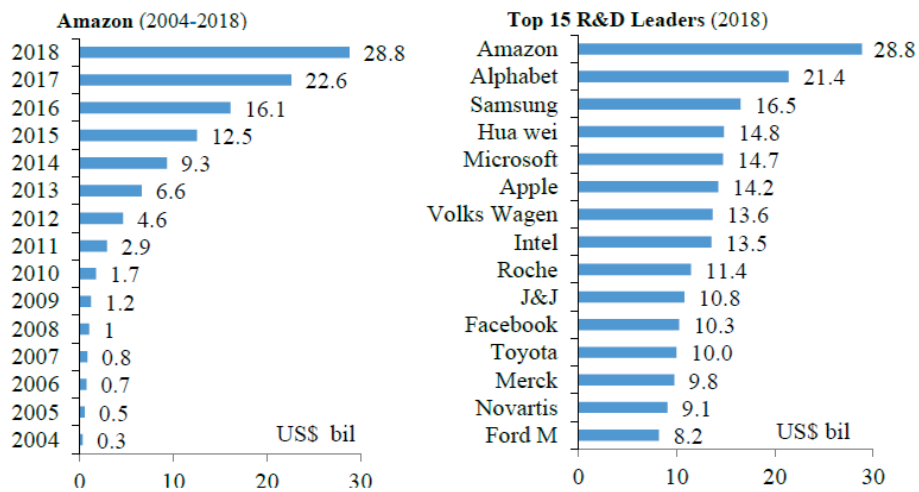
Figure 7. Amazon's conspicuous jump to become the world's top R&D leader- R&D investment.
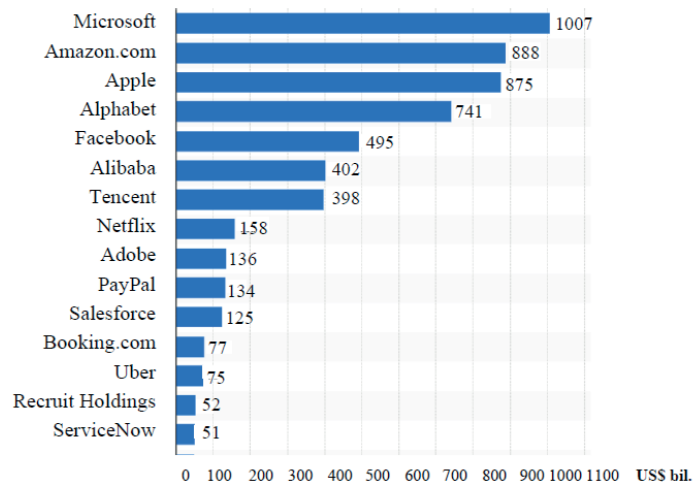
Original sources: [34, 35].

Figure 8. Market capitalization of the top 15 Internet companies (June 2019).

Source: [36].

This can be attributed to its R&D-driven disruptive business model endeavoring to transform into a new concept of R&D in neo open innovation that harnesses the vigor of soft innovation resources [11, 12, 32].

Amazon, based on its fundamental strategy of R&D as a culture, has been promoting companywide experimentation to cause customers obsessed with making purchase decisions. This has enabled Amazon to deploy an architecture for participation that leads to emerge the majority of digital technologies by harnessing the power of users as illustrated in Fig. 9.
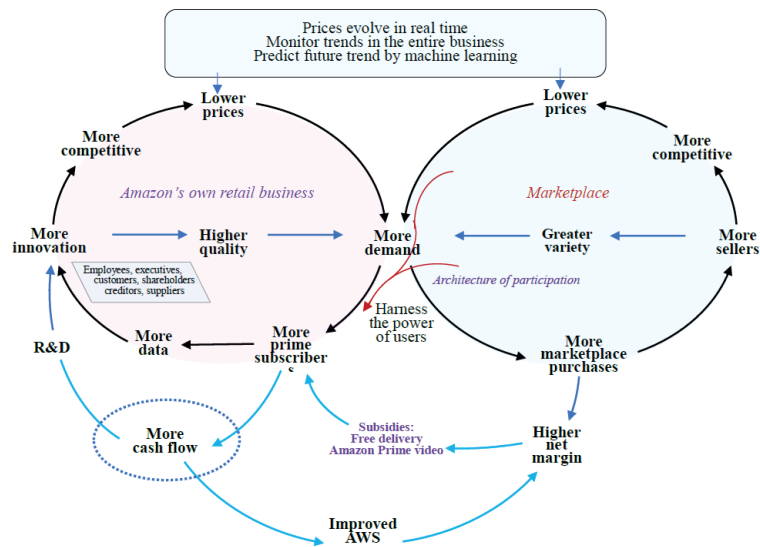
Figure 9. The dynamism of Amazon in harnessing the power of users.

Source: Authors' elaboration based on [37].

Such user-driven innovation accelerated a dramatic advancement of the Internet that, in turn, accelerated the co-emergence of soft innovation resources in the marketplace. This emergence activated a self-propagating function identical to ICT [38, 39] that induced functionality development, leading to supra-functionality beyond an economic value (see Fig. 3) that satisfies a shift in customers' preferences (Fig. 2), which Amazon has been treating as the highest priority. Enhancement of supra-functionality beyond an economic value further stimulates user-driven innovation leading to a virtuous cycle between advancement of the Internet, emergence of soft innovation resources in the marketplace, enhancement of supra-functionality beyond an economic value, and activation of user-driven innovation as illustrated in Fig. 10
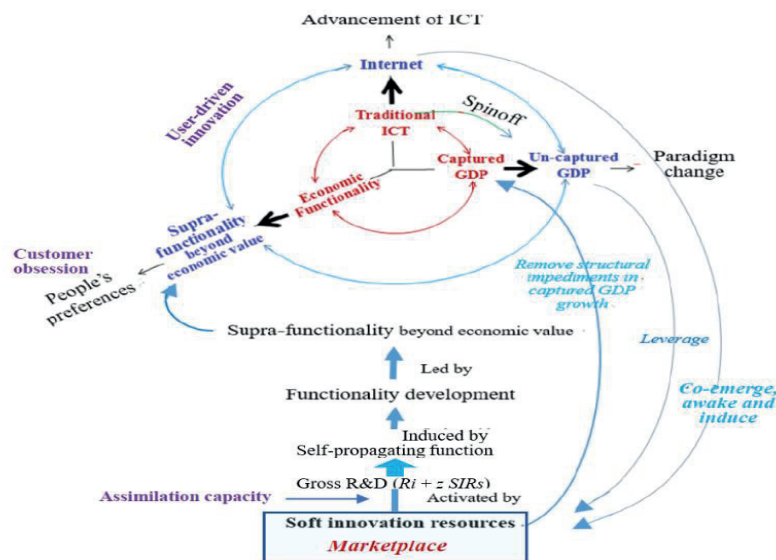

Figure 10. Dynamism in transforming Amazon into an R&D-driven business model.

Source: Authors' elaboration based on [11, 33].

While this system depends on the assimilation capacity of soft innovation resources, Amazon has developed a high level of capacity, supported by a rapid and notable increase in R&D investment. Such a sophisticated system can be attributed to strong inertia induced by the customer-centric visionary leadership of Jeff Bezos (founder and CEO of Amazon), together with motivated, brilliant and consistently innovative employees equipped with species survival and an evolution system that watches for the necessity of disruptive business change as illustrated in Fig. 11.

Figure 11. Illustration of Amazon's R&D.

Source: Authors' elaboration based on [11].

These efforts function as a virtuous cycle, leading to the transformation of "routine or periodic alterations" into "significant improvement" during R&D processas illustrated in Fig. 12.
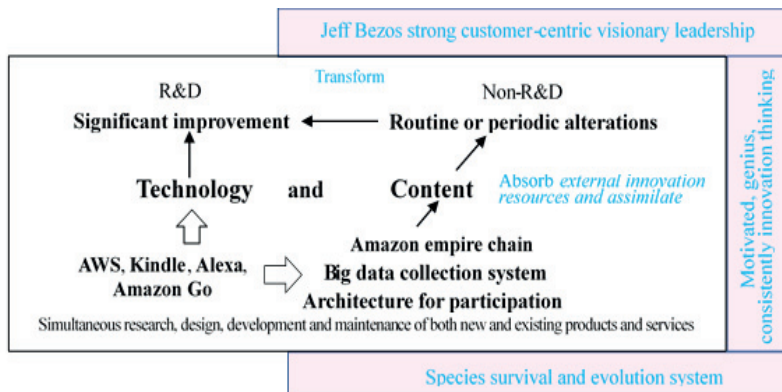
Figure 12. Scheme of Amazon's unique R&D model.

Source: [12].

4.1.2. Fusion of Technology Management and Financial Management

Amazon's unique R&D inducing system that transforms routine or periodic alteration activities into significantly improving activities during its R&D process by assimilating external resources of innovation based on an empire chain, a big data collection system, and also the architecture for participation gives rise to insightful suggestions regarding a new concept of R&D in neo open innovation that overcomes the dilemma between R&D expansion and productivity decline.

Consequently, elucidation of inside the black box of its techno-management system that enabled to secure such a large amount of R&D investment has become critical subject.

Amazon constructed a sophisticated cash conversion cycle (CCC) in the marketplace that creates affluent cash flow (CF) that enables aggressive R&D which incorporates characteristics of uncertainty, long lead-times, and successive inflows of very large amounts of funding without interruption.

Amazon succeeded in fusing its unique R&D transformation system and a sophisticated financing system centered on CCC-driven CF management that induced the following dynamism:

(i)   With strong user-driven innovation, Amazon has constructed an overwhelming power to both customers and vendors in its marketplace.

(ii)   This power enabled the construction of an extremely advanced CCC as negative 20 to 30 days.

(iii)   Advanced CCC decreased average interest rates of operating funds leading to a decrease in prices of goods and services, and enabled Amazon to deploy dynamic pricing which induced interactions with customers while increasing free CF.

(iv)   Induced interactions, in turn, further advanced CCC, leading to the construction of the first virtuous cycle.

(v)   Endorsed and supported by increased free CF, induced interactions accelerated the transformation of R&D, leading to increasing qualified technology stock.

(vi)   Increased stock contributed to sales increase, as well as the construction of a lean cost structure.

(vii)   Both contributed to an increase in operating profits and a subsequent increase in free CF, thus constructing the second virtuous cycle.

(viii) Sales increase contributed to further advancement of CCC management, leading to the third virtuous cycle.

Thus, three virtuous cycles have been constructed regarding Amazon's CCC management, enabling its notable CF management as illustrated in Fig. 13.
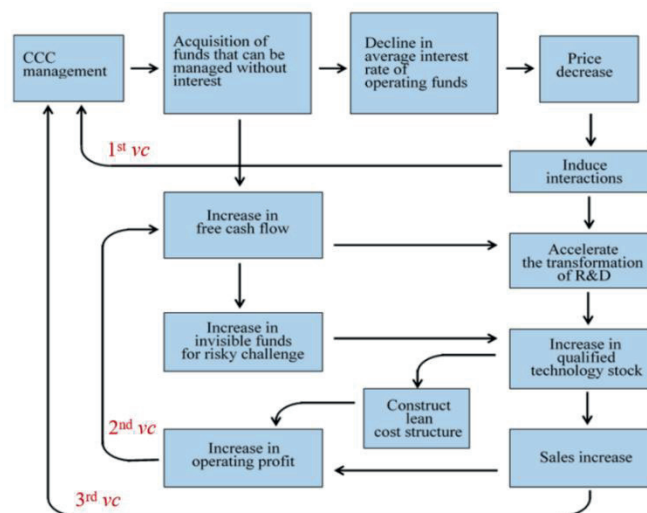

Figure 13. Dynamism of CCC in accelerating the transformation of R&D.

Original Source: Authors' elaboration based on [13].

In addition to this cash flow-based financing, Amazon also uses a different method of financing for business acquisitions and investments for reinforcing the above virtuous cycles by capturing a growth engine and also stimulating new R&D, taking into account the capital market conditions and, thereby deploying an exquisite combination of own cash and debt financing.

All financing strategies and R&D-driven business development strategy thereon has been deployed as a sophisticated consolidated machine that was constructed through three phases of development after the IPO in 1997 as illustrated in Fig. 14, consisting of:

(i)   Phase I (1997-2001)

Focal efforts were devoted to establishing financial and R&D bases beyond books and the US market through active merger and amalgamation (M&A) largely dependent on long-term debt.

(ii)   Phase II (2002-2008)

Developed business activities by fully utilizing fruits of the advancement of M&A, leading to gaining operating income that enabled CCC-oriented CF creation; thereby, R&D was promoted - which accelerated R&D substitution for M&A, leading to strengthening indigenous R&D base and decreasing long-term debt dependence.

(iii)   Phase III (2009-2018)

Increased CF, particularly free CF through advancement of business and construction of lean cost structure which induced R&D significantly leading to contributing to further advancement of business and subsequent CCC management. Thus, a virtuous cycle between them was constructed which re-activated M&A including the biggest acquisition of Whole Foods which functioned as capturing the growth engine and reinforced the fragility of the virtuous cycle.
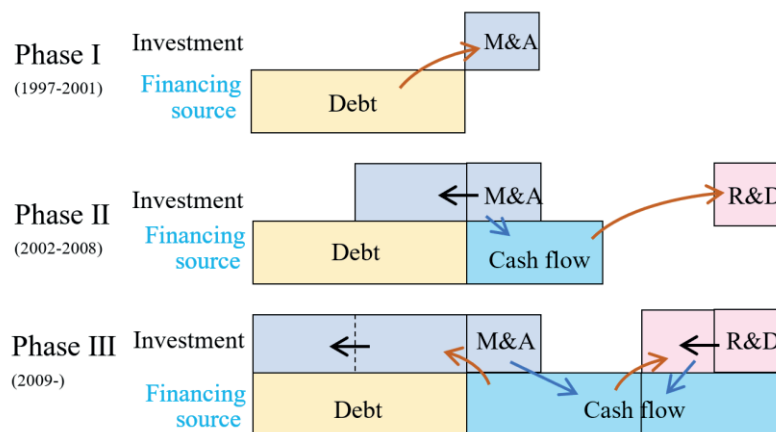

Figure 14. Scheme of Amazon's development trajectory of R&D financing.

⟶ : Business / R&D emergence ; ⟶ : Cash flow creation ; ⟶ : Expansion

Source: Authors' elaboration based on [13].

Noteworthy is all functions as marketplace dynamism inducing CCC advancement, CCC-driven CF management and R&D transformation from routine or periodic alteration to significant

improvements during the R&D process are well-orchestrated as a consolidated sophisticated machine.

4.1.3. Investor Surplus Leveraging Stakeholder Capitalization

As the digital economy progresses, securing R&D investment has determined competitiveness. As reviewed earlier, Amazon, a company with a market capitalization of US$ 1 trillion since 2018 following Apple, has been a world leader in R&D investment since 2017. In 2018, it invested US$ 28.8 billion, 35% more than the second biggest investor, Google. The rapid increase in this investment has shown no sign of slowing down the pace in 2019 amounting to US$ 35.9 billion [40].

Such a remarkable accomplishment can be attributed to its institutional systems that orcheste techno-financing systems, which fuse a unique R&D transformation system and a sophisticated financing system centered on the CCC as demonstrated above. These institutional systems support and endorse aggressive investment in R&D which incorporates characteristics of uncertainty, long lead-times, and successive inflows of very large amounts of funding without interruption as a lack of fund turns the return of all previous efforts to blisters.

While some of this investment can be endorsed by Amazon's positive business results, such as sustained increases in sales and free cash flow, such a large amount of aggressive investment is beyond endorsement. In addition to actual economic performance, investors have been betting on a high level of risky investment with the expectation of Amazon's future success, trusting its R&D-inducing institutional systems.

While the former can be considered to be a general reaction to a producer surplus, the latter can be postulated as an investor surplus in which investors bet on overly optimistic future prospects instead of actual accomplishments. This is similar to a consumer surplus in which consumers pay more than the actual market price for attractive goods and services.

In light of Amazon's notable success in rapidly increasing R&D investment while simultaneously accomplishing remarkable productivity and subsequent production increase despite the dilemma between them, elucidation of the institutional systems that enable Amazon to invest a very large amount of financing resources in aggressive R&D has become global concerns.

Market capitalization represents gross market value, which reflects the value of institutional systems of the company that induce large amount of aggressive R&D investment in Amazon. Corresponding to the current corporate governance doctor in encouraging company to shift from shareholder capitalism to stakeholder capitalism [41], this gross value can be decomposed into a producer surplus and an investor surplus. While the former represents actual objective economic performance, the latter is highly subjective and reflects largely uncaptured GDP in the digital economy, where customer's preferences have been shifting to supra-functionality beyond an economic value as illustrated in Figs. 2 and 3.

Comparison of the performance in constructing this value among the big four online service companies, Google, Apple, Facebook, and Amazon (GAFA) reveiles the following noteworthy contrast explaining the dynamism of an investor surplus that induces R&D investment:

    (i)   Among GAFA, Amazon demonstrated the highest dependence on an investor surplus as demonstrated in Fig. 15, which suggests that investors are betting on the continuation of Amazon's solid growth by means of its aggressive investment in R&D, supported and endorsed by its institutional systems.
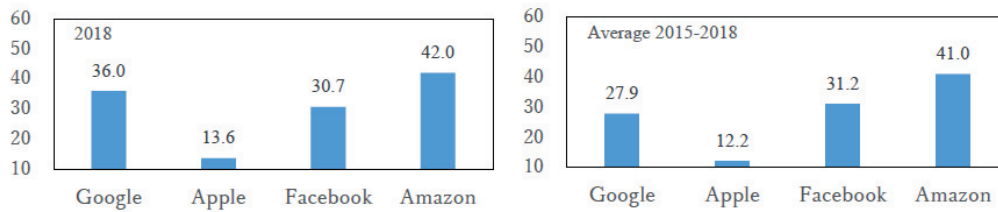
Figure 15. Comparisonof price free cash ratios for GAFA (2018, 2015-2018).

Note: $MC = N \times \frac{FCF}{N} \times \frac{S_p}{FCF/N}$

Where MC: market capitalization; N: number of shares; FCF: free cash flow;Sp: stock prices. Here, $\frac{S_p}{FCF/N}$ the price free cash ratio which can be treated as a proxy of an investor surplus.

(ii) Amazon's investor surplus demonstrated a high elasticity to R&D investment and supported the above mentioned supposition as demonstrated in Fig. 16.
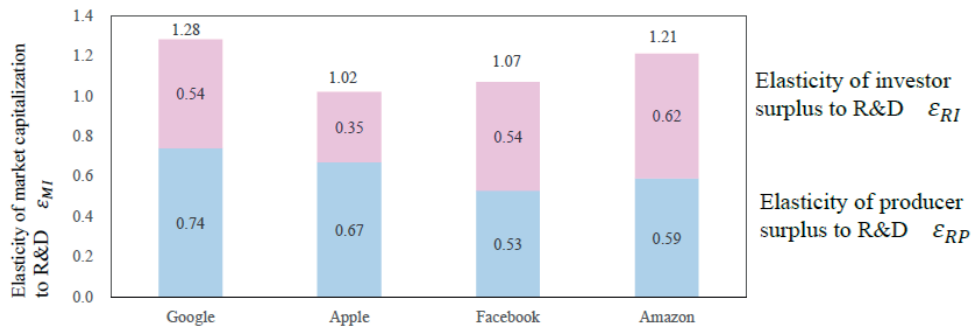
Figure 16. Comparison of the elasticity of market capitalization to R&D investment for GAFA (2005-2018).

Note: Elasticity of MC to R (MC elasticity to R) ε_RM implies 1% increase in MC increases ε_RM% increase in R and represents the efficiency of MC in inducing R.

(iii) Amazon's investors incorporate not only shareholders but also broad stakeholders centered on users (Fig. 8), and they expect not only economic value but also supra-functionality beyond such value, encompassing socio-cultural and ecological values (Figs. 2 and 3).

(iv) Thus, Amazon has taken the initiative in terms of stakeholder capitalism leading it to realize an outstanding CCC and secure abundant free cash, enabling aggressive R&D that excites investors.

Note: Market capitalization, which reflects the value of the institutional systems, is decomposed to the following equation, consisting of objectively reflecting the economic performance and the subjective "dream": expectation relating to the company's future success.

$$MC = N \times \frac{E}{N} \times \frac{S_p}{E/N} \qquad (1)$$

where E: earning (net income).

While E/N represents earning per share (EPS) and, together with N, it represents the actual economic performance, $\frac{S_p}{E/N}$ rerepresents price earning ratio (PER), which is highly subjective.

Equation (1) depicts gross market value, encompassing the actual economic value (in terms of N and EPS) and the value of the "dream" of future success (PER).

Amazon's financial focus is on long-term growth in free cash per share rather than earning to address its leading target of being an R&D-driven company [42].

Therefore, equation (2) using free cash flow per share (FCPS) for EPS in equation (1) replicates the financial focus of a world-leading R&D-driven company.

$$MC = N \times \frac{FCF}{N} \times \frac{S_p}{FCF/N} \quad (2)$$

The foregoing contrast highlights significant role of an investor surplus for Amazon, and supported the supposition that investors bet on the continuation of Amazon's solid growth by means of its aggressive investment in large amounts of R&D.

As analyzed in 4.1.1, based on its unique business model and ambitious endeavour toward customer-centric R&D-driven advancement, Amazon has developed its comprehensive empire chain, big data collection system, and the architecture for participation, harnessing the power of users and leading to user-driven innovation. This innovation, in turn, accelerates further advancement of the Internet. Advanced Internet awakens and induces environmentally friendly soft innovation resources (SIRs) leading to a virtuous cycle between them as demonstrated in Fig. 9.

Since SIRs are considered to be a condensate and crystal of the advancement of the Internet [32, 43], in line with Metcalfe's law , the magnitude of SIRs is proportional to the interactions with users. Therefore, Amazon's user-driven innovation strongly awakens and induces broad areas of SIRs consisting of Internet-based resources that have been either sleeping or untapped, and it results in multisided interaction in the markets where the consumer is looking for functionality beyond economic value as illustrated in the bottom of Fig. 17
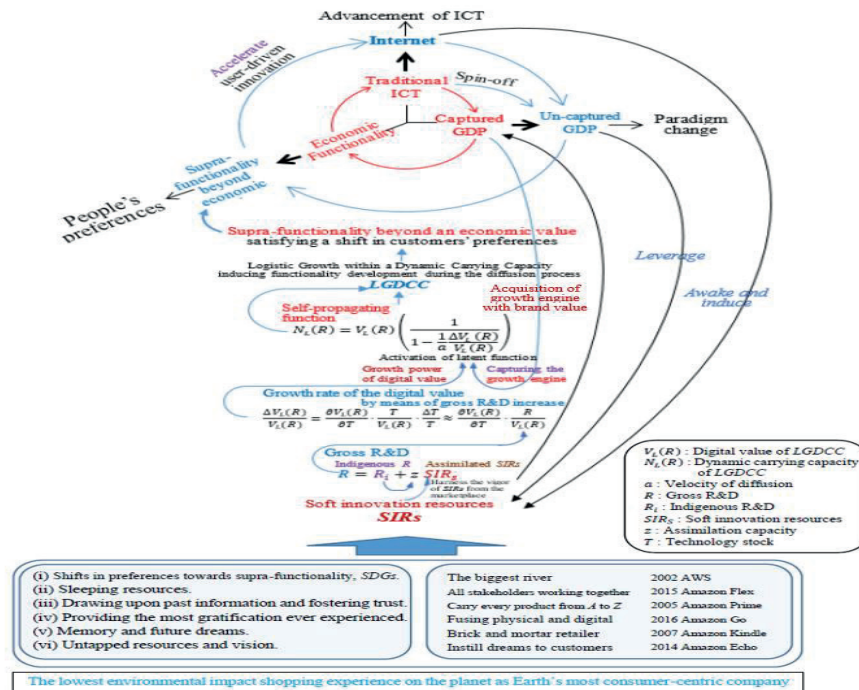
Figure 17. Dynamism of an investor surplus in inducing R&D investment in Amazon.

Source: Authors.

With distinct assimilation capacity supported by rapidly increasing R&D investment (Fig. 1), Amazon has assimilated these broad SIRs, leading to a significant increase in gross R&D, consisting of indigenous R&D and assimilated SIRs.

Increased gross R&D contributes to significant growth, which activates a latent self-propagating function indigenous to ICT [38, 39] leading to emerging supra-functionality beyond an economic value that satisfies a shift in customers' preferences in the digital economy which Amazon has been treating as the highest priority. Emerged supra-functionality accelerates user-driven innovation, which promotes further advancement of the Internet.

Thus, a notable virtuous cycle, user-driven innovation → advancement of the Internet → awakening and inducement of SIRs in a marketplace → increase in gross R&D → activation of self-propagating function→ emergence of supra-functionality beyond an economic value → acceleration of user-driven innovation, has been constructed, as illustrated in Fig. 17.

Institutional systems that orchestrate techno-financing systems, as reviewed in 4.1.2, enable this virtuous cycle, and given this cycle, R&D-driven sustainable growth leading to increasing gross market value can be expected. With this dynamism, investors bet on the continuation of Amazon's solid growth by means of its large amount of aggressive endeavours in R&D investment, as demonstrated by the high elasticity of investor surplus to R&D investment (Fig. 16).

Amazon does not pay dividends and has prohibited share buybacks since 2012. Therefore, it is natural to raise the question as to what investors expect from Amazon's huge risk investment? The above-mentioned dynamism provides a reasonable answer to this question, with significant

implications for Amazon's investor surplus. First, investors incorporate not only shareholders, but also broad stakeholders centered on users. Second, these stakeholders expect not only economic value but also supra-functionality beyond such value, encompassing social, cultural, and ecological values.

Thus, it can be concluded that Amazon leverages the expectations of a wide range of stakeholders by providing supra-functionality beyond an economic value that satisfies a shift in users' preferences in the digital economy and thereby takes the initiative in terms of stakeholder capitalism. This initiative leads to the realization of an outstanding cash conversion cycle (CCC), which secure abundant free cash and enables aggressive R&D that excites investors.

4.2. Challenge to Fashion

4.2.1 Lesson from the Bitter Experience

Amazon has been making extensive efforts to reinforce the above virtuous cycle in terms of acceleration, widening, appealing to stakeholders, and avoiding fragility. The acquisition of Whole Foods in 2017 can be considered aiming at reinforcing this cycle by capturing the growth engine with a brand value of ESG for avoiding the fragility of sustainable growth derived from technological and financial risks and uncertainties as well as environmental change in corporate governance [44].

Challenge to fashion can be considered in the same context for Amazon. Fashion can be strong growth engine as it incorporates growth nature with high level of income growth elasticity as reviewed in Fig. 4, while it takes a long time in building a fashion brand. In addition, it stimulates broad area of SIRs which Amazon's user-driven innovation awoke and induced as illustrated in the bottom of Fig. 17: (i) shift in preferences towards supra-functionality, (ii) sleeping resources, (iii) drawing upon past information and fostering trust, (iv) providing most gratification ever experienced, (v) memory and future dreams, and (vi) untapped resources and vision.These are corresponding to people's preferences shift,and Amazon's success in overcoming the dilemma between R&D expansion and sustainable growth can be attributed to assimilation of these resources as reviewed earlier.

Fashion advances all of these SIRs which, in turn, leads to further advancement of the fashion industry. Thus, Amazon endeavours co-evolution between its development and fashion advancement by expanding its share in its apparel business.

Apparel is a highly profitable category for Amazon. Apparel, including footwear, is now its most bought category in 2020, up from fourth place in 2019, surpassing books, beauty and electronics. Amazon quietly became the leading apparel retailer in the US topping US$ 30 bil. sales (13% of its total sales) in 2019.

In line with such jump and increase in its private-label offerings, Amazon became keen to move beyond selling the apparel as traditional value. It started fashion-driven apparel focusing on higher-value categories.

This was not Amazon's first attempt to breaking into the luxury fashion market. It tried similar move in 2012, but was not successful.

Part of the problem was the eCommerce brand's image. Despite conquering most of retail and selling a lot of clothes, Amazon has consistently struggled to sell fashion. Its quest to dominate fashion has faced several historical obstacles, as customers have not trusted buying apparel online out of a desire to try on the items first and that Amazon was not perceived as a "cool" brand.

4.2.2 The New Platform

On the basis of such bitter experience, Amazon re-started fashion challenge focusing on changing its image to cool brand.

It acquired the global television rights to The Lord of the Rings(series of three epic fantasy adventure films)in 2017, committing to a multi-season television series.This was an attempt to capture young affluent consumers' passion as acquiring a hot digitally native vertical brand would be essential for shedding its "uncool" label.

Successively, by making full utilization of digital technologies as AI, IoT, VR/AR, and mobile devises as reviewed in 3.1,Amazon introduced a number of innovations designed to turbocharge its fashion-driven apparel business by making full utilization of its strength in big data collection system, user-driven innovation, and advanced logistics system.

It launched Prime Wardrobe, that allows customer to try a several items on at home before purchase, and Personal Shopper by Prime Wardrobe with most suitable pieces selection advice by Amazon stylists. It debuted Echo Look, a new Alexa-powered device that the company dubs a "hands-free camera and style assistant." The addition of a camera enables the device to record and comment on its owner's clothing choices, using a combination of machine learning and human stylist feedback. This advice also takes the form of recommendations, which can drive revenue to Amazon fashion, and specifically its private-label brands. In addition, it launched the Drop that sells limited edition items designed by influencers, created an AI algorithm for designing clothes by analyzing a bunch of images and copy it to new items, and patented an AR mirror that shows customer wearing virtual clothes in virtual locales.
Consequently, Amazon's share of fashion shoppers jumped from 50% in 2017 to 61% in 2018[45]. New textile-led fashion sesign has emerged as a result of reflective learning combining practically oriented and theoretical knowledge [46]. Amazon's dynamic system among price-matching, controlling brand presentation, and price relative to competitors functioned well [47].

It should not be overlooked that such positioning in the fashion industry can be attributed not only to digital solution but also largely to new environments, shifting to sharing economy and circular economy which urges the fashion industry change to disruptive business model as reviewed in section 3 [48].Structural change in consumer's shopping behavior and desires as from owned to sharable as well as from disposable to reusable has shed light on Amazon's timely disruptive business model enabled by its sustainable digital innovation and initiated by its new platform.

4.3 The Inducing Role of the Fashion Industry Toward Stakeholder Capitalism

The fashion industry is demanding industry forming part of social and cultural phenomenon.

Advancement of the digital economy increases demands to this industry by accelerating a shift in customer's preferences from economic functionality to supra-functionality beyond an economic value, and accelerates subsequent identical features of the industry as volatility, velocity, variety, complexity and dynamism as reviewed in Fig. 5. At the same time, this advancement provides the fashion industry new solution, digital solution. In addition, it emerges new environments, shifting to sharing economy and circular economy which urges the fashion industry change to disruptive business model.

Above reviews on Amazon's fashion challenge, new streams in the digital economy as digital innovation, shifts to sharing and circular economies, and their impacts on the fashion industry

suggest that Amazon's apparel strategy has transformed into disruptive business model as typically demonstrated by the successive introduction of such new innovative fashion models as Prime Wardrobe, Personal Shopper by Prime Wardrobe, Echo Look, the Drop, AI algorithm for designing clothes, and AR mirror.

They are crystals of SIRs, core of Amazon's sophisticated virtuous cycle between gross R&D expansion, growth increase, supra-functionality creation, activation of user-driven innovation, advancement of the Internet, and further SIRs emergence. This cycle has enabled Amazon shedding its uncool label from its fashion challenge, thereby it pours its business assets to the fashion industry leading its disruptive innovation.

Fundamental feature of fashion as a popular aesthetic expression indigenous to human life triggered this cycle. Since this feature is the basis of all of SIRs as illustrated in Fig. 18, this co-evolutional dynamism between development of Amazon and advancement of fashion provides insightful suggestions toward stakeholder capitalization.

Since fashion embraces not only production but also consumption en compassing the design, manufacturing, distribution, marketing, retailing, advertising, and promotion of all types of apparel, this co-evolution induces broad stake holders involvement. In addition, since fashion embraces not only the business of fashion but also the art of fashion, such broad stakeholders bet to the future prospect of the company. Thus, this co-evolution leads a way to stakeholder capitalism.
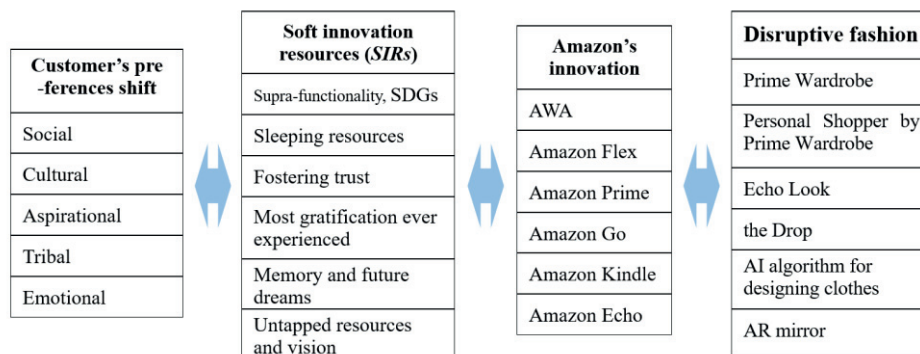
Figure 18. Co-evolution between SIRs-induced innovation and disruptive fashion advancement.

Source: Authors.

5. CONCLUSION

In light of the increasing significance of co-evolution between the transformation of R&D that overcomes the dilemma between its expansion and productivity decline, and digital solution of the advancement of the fashion industry, that satisfies people's preferences shift to supra-functionality beyond economic valueen compassing socio-cultural and aspirational values, this paper analyzed a prospect of this co-evolution.

An empirical analysis of co-evolutional development trajectories of Amazon, that leads a pioneer endeavor to the above transformation, and the fashion industry was conducted.

Fashion reflects the change 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.

However, under the digital economy, contemporary fashion industry is in the midst of global dynamic change stimulating it volatility, velocity, variety, complexity and dynamism, which necessitate digital solution.

Digital business leader Amazon has succeeded in constructing an R&D-driven disruptive business model transforming into a new concept of R&D that overcomes the dilemma between R&D expansion and productivity decline. This success can be attributed to a virtuous cycle among user-driven innovation, advancement of the Internet, co-emergence of soft innovation resources, and activation of a self-propagating function that induces functionality development, leading to supra-functionality beyond an economic value that satisfies a shift in customers' preferences.

Given a timely digital solution, fashion industry could reinforce this cycle which, in turn, advances digital solution for its new development in the digital economy leading to co-evolutionary development between them.

Thus, with indigenous nature of the fashion industry embracing broad stakeholders and also the art of fashion hitting them, broad stake holders involvement betting on a higher R&D with the expectation of the future prospects of company involving a new fashion industry in the digital economy can be expected. This corresponds to a new business doctrine toward stakeholder capitalization to which global business leaders are expected to accomplish.

These findings give rise to the following insightful suggestions for this accomplishment:

(i)   Co-evolutional development between Amazon's SIRs-driven innovation and disruptive advancement of fashion should be applied to disruptive business model aiming at overcoming the dilemma between R&D expansion and productivity decline.

(ii)   Dynamism enabling this co-evolution should be elucidated, conceptualized and operationalized.

(iii) Function of fashion tempting broad stakeholders bet to investing it should be elucidated, conceptualized, and then applied to stakeholder capitalization.

(iv)   Dynamism of fashion advancement through orchestrating shifts to digital economy, sharing economy, and circular economy should be applied to digital fashion advancement.

While this study provides insightful suggestions to stakeholders involving in the above co-evolution, it remains non-general application. Therefore, future work should focus on further elucidation, conceptualization and operationalization of the functions that the above orchestration may lead to transform the textile industry, and also broad industry at large.

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II

AMAZON'S INITIATIVE TRANSFORMING A NON-CONTACT SOCIETY: DIGITAL DISRUPTION LEADS THE WAY TO STAKEHOLDER CAPITALIZATION

by

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Amazon's initiative transforming a non-contact society - Digital disruptionleads **the** way to stakeholder capitalization

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A R T I C L E   I N F O

A B S T R A C T

Contrary to the decisive role of R&D centered on information and communication technology (ICT) in the digital economy, its excessive expansion has resulted in declining productivity due to the two-faced nature of ICT.

Consequently, the novel concept emerges of innovation that maintains sustainable growth by harnessing the vigor of soft innovation resources (*SIRs*).

Pioneering endeavors can be observed at the forefront of the global ICT leaders. World R&D leader Amazon has been harnessing the power of users that seek *SIRs*. This functions as a virtuous cycle, leading to the transformation of R&D by fusing a unique R&D system with a sophisticated financing system. With this orchestration, Amazon leverages the expectations of a wide range of stakeholders, and takes the initiative of stakeholder capitalism in which stakeholders bet on Amazon's prospecting future.

This paper attempts to elucidate the driving force of this notable accomplishment, taking Amazon's recent challenge in developing advanced digital fashions (*ADFs*) successively as prospecting *SIRs*. Since fashion reflects the change in socio-economic and cultural life, the fashion industry is in the midst of dynamic global change in the digital economy, which necessitates a digital solution.

Based on a co-evolution analysis of the development trajectories of Amazon and the fashion industry, it was demonstrated that Amazon has secured a digital solution by developing *ADFs* successively, and that this success can be attributed to learning orchestration externality. Thus, broad stakeholders' involvement betting on its challenge, expecting the future prospects of Amazon and the fashion industry, can be expected. Non-contact society accelerates this expectation toward on-demand *ADFs* manufacturing.

These findings give rise to suggestions regarding a new concept of R&D and subsequent neo -open innovation in the digital economy.

1. Introduction

Contrary to the decisive role of R&D centered on information and communication technology (ICT) in the digital economy, its excessive expansion has resulted in declining productivity due to the two-faced nature of ICT [1].

Consequently, the novel concept of innovation emerges that maintains sustainable growth while avoiding the dilemma by harnessing the vigor of soft innovation resources (*SIRs*). *SIRs* are latent innovation resources that can be awoken and activated by deploying an ICT-driven disruptive business model with the consolidated challenge for social demand [2].

Pioneering endeavors can be observed at the forefront of the global ICT leaders [3,4]. The world's top R&D firm, Amazon, has been engaging in pioneering innovation and companywide experimentation, thereby enabling it to harness the power of users that seek *SIRs*. This has functioned as a virtuous cycle, leading to the transformation of "routine or periodic alterations" into "significant improvement" during the R&D process, and has explored new *SIRs* successively [5].

This transformation has been enabled by fusing a unique R&D system with a sophisticated financing system centered on cash conversion cycle-driven free cash flow management [6].

With this orchestration, Amazon leverages the expectations of a wide range of stakeholders by satisfying a shift in people's preferences, from
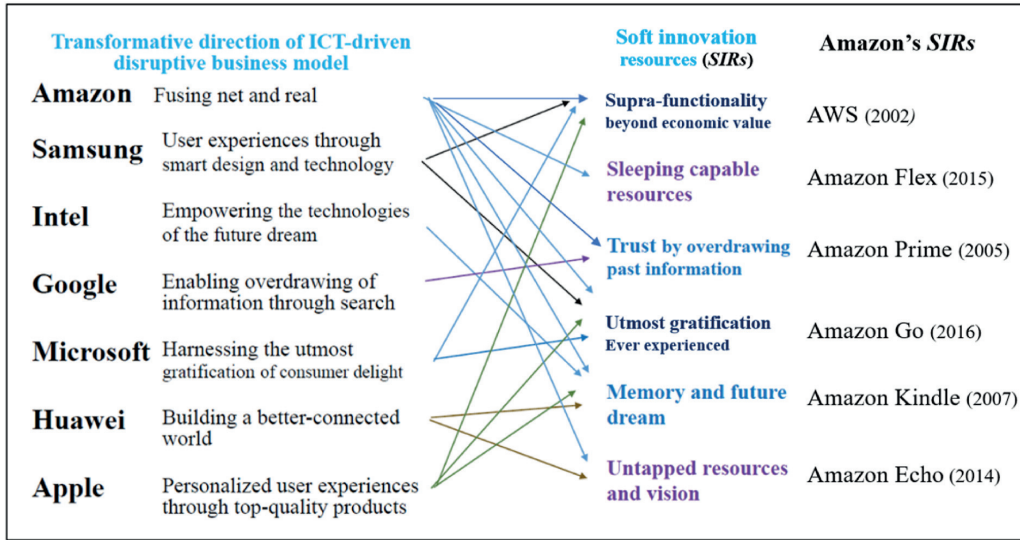

Fig. 1. Soft innovation resources emerged by global ICT leaders, and typical examples in Amazon.

economic functionality to supra-functionality, beyond economic value encompassing socio-cultural, aspirational, tribal, and emotional values [1,7,8].

In this way, Amazon has constructed a virtuous cycle among R&D-driven growth, the satisfaction of the shift in people's preferences to supra-functionality beyond economic value, the advancement of ICT, activation of *SIRs*, gross R&D (consisting of R&D investment and assimilated *SIRs*) increase, and well-balanced growth. Consequently, Amazon takes the initiative of stakeholder capitalism in which stakeholders bet on its prospecting future through its aggressive R&D [9]. The orchestration of techno-financing systems enables firms to secure a huge amount of risky investments by inducing an R&D bet from a broad range of stakeholders, which has paved a way to stakeholder capitalization [9].

Fashion reflects the change in aesthetic, economic, political, cultural, and social life [10]. These changes, in turn, change fashion, and apparel boosts this change [11]. Thus, in response to the above shift in people's preferences, the fashion industry has been gaining momentum worldwide [12].

However, the contemporary fashion industry is in the midst of global dynamic change in the digital economy [13,14], urging its volatility, velocity, variety, complexity and dynamism [15,16], which necessitate the digital solution. These features have urged Amazon to expect fashion as prospecting *SIRs* [17].

Given a timely digital solution, the fashion industry could reinforce the above R&D-driven virtuous cycle [18] which, in turn, advances the digital solution leading to co-evolution between them. Thus, broad stakeholders' involvement betting on a higher R&D with the expectation of the future prospects of the industry as well as the company can be expected [9].

To date, while many studies have analyzed the identical features of fashion and the fashion industry (e.g., Refs. [19–23], and also Amazon's R&D system from the viewpoints of technology operation strategy as well as financial management systems (e.g., Refs. [5,6,9,24–26], no one has analyzed their co-evolutionary advancement leading to further advancement of the digital solution of the fashion industry and Amazon's R&D-driven customer-centric virtuous cycle toward stakeholder capitalism. Dumaine [27] has recently provided a suggestive postulate that the company's strength lies in the "Artificial intelligence (AI) Flywheel" mechanism, which uses vast amounts of data and AI to gain

momentum for growth.

Prompted by Amazon's recent challenge in developing advanced digital fashions (*ADFs*) successively with aggressive AI-oriented R&D, an empirical co-evolutional analysis of the development trajectories of Amazon's recent seven *ADFs* and the fashion industry, with special attention to the role of AI advancement, was conducted in this paper. Here, *ADF* can be defined as a new fast fashion business that leverages digital innovation assets and the learning effects of preceding development.

It was demonstrated that Amazon has succeeded in securing a timely digital solution by developing seven *ADFs* successively. Advancement of AI and Amazon's enthusiastic efforts to be an AI giant [28] enabled this success. Amazon's business culture as an R&D-based customer -centric company and its subsequent R&D strategy inevitably utilized AI in a unique way, as inducing multiple hierarchy-level functions for approaching human behavior and thoughts by learning from preceding innovations. Such institutional systems have enabled Amazon to enjoy the effects of learning orchestration externalities through the course of its successive development of seven *ADFs*.

While Amazon has developed its notable business model depending on institutional systems by shifting its driving force from network externality to big data externality, this analysis demonstrated that learning orchestration externality takes a lead in the current digital economy. This inevitably leads to broad stakeholders' involvement betting on its challenge, expecting the future prospects of Amazon and *ADFs*. Non-contact society after COVID-19 accelerates this trend toward on-demand apparel manufacturing.

An insightful suggestion toward stakeholder capitalism is thus provided.

Organization of this paper is as follows: Section 2 provides an overview of Amazon's endeavor in advanced fashion. Learning orchestration externality emerging in advanced fashion is examined in Section 3. Section 4 analyzes Amazon's endeavor toward stakeholder capitalization. Section 5 summarizes the noteworthy findings, policy suggestions, and future research.
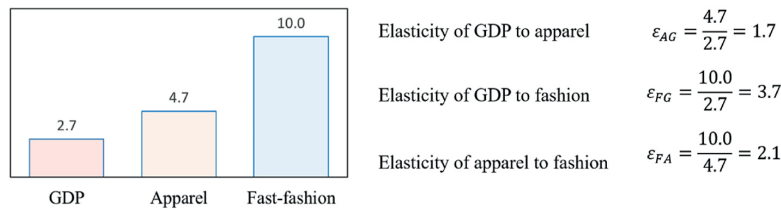
$$\varepsilon_{AG} = \frac{4.7}{2.7} = 1.7$$ Elasticity of GDP to apparel

$$\varepsilon_{FG} = \frac{10.0}{2.7} = 3.7$$ Elasticity of GDP to fashion

$$\varepsilon_{FA} = \frac{10.0}{4.7} = 2.1$$ Elasticity of apparel to fashion

Fig. 2. Comparison of Growth Rate of GDP, Apparel and Fast-fashion in the World. (2011–2015) - % p.a..
Sources: Singh [29] based on Market Line and Euro monitor International, and Statista [30].

Fig. 3. Co-evolution between *SIRs*-induced innovation and advanced digital fashion development in Amazon.

2. Amazon's endeavor to be a digital fashion leader

2.1. Virtuous cycle for customer-centric R&D-driven advancement

Amazon endeavors to make customer-centric R&D-driven advancement as the basis of its business model. With this business model, it has been endeavoring to frontier innovation and companywide experimentation for *growing its empire* and *subsequent big data collection* system.

This leads to notable interaction with users for user-driven innovation based on an architecture of participation, and a high level of assimilation capacity based on rapidly increasing R&D investment [5]. This enables it to harness the power of users who seek *SIRs* as demonstrated in Fig. 1.

This interaction functions as a virtuous cycle in Amazon, leading to the transformation of "routine or periodic alterations" into "significant improvement" during its R&D process [5].

These systems are considered a source that enables Amazon to deploy a successful neo-open innovation, leading its outstanding accomplishment in both R&D and sales increases by overcoming the dilemma between them. Here, neo-open innovation implies the novel concept of innovation emergence that maintains sustainable growth by avoiding the dilemma of productivity decline through increases in gross R&D, including assimilated *SIRs* by harnessing their vigor [2].

This deployment has been enabled by fusing a unique R&D system with a sophisticated financing system, centered on cash conversion cycle-driven free cash flow management [6].

With this orchestration, Amazon leverages the expectations of a wide range of stakeholders by providing supra-functionality beyond economic value, and takes the initiative of stakeholder capitalism in which stakeholders bet on its prospecting future through aggressive R&D [9].

Consequently, a notable virtuous cycle has been constructed: *user-driven innovation → advancement of the Internet → awakening and inducement of SIRs in a marketplace → increase in gross R&D (consists of indigenous R&D and assimilated SIRs) → solid growth → activation of self-propagating function → emergence of supra-functionality beyond economic value → acceleration of user-driven innovation* [9].

2.2. Challenge to fashion

(1) Lesson from the Bitter Experience

Challenge to fashion can be considered in the same context for Amazon. Fashion can be a strong growth engine as it incorporates a growth nature with high level of income growth elasticity, as demonstrated in Fig. 2.

Amazon has been making extensive efforts to reinforce the above virtuous cycle in terms of acceleration, widening, appealing to stakeholders, and avoiding fragility. The acquisition of Whole Foods in 2017 can be considered aiming at reinforcing this cycle by capturing the growth engine with a brand value of *ESG*[1] for avoiding the fragility of sustainable growth derived from technological and financial risks and uncertainties, as well as environmental change in corporate governance [31].

In addition, Amazon develops a broad area of *SIRs,* as demonstrated in Fig. 1. These *SIRs* include what Amazon's user-driven innovation awoke and induced, such as (i) a shift in preferences towards supra-functionality (e.g., AWS in 2002), (ii) sleeping resources (e.g., Amazon Flex in 2015), (iii) drawing upon past information and fostering trust (e. g., Amazon Prime in 2005), (iv) providing the most gratification ever experienced (e.g., Amazon Go in 2016), (v) memory and future dreams (e.g., Amazon Kindle in 2007), and (vi) untapped resources and vision (e.g., Amazon Echo in 2014). These are corresponding to people's preferences shift, and Amazon's success in overcoming the dilemma between R&D expansion and sustainable growth can be attributed to assimilation of these resources as reviewed earlier.

Fashion advances all of these *SIRs,* which, in turn, leads to further advancement of the fashion industry. Thus, Amazon endeavours co-evolution between *SIRs* development and fashion advancement, as illustrated in Fig. 3.

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[1] Whole Foods has taken a pioneering initiative in balanced *ESG* strategy: Environment-Social-Governance.
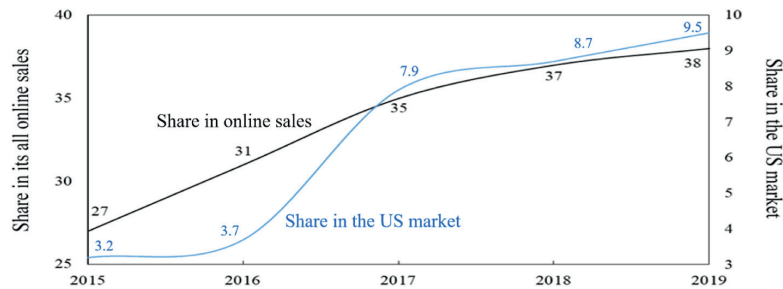
Fig. 4. Trends in Amazon's apparel sales share (2015–2019): %.
Sources: Statista [33]; Keyes [34]; Richter [35]; Wichser et al. [36]; Pymnts [37].

Thus, Amazon has been expanding the fashion-driven apparel business, which is a highly profitable category for Amazon. Fig. 4 demonstrates the increasing share of apparel sales on Amazon in all of its online sales as well as in the US market. Amazon has jumped to the second-largest seller of apparel in the US, with 7.9% share after Walmart (8.6%) in 2017, from 3.7% share in 2016. Apparel, including footwear, is now Amazon's most bought category in 2018–2019, up from fourth place in 2017–2018, surpassing books, beauty, and electronics. Amazon quietly became the leading apparel retailer in the US in 2019 [32].

With this jumping inertia of apparel, taking into account the strong growth engine of fashion, which incorporates a growth nature with a high level of income growth elasticity as reviewed in Fig. 2, Amazon became keen to move beyond selling apparel as traditional value. It started fashion-driven apparel focusing on higher-value categories.

This was not Amazon's first attempt at breaking into the luxury fashion market. It tried a similar move in 2012, but was not successful.

Part of the problem was the e-commerce brand's image. Despite conquering most of retail and selling a lot of clothes, Amazon has consistently struggled to sell fashion. Its quest to dominate fashion has faced several historical obstacles, as customers have not trusted buying apparel online out of a desire to try on the items first; additionally, Amazon was perceived as an uncool brand seller that will not satisfy customers' desire to try before buying the item.

(2) The New Platform

Based on such bitter experience, Amazon re-started the fashion challenge, focusing on shedding its image to a cool brand.

It acquired the global television rights to The Lord of the Rings (a series of three epic fantasy adventure films) in 2017, committing to a multi-season television series. This was an attempt to capture young affluent consumers' passion, as acquiring a hot digitally native vertical brand would be essential for shedding its uncool label.

Successively, by making full utilization of digital technologies, such as artificial intelligence (AI), the Internet of things (IoT), virtual reality (VR), augmented reality (AR), and mobile devices, Amazon introduced several innovations designed to turbocharge its fashion-driven apparel business by making full utilization of its strength in the big data collection system, user-driven innovation, and advanced logistics system.

Consequently, Amazon's share of fashion shoppers jumped from 50% in 2017 to 61% in 2018 [17]. Amazon can further increase its apparel market share if it diversifies the apparel business from selling basic and functional apparel to trendy styles [38].

2.3. The inducing role of the fashion industry toward stakeholder capitalism

The fashion industry is a demanding industry, part social and part cultural phenomenon.
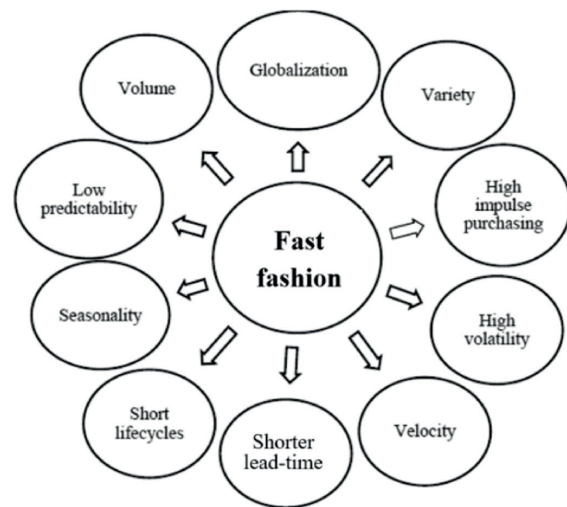
Fig. 5. Key features of the fashion industry in the digital economy.
Source: Authors' elaboration based on Ciarniene et al. [10].

Advancement of the digital economy increases demands in this industry by accelerating a shift in customer's preferences, from economic functionality to supra-functionality beyond economic value, and accelerates subsequent identical features of the industry such as volatility, velocity, variety, complexity and dynamism, as reviewed in Fig. 5 [10].

At the same time, this advancement provides the fashion industry with a new solution, a digital solution. In addition, it causes the emergence of new environments, shifting to a sharing economy and a circular economy, which urge the fashion industry to change to a disruptive business model.

The above reviews on Amazon's fashion challenge, new streams in the digital economy as digital innovation, shifts to sharing and circular economies, and their impacts on the fashion industry suggest that Amazon's apparel strategy has transformed into a disruptive business model, as typically demonstrated by the successive introduction of such new innovative fashion models as *Prime Wardrobe*, *AI Algo. Fashion designer*, *Echo Look*, *AR Mirror*, *Personal Shopper*, *Style Snap*, and *The Drop*.

Such examples are crystals of *SIRs*, at the core of Amazon's sophisticated virtuous cycle between *gross R&D expansion*, *growth increase*, *supra-functionality creation*, *activation of user-driven innovation*, *advancement of the Internet*, and *further SIRs emergence*. This cycle has enabled Amazon in shedding its uncool label from its fashion challenge, thereby allowing it to pour its business assets into the fashion industry and to

Fig. 6. Amazon's orchestration strategy in emerging advanced digital fashion.

lead disruptive innovation.

A fundamental feature of fashion as a popular aesthetic expression indigenous to human life triggered this cycle. Since this feature is the basis of all of *SIRs* as illustrated in Fig. 3, this co-evolutional dynamism between the development of Amazon and the advancement of fashion provides insightful suggestions toward stakeholder capitalization.

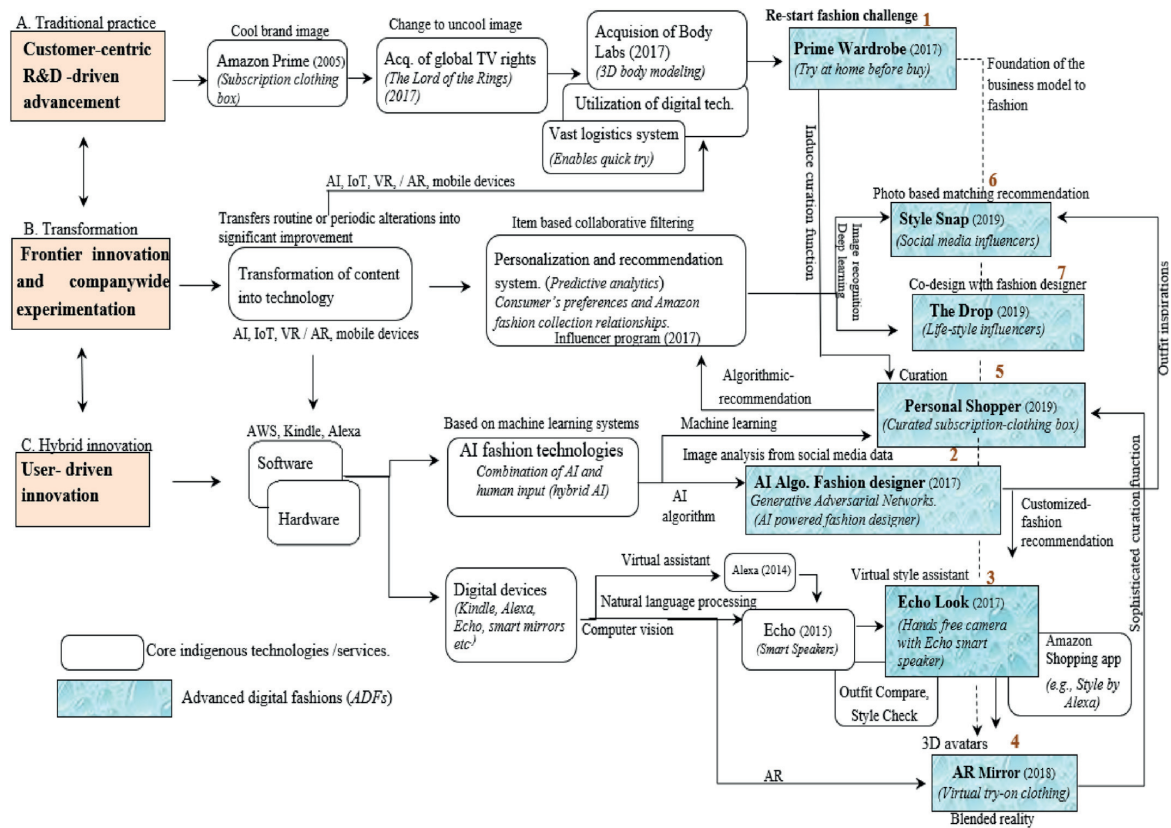Another aspect that draws attention toward stakeholder capitalization is the fundamental nature of the fashion industry. Multiple stakeholders are involved in the value chain, ranging from procurement of materials, manufacturing, marketing, and consumption. These stakeholders bet to enhance the future prospects of the company.

3. Learning orchestration externality emerging disruptive fashion

3.1. Orchestration Strategy in Emerging Advanced Digital Fashion

As reviewed in the preceding section, a basic principle for Amazon in conducting its R&D endeavor as an R&D-driven company can be highlighted as follows:

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

Amazon endeavors to make customer-centric R&D-driven advancement as the basis of its business model.

(ii) Frontier innovation and companywide experimentation

It has been endeavoring to frontier innovation and companywide experimentation for growing its empire and subsequent big data collection system.

(iii) User-driven innovation

It demonstrates notable interaction with users for user-driven innovation based on an architecture of participation, and a high level of assimilation capacity based on rapidly increasing R&D investment.

Amazon has been deploying orchestration strategy in endeavoring innovation by effectively utilizing the learning effects of similar challenges conducted in each respective area above the three pillars, which can be defined as learning by orchestration. Its endeavor in developing advanced digital fashions (*ADFs*) can be considered the typical case, as illustrated in Fig. 6.

In line with this orchestration strategy, Amazon has emerged such *ADFs* successively as Prime Wardrobe (2017), AI Algo. Fashion designer (2017), Echo Look (2017), AR Mirror (2018), Personal Shopper (2019), Style Snap (2019), and The Drop (2019).

Functionality and effects of learning orchestration externalities of each respective seven *ADFs* are demonstrated as follows:

(1) Prime Wardrobe (2017)

This triggered Amazon's re-start of the fashion challenge. This attempted to change Amazon's image from the uncool brand of just selling, to building trust and credibility [34,39]. This enables customers to try several items at home before purchase, and thereby satisfies their

demand for touching and feeling the apparel before purchase [40].

Amazon started from acquiring the global television rights to The Lord of the Rings (a series of three epic fantasy adventure films) in 2017, committing to a multi-season television series [41]. This was an attempt to capture young affluent consumers' passion, as acquiring a hot digitally native vertical brand would be essential for shedding its uncool label.

In parallel, Amazon attempted to reinforce its technology and distribution base for improving its competitive advantages in the fashion industry. Acquisition of Body Labs (2017) empowered 3D body modeling [42]. Incorporating the advanced digital innovation such as AI, particularly machine learning, IoT, VR/AR and mobile devices initiated through the transformation of content into technology, contributed to enhancing competitiveness. A vast logistics system enabled customers' quick try.

Thus, **Prime Wardrobe** succeeded in Amazon's re-start in the fashion business by shedding its uncool brand image.

Furthermore, this constructed the foundation of the business model by which to understand customers' needs on product and style preferences, as well as measurement of personal data. In addition, this induced an innovative business with a curation function: Personal Shopper (2019).

(2) AI Algo. Fashion designer (2017)

While **Prime Wardrobe** allowed customers to try several (given) items on at home before purchase, their potential desires would extend beyond these items.

To gain dominance in the fashion sector, Amazon aimed at providing customer-centric fashion solutions to each customer individually. To achieve this goal, Amazon used human designers as well as AI-based methods, such as machine learning and deep learning, by which to understand consumers' preferences, especially from social media data, and hence developed particular algorithms that have an ability to identify fashion trends through visuals appearing on the web [43,44].

AI Algo. Fashion designer provides new items by copying all possible fashion trends analyzed by human designers and AI, particularly by machine learning and deep learning.

Amazon's R&D team at Lab126 in the USA has developed an algorithm that learns about a particular fashion style from images, and then generates new items in similar styles from scratch. This uses machine and deep learning-based Generative Adversarial Networks (GAN), wherein two neural networks compete with each other [45].

By using this algorithm, Amazon is able to keep an eye on fashion trends by identifying and analyzing fashion-related images on the web. This revolutionary algorithm has the ability to design styles by itself. This algorithm also indicates that AI-powered fashion technologies can take over human designers, and the future fashion industry could possibly be more dependent on scientific/mathematical methods in the fashion design process [46].

Amazon has taken the lead in providing this breakthrough development, wherein algorithms find fashion inspiration from the Internet, analyze visuals and images to find fashion trends, and then generate similar styles from scratch without any human input. Amazon has provided the long-awaited solution that machines can design fashion without human supervision [55]. However, these algorithms are continuously learning from data, and are not yet capable enough in producing the best results for each customer without human supervision [45].

This algorithm empowers Amazon's other imagery-based forthcoming fashion technologies such as, Echo Look (2017) and its derivatives, with similar features such as Style by Alexa, either by using images taken for them or by providing customized fashion recommendations through them. It is also leveraged to induce Style Snap (2019) by advancing outfit inspirations from customers' provided photos function.

(3) Echo Look (2017)

While **AI Algo. Fashion designer** has satisfied customers' demand to try before purchase, they are still curious and want to see themselves wearing selected outfits before purchasing. Therefore, for these highly fashion-conscious customers, Amazon introduced a new device incorporating a personal style assistant.

By incorporating the hands-free camera and style assistant function, **Echo Look** captures images and short videos of customers wearing the outfits. This functionality can be attributed to smart speakers in Echo, which emerged in 2015 [47].

Before the launch of **Echo Look**, Amazon introduced Outfit Compare, a mobile feature by which customers can share the images of two outfits if recommendation is needed from Amazon's fashion team [48]. Amazon then further enhanced this software to be used for the hardware device. The technology behind the hands-free camera is computer vision [49]. It comprises a corresponding app., i.e., Style Check, for a second opinion on outfits. Users upload two photos, and Style Check provides the ratings. Style Check's fashion advice service is based on machine learning and human fashion designers [50].

Algorithms and human designers provide the final recommendations based on uploaded images. **Echo Look** collects more contextual consumer preference data, such as their body structures and buying habits, etc. The visual data enhance the skills of machine learning algorithms in designing and recommending customized outfits for each customer individually, leading to dependence on statistical and deep learning. Customized recommendations have significantly improved consumer trust in Amazon's fashion endeavors.

Echo Look has transformed Alexa from virtual assistant to virtual fashion assistant. It contributed not only to the selling of apparel through Alexa but it also trained Alexa in becoming a style advisor, which represents Amazon's innovative way of applying AI to fashion.

Its functionality has been transferred to the mobile-based "Style by Alexa" app., available at the Amazon Shopping app. [51].

While **Echo Look** has satisfied customers in gaining style assistant function, its outfit display was behind a possible idealistic one and has remained a "display-less device." This deficit has induced AR Mirror (2018) to complement this deficit, although functionality is not the same but comparable [52]. Thus, **Echo Look** laid the foundations for further user-driven innovations in a digital fashion [53].

(4) AR Mirror (2018)

While **Echo Look** has solved the customer's concerns about their looks in selected outfits, they expected more, such as real-time customized recommendations, instead of uploading photos on corresponding apps. for fashion advice. This motivated Amazon's patented **AR Mirror** for real-time fashion visualization.

AR Mirror uses virtual clothing with an augmented reality (AR) function and mirrors to recommend styles to customers. Superimposing virtual outfits on a customer's reflection in a mirror, it also creates virtual backgrounds at the same time if outfits are for a specific purpose/destination. The mirror shows virtual clothing overlaid onto the potential buyer's body and also shows virtual backgrounds, so that customers envision their outfits for specific destinations [54].

Customers view themselves in a blended reality environment, whereas AR technology provides virtual try-on fashion in customers' preferred virtual locations [55]. The device consists of a camera, projectors and a screen. A camera at the top of the mirror tracks the user's body and then a screen behind the reflective panel works with projectors to illuminate the picture [56]. Also, computer vision-based Body Labs (acquired in 2017) software is used to create human-like 3D avatars for outfit modeling. Its unique features include sizing of the human body, sizing of outfits, and putting them together in a virtual environment.

Customers can virtually try on clothes in the comfort of their homes before they purchase. Amazon would get more in-depth customer data, such as 3D visual measurements of body shapes through depth-sensing-cameras in the device [57]. This improves customers' shopping

experience by allowing Amazon to produce customized outfits, and it prevents accumulating large fashion inventories. It also prevents customers' physical store visits.

The successive development of advanced digital fashions, such as **Prime Wardrobe** and **AI Algo. Fashion designer** with the copy -all-possible-fashion- trends function, **Echo Look** with the personal style assistant function, and **AR Mirror** with a real-time customized recommendation function, has enabled Amazon to accumulate sophisticated curation ability, which satisfies customer-centric business [58].

(5) Personal Shopper (2019)

Prime Wardrobe has initiated foundations of the business model to disruptive fashion, and a series of successive advanced digital fashions have provided customers with sophisticated curation services.

However, the more choices customers have, the harder it is for them to decide, and, in turn, the less likely they are to purchase. Moreover, customers are more prone to feel remorse after choosing among a plethora of options. In addition, customers' preferences are rapidly changing. They do not want to spend time on building their style profiles and to wait for the curation process until products are shipped. They expect immediate real-time solutions. Subscription boxes can be the solution to indecisiveness and regret, as they curate products according to a customer's personal preferences, which also simplifies the process. Furthermore, letting customers apply personalization become the center of the retailer-customer relationship in a way that encourages extreme loyalty.

Personal Shopper, based on machine learning, provides the subscription-based, personalized curated clothing box by understanding every customer's unique needs, whether it is taste, style preferences, size, cost or even psyche. New clothes, decided on a real-time basis, are directly shipped to the customer's door. The styling fee is charged on top of the Prime membership fee [59].

Its preceding service was based on the traditional browsing of the Internet. Its counterpart had two major elements: Prime membership, and try at home before purchase. The sophisticated curation function went a step further in providing customized fashion for a set monthly fee. Customers first build their style profiles through a questionnaire, then AI algorithms, particularly machine learning, and human designers use the style profiles for curation [60]. Finally, customers can choose eight curated items at once, and then the subscription box is shipped to them with an option to pay only for the items they keep [61].

Without the expert's opinion, buying fashion online does not necessarily represent actual products that satisfy customers' needs [62]. However, **Personal Shopper** service has eliminated such issues, because customers communicate with designers throughout the curation process [61]. Customers are able to see final products before home delivery, while enjoying free shipping.

This can be largely attributed to the abovementioned sophisticated curation ability accumulated through a series of advanced digital fashion development [58]. The advancement of machine learning has enabled the construction of personalized data.

The prerequisite questionnaire provided important customers' preference data, such as size, color, and style. This allowed customers to develop personal relationships with Amazon designers through a feedback system. This relationship and style profile allowed Amazon to track the customized fashion needs of all customers individually. It improved customer loyalty, provided convenience, comfort, and the customized fashion aided in shedding its uncool image [63].

Since **Personal Shopper** has provided Amazon with a direct contact with customers, Amazon collects an enormous amount of customer data regarding their preferences. It also improved its algorithmic fashion recommendation system.

(6) Style Snap (2019)

In the preceding advanced digital fashions, curation was conducted by using the questionnaire. However, some customers like a fashionable outfit but cannot express the style or need in an immediate response about its availability. They are less expressive or do not use voice or text for fashion recommendation. In addition, the prerequisite questionnaire provides customers with preference data and indicates that customers are familiar with their required styles.

A fashion recommendation feature based on using visuals using can solve these problems [64]. **Style Snap** satisfies this, by providing photo-based matching recommendations in real-time.

The feature is for customers who were inspired by a style elsewhere, such as in a street, shop, or social media; they upload a picture, selfie, or screenshot of it and receive matching recommendations in real-time. In addition, recommended fashion products come with price, brand, ratings and reviews, thus enabling customers to filter products according to their preferences [65,66].

Style Snap is based on deep learning and computer vision that are continuously learning from data and images. It empowers Amazon's influencers program introduced in 2017 by enabling social media fashion influencers to recommend Amazon fashion products for a set commission [67].

Style Snap creates a visual shopping experience. Amazon's vast fashion inventory is available at its marketplace, to identify similar fashion images; this service uses image recognition of a subset of computer vision and deep learning methods [68]. By using these methods, this service provides the best possible results that match with customers' needs. It is a deep learning-based fashion search tool in which neural networks have developed an ability to remember fashion images from large data sets, and to learn new features at the same time with new data. This ultimately enables **Style Snap** to process large data and to find the best possible matches [65].

While **Style Snap** triggered a dependence on external resources for recommending similar styles, it continues to recommend fashion only from Amazon's fashion inventory [66]. It induced fashion influencers to develop their followers on social media further.

(7) The Drop (2019)

To further harness influencers' fashion designs by incorporating external resources such as street style trends by using machine learning, Amazon introduced **The Drop**, which enables social media influencers to present their fashion collection for a limited time on Amazon's Marketplace [69].

While **Style Snap** triggered the enabling of social media influencers to recommend visual-based fashion inspirations to Amazon customers, **The Drop** is a step further, allowing renowned lifestyle influencers and designers on social media to co-design fashion with Amazon's designers. Limited edition street style fashions, designed by influencers exclusively for Amazon, are available at Amazon's Marketplace for 30 h [70].

The Drop collection goes live after every few weeks, every time a new influencer brings a new collection. Fashion influencers who compete on fashion-related reality TV shows bring their collections to **The Drop**. Fashion competition TV series such as "Project Run Way" and Amazon's own show, "Making the Cut," aired at Amazon Prime Video are prominent examples.

As billions of users consume social media channels (YouTube, Snapchat, Face-book, etc.), a new entertainment is formed. Amazon capitalized this segment by merging entertainment, social media-content, and fashion. Influencers, designers and Amazon co-create fashion together. This provides Amazon with valuable data from external fashion professionals, and familiarizes Amazon's fashion algorithms and human designers with worldwide fashion trends.

Social media fashion influencers have developed higher trust and credibility among users. Due to their specific content on social media, they have large followerships, which makes them nontraditional celebrities [71]. Many brands use them for influencer marketing
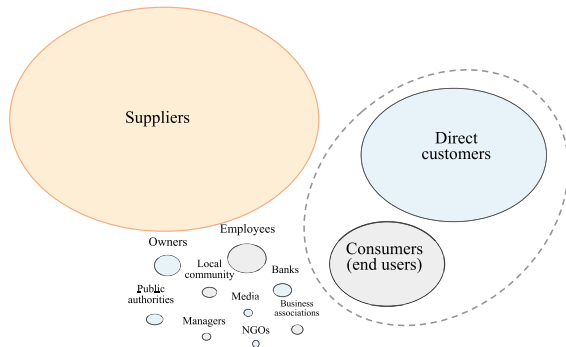
Fig. 7. Relative importance of stakeholders in the Swedish fashion industry. Source: Authors' elaboration based on Perdersen et al. [73].

campaigns on social media. The combination of the attractive clothes and extremely limited release makes the hype exciting and makes customers feel like they achieved something very exclusive [72]. Influencers share their experiences with users who influence their preferences. It provides a real–time shopping experience as every collection goes live and is available for less than 30 h on Amazon Marketplace.

With **The Drop**'s continued success, it is likely that the influencer collaborations will continue to grow in size, scope and even category. Influencers are successful at driving a quick response from their followers. In Amazon's influencer program, which emerged in 2017, social media stars can create a page, recommend products they like on Amazon, and earn commission on sales. Influencers are able to leverage their expertise and charisma to be salespeople for products not necessarily their own. Additionally, they leverage different channels, including social media, blogs, videos, webinars, email lists and columns to market to the potential audience.

Thus, *ADF* has explored a new business model utilizing external innovation resources by co-designing with external designers. This corresponds to neo-open innovation, which is the novel concept of innovation emergence that maintains sustainable growth by avoiding the dilemma between R&D expansion and productivity decline by

harnessing the vigor of *SIRs*, as reviewed in sub-section 2.1. *ADFs* can be expected to play a prominent role as *SIRs*.

In addition, **The Drop** merges broad influencers' channels including entertainment, social media, blogs, videos, webinars, email lists and columns, and fashion. Through this process, broad stakeholders— not only Amazon and its direct customers but also broad external influencers including entertainment, social media, and designers— enjoy higher services corresponding to growth in size, scope and category. The scope of stakeholders involved is much broader and balanced than that of traditional stakeholders' involvement in the fashion industry, as demonstrated in Fig. 7 [73].

This provides Amazon with valuable data, information and flavor from external fashion professionals and fashion lovers, and familiarizes Amazon's fashion algorithms and designers with worldwide fashion trends.

This effect can be defined as the effect of learning orchestration externality.

3.2. Learning orchestration externality

(1) Learning Orchestration

These analyses demonstrate that Amazon has emerged a series of *ADFs* successively by deploying an orchestration strategy in endeavoring new innovation by effectively learning from preceding innovation, as summarized in Table 1.

Table 1 demonstrates that advancement of AI through its multi-hierarchical functions, such as machine learning, computer vision, statistical learning, and deep learning, as well as technologies utilizing these functions, such as AR and VR, played a leading role in this orchestration.

(2) Pivotal Role of AI

AI plays a pivotal role in the digital solution to the historical demand of the fashion industry, as illustrated in Fig. 8 [74].

AI incorporates such unique characteristics as inducing multiple hierarchy-level functions for approaching human behavior and thoughts, as illustrated in Fig. 9. This inducement depends largely on learning from preceding innovations.

Table 1
Learning orchestration of advanced digital fashion emergence in Amazon.

Advanced Digital Fashion	Functionality	Lessons from preceding innovation	Assets obtained that transferred to/motivated followers	Core function of AI
1. **Prime Wardrobe** (2017)	Enables customers to try several items at home before purchase.	3D body modeling AI (ML), IoT, VR/AR, mobile devices	Foundation of the business model to understand customers' need and style preferences.	ML
2. **AI Algo.Fashion designer** (2017)	Provides new items by copying all possible fashion trends.	ML and DL based Generative Adversarial Networks (GAN)	Prospect of machines' capability to design fashion without human supervision.	ML, DL
3. **Echo Look** (2017)	Captures images and short videos of customers wearing the outfits.	Echo, Outfit Compare (share photos), Style Check (second opinion)	Enhanced the skills of ML algorithms in designing and recommending customized outfits. Trained Alexa to become a style assistant	ML, CV, SL, DL
4. **AR Mirror** (2018)	Provides real-time customized recommendation by using virtual clothing.	CV-based Body Labs software	Accumulated in-depth customer's data, such as 3D visual measurements of body shapes and sophisticated curation ability.	CV, AR, VR
5. **Personal Shopper** (2019)	Provides the subscription-based personalized curated clothing box.	sophisticated curation ability accumulated through series of *ADFs* development	Secured big customer data on their preferences and improved algorithmic fashion recommendation system thereby. Improved customer loyalty and provided convenience, comfort, and customized fashion.	ML
6. **Style Snap** (2019)	Provides photo-based matching recommendations in real time.	Influencer program.	Enabled to process large data and find best possible matches	CV. DL
7. **The Drop** (2019)	Allows renowned life-style influencers to co-design with Amazon's designers.	Social media fashion influencers	Explored a new business model utilizing external innovation resources by co-designing with external designers.	ML

ML: machine learning; CV: computer vision, SL: statistical learning, DL: deep learning.
AR: augmented reality, VR: virtual reality.

Advancement of ICT centered on the Internet such as online retailers and social media platforms have given way for trends to be identified, marketed and sold immediately. Styles and trends are easily conveyed online to attract the trendsetters. Posts on Instagram or Facebook can easily increase awareness about new trends in fashion, which subsequently may create high demand for specific items or brands.

Furthermore, this advancement has established the foundation for advanced digital fashion inducement.

Improvement of manufacturing technologies particularly of

(i) **Wearable technology** including smart fabrics that enhances wearer comfort by changing color or texture based on environmental changes.

(ii) **3D printing technology** that has influenced prominent designers, and will become more accessible to designers and eventually consumers.

Mobile devices enables customers to enjoy a seamless mobile-friendly shopping experience by clicking on the item they like and be redirected to the product page – effectively reducing search time. Businesses can provide their customers with a simple way to discover products and shop, all through their handy smartphones.

Artificial intelligence (AI) builds systems that can function intelligently and independently, and enables retailers collect, organize, analyze, and sort data into relevant categories, that can then be used to predict and understand what their customers are looking for.

Virtual reality (VR)/augmented reality (AR) merge the physical and online worlds of retail. Before buying, customers can try outfits based on avatars, and outfits are virtually personalized to the customers required sizes. Such innovations improve the digital shopping experience.

Internet of things (IoT) improves customer experiences and apparel items will have digital capabilities that open communication between retailer and customer. Apparel interacts with the customer to collect data that helps retailers understand needs and concerns, and implement it to create a more personalized experience.
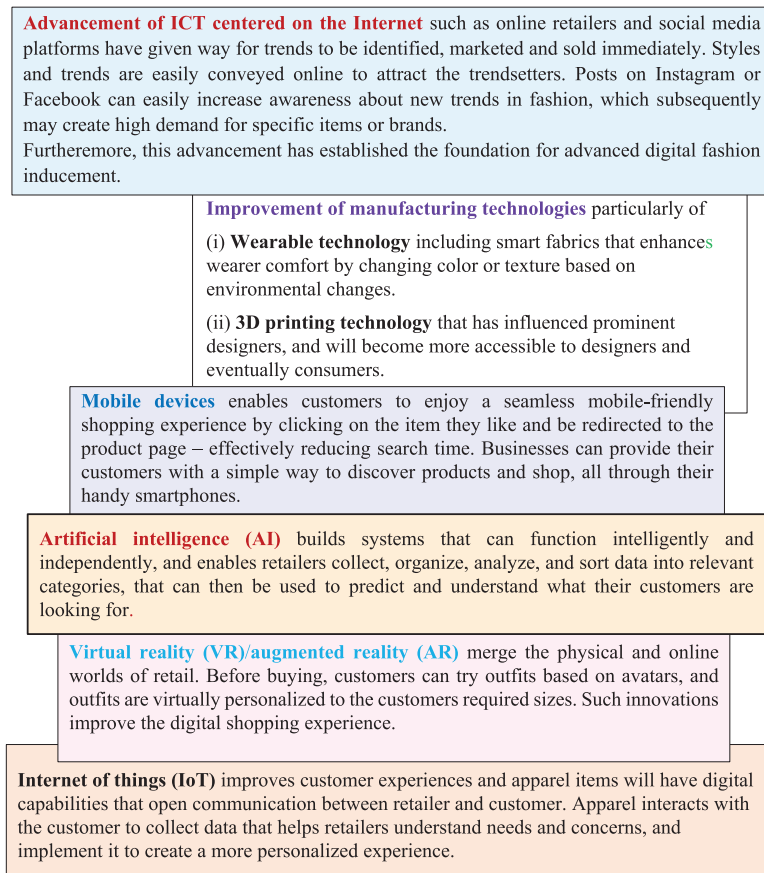
Fig. 8. Pivotal role of artificial intelligence for digital solution to the fashion industry.

AI attempts to mimic human behavior, equipped with a program that can sense, reason, and adapt by learning images and patterns of human behavior, thereby building systems that can function intelligently and independently that make the computer do things requiring intelligence. Currently, AI can be recognized as the main sub-domain of computer science [75,76].

AI techniques in fashion analyze and process big data to understand the needs, design products and services for each customer, i.e., customization and personalization [77]. The techniques are aimed at mimicking human behaviors that move, see, speak and listen, read and write, recognize objects, and remember. AI has been growing by developing its functions through multi-hierarchical learning as follows.

Symbolic learning is symbolic-based image processing. Humans can understand their environment and move therein. This is the field of robotics that can mimic the human behaviors of walking, running, sitting, etc. Humans can see and process what they see Ref. [78]. This is a part of computer vision that allows computers to analyze and process images and videos to identify fashion trends.

Machine learning is used for the development of algorithms that allow computers to learn by themselves from the data. It makes software more precise in making classification and prediction. For example, in the fashion industry, it is used to understand different features of images by classifying them in providing accurate recommendations and predictions [79].

Statistical learning is used for classification in **speech recognition** and **natural language processing**. While the former is used to recognize speaking and listening, the latter is used to extract useful insights from large unstructured data as reading and writing [78].

Deep learning is a subset of machine learning. It uses a convolution neural network for recognizing objects, and a recurrent neural network for remembering [80]. This learning allows Amazon to determine which products a customer is likely to purchase, based on customer's purchase history.

(3) Amazon's Endeavor to be an AI Giant

It was in 2014 when Jeff Bezos was advised by Srikanth Thirumalai, former IBM computer scientist, of the latest notable advances in AI. While Amazon had realized a potential significance of AI, at that time it had yet to significantly tap into the advances in AI and was falling behind Google, Apple, Facebook, and Microsoft for AI dependence. It took a lot of debates to transform Amazon from an AI wannabe into a formidable power [28].

Echo is Amazon's key innovation. It is an AI–based smart speaker powered by the Alexa voice platform. The trickiest part of the Echo was speech recognition. While building a machine-learning system that could understand and respond to conversational queries in noisy conditions required massive amounts of data, Amazon did not have an industrial-strength system in place for applying machine learning to product development. However, Amazon had incorporated all necessary pieces, such as an unparalleled cloud service, data centers loaded with graphics processing units (GPUs) to crunch machine-learning
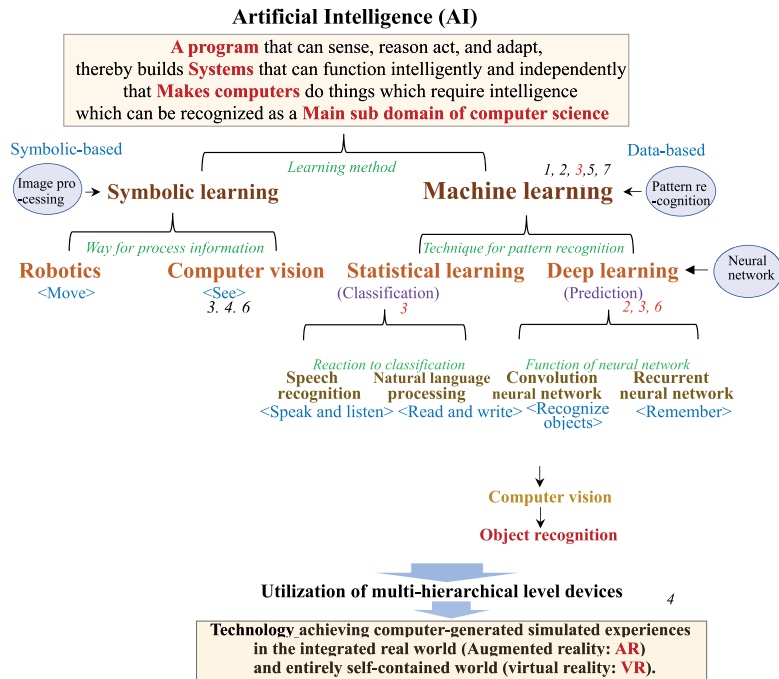
Fig. 9. Hierarchy of AI focusing on Learning and Recognition Methods by Core Functions and on their Application Devices.

algorithms, and engineers who knew how to move data around like fireballs. Amazon used those parts to create a platform that was itself a valuable asset, beyond its use in fulfilling the Echo's mission.

Levy [28] noted that integrating Echo with Alexa was a game-changer that stimulated AI-based innovations. Alexa became the catalyst for further AI advancements. Amazon successfully integrated voice technology into other products such as Fire TV, Dash Wand, Amazon Fresh and, finally, AWS. Over the years, Alexa has reached numerous customers with several skills. The advancement in voice technology fueled Amazon's growth more rapidly because Alexa interacts with humans and collects their data to be used in developing machine-learning algorithms.

With AI and machine learning, Amazon has become a market leader of customer–centric digital innovations. The Flywheel is a fundamental strategic virtuous cycle that represents the positioning of AI throughout Amazon's innovation process [27]. Amazon Echo, Amazon Go, Amazon Flex, recommendation systems, and advanced fashion technologies are heavily dependent on AI and machine learning algorithms. In the Flywheel approach, technological innovations in one sector stimulate/empower the innovation process in other sectors of the firm [28]. For example, although Alexa was introduced for other tasks, such as music playing, home automation, or voice-based shopping, etc., it now has transformed to a personal fashion assistant representing Echo Look. It not only recommends fashion trends but also at the same time collects valuable insights from customers. These insights can be used to fuel machine-learning algorithms for further innovations, thus aiding in continuous spinning of the Flywheel. Therefore, the success of Amazon's diverse business lies in continuous spinning of the Flywheel, because every customer-centric innovation is a spoke of the Flywheel, which has implications on other existing and future products and services.

Even though fashion is not Amazon's core business, nevertheless Amazon has still been able to run a fashion business successfully. The preceding innovations, such as AWS, which offer numerous services including advanced computing, data storage, machine learning, deep learning, AR, VR, etc., and Prime, are building blocks in the development of Amazon's advanced digital fashion endeavor, ultimately empowering the wheel with fashion customers.

Amazon's business culture as an R&D-based customer–centric company, and its subsequent R&D strategy as transforming routine or periodic alteration into significant improvement, inevitably utilized AI in unique ways, such as inducing multiple hierarchy-level functions for approaching human behavior and thoughts by means of learning from preceding innovations. This institutional system has enabled Amazon to enjoy the effects of learning orchestration externalities through the course of its successive development of seven *ADFs*.

3.3. Advanced digital fashion in a non-contact society

Confronting an unexpected COVID-19, the apparel industry has been suffering stagnation. The fashion industry cannot be an exception. Fashion designer Junko Koshino provided a warning that, "*The significance of fashion is being re-questioned by COVID-19. Apparel companies must abandon their past success experiences*" [81].

The highly integrated global supply chains represent the fashion industry. Several challenges affected this industry during pandemic, such as disruptions in global supply chains, reduced fashion manufacturing orders, increasing employment crises, retail stores rethinking their business models, and customers remaining socially distant. COVID-19 revealed the fashion industry's fragility and structural impediments that necessitate a shift from traditional business models to digitally-driven ones.

COVID-19 has accelerated transformation of the fashion industry from brick-and-mortar stores to digital channels. Digital solutions, from product development to delivery with minimal physical contact, are being accelerated. For example, fashion shows and weeks throughout the world are held virtually [82]. In Helsinki, Finland's fashion week (digital village) used advanced 3D technology, which created and sold digital versions of fashion items [83]. Visitors joined the virtual shows as

avatars [84].

There are also new discoveries with COVID-19 which suggest that combining digital to create new value is essential [81]. Amazon has demonstrated its indigenous strength to transform the crises into a springboard for the new innovation.

As reviewed earlier, The Drop has enabled Amazon to capture worldwide fashion trends, influencers' markets and their followers by providing street style limited edition fashion in collaboration with social media fashion influencers. Customers can examine these fashion collections for a limited time on Amazon's Marketplace for their decision making. This service explores the possibility of *on-demand manufacturing service* enabling customers outfits by their own initiatives [85].

In 2017, Amazon was given a patent for on-demand apparel manufacturing. The smart system starts production as soon as Amazon confirms the customer's order. The manufacturing system is controlled by a computing environment. The manufacturing process is completed in small batches that are based on sizes, shapes, fabric types and delivery locations [86]. This venture could facilitate Amazon in providing fashion manufacturing as a service in the same way as it provides its logistics services to third-party sellers [87].

While customers have been craving this system and expecting it to move beyond limited street style fashion, the current marketplace-initiated system impedes their satisfaction. Therefore, the timely application of on-demand apparel manufacturing to broad digital fashions by overcoming the structural impediments indigenous to the current marketplace-initiated business model is strongly expected.

In line with its successive *ADFs* development, Amazon introduced a new digital platform for luxury fashion, **Luxury Stores**, in 2020 by collaborating with renowned luxury fashion designers and brands.

Luxury Stores provides a new shopping experience that features established and emerging luxury fashion and beauty brands. This enables access to the latest collections and exclusive items from each luxury brand through mobile, fast and free delivery [88]. Unlike Amazon's traditional business model, it created a store within a store experience, because luxury fashion items will be sold directly from brands while using Amazon's interactive platform. It allows luxury fashion brands to control prices, inventories, and customer service queries in order to keep their brand's identity, whereas on the backend Amazon provides services for personalization, content creation and a vast range of Prime members [89].

This business model incorporates the following advantages to Amazon as well as to its stakeholders:

 (i) Amazon is always listening to and learning from its customers, and is inspired by feedback from Prime members.
 (ii) Contrary to Amazon's sole control in its traditional business, luxury fashion brands are able to control prices, customer services, and inventories, while Amazon provides merchandizing tools and customers data for creating and personalizing content for each brand's identity.
 (iii) Amazon can gain trust from luxury fashion brands by allowing them freedom.
 (iv) For fashion and beauty shoppers, mobile technologies are more convenient.
 (v) This business model could be a logical extension of Amazon's fashion innovations in creating new luxury fashion experiences for customers.
 (vi) Amazon can increase its sales volume which enables it to leverage its position as the leading fashion retailer and to extend its reach in the luxury fashion industry, while providing luxury fashion brands as solution for increasing their sales without depending on brick-and-mortar retailing, in a non-contact society.

Attracting luxury fashion brands to its platform was Amazon's long-awaited ambition, but it failed due to its solo-channel approach, selling basic apparel by its own control over branding, pricing and discounts.

Due to these impediments, luxury fashion brands have been reluctant to collaborate with Amazon.

Luxury Stores is expected to remove these impediments. Through this business model, Amazon enters into luxury fashion and sheds its image of an uncool fashion brand by opening a multichannel approach that allows luxury fashion brands control over branding, pricing and discounts. Simultaneously, it provides a timely solution to luxury fashion brands in a non-contact society by enabling customers to access their fashion by mobile phones and by staying at home, while most of luxury fashion business relies on physical stores due to the sensory experience [90].

A non-contact society encouraged the digitization that enabled the fashion industry to resurge its growth with new business models. Stay-at-home policies enabled Amazon to rethink its business strategy encompassing new services, actors and customers, i.e., by introducing **The Drop** with on-demand manufacturing, and **Luxury Stores** with a multichannel approach.

With this breakthrough by **Luxury Stores**, it is expected that *ADFs* may remove the structural impediments impeding on-demand manufacturing in the fashion industry.

On-demand manufacturing in the fashion industry is not widely adopted, although there has been growing interest in recent years.

In the fashion industry, since a traditional manufacturing system is based on matching demand and supply, attempts at on-demand manufacturing have failed. Covid-19 acted as a catalyst in finding new solutions. It encourages local production that solves emerging issues such as lockdowns, store closures, and halted international shipments during crises such as a pandemic. Due to the sharp decline in demand, fashion brands are struggling with excessive unsold items. Manufacturing fashion products on demand might be appealing because it will allow brands to rapidly respond to changing customers preferences that encourage personalization and customization, leading to luxury fashion development.

This necessitates reconsideration of the business model. While traditional fashion businesses rely on the single channel business model, they need digital solutions encompassing direct-to-customer models. Widespread use of mobile devices supported by AWS-initiated AI advancement enables this solution, while supporting staying-at-home policies during pandemic.

The multichannel approach with which **Luxury Stores** is equipped increases flexibility in demand and supply matching, and corresponds to the above critical demand in a non-contact society, leading to removing structural impediments that impede on-demand manufacturing in the fashion industry. This approach can bring more data from luxury fashion brands and existing customers. The insights gained from this data could be a catalyst for on-demand fashion manufacturing.

These noteworthy trends suggest the emergence of hybrid externality, combining learning orchestration and on-demand *ADFs* manufacturing.

Over the last quarter-century, Amazon has explored its notable business model according to change in institutional systems encompassing economic, cultural and social life, by shifting from network externality to big data externality.

The above reviews on successive emergence of *ADFs* suggest that learning orchestration externality takes a lead in the current digital economy, where people's preferences have been shifting from economic functionality to supra-functionality, beyond economic value. This inevitably leads to broad stakeholder's involvement, betting on its challenge and expecting the future prospects of Amazon and *ADFs* that can be expected. A non-contact society after COVID-19 accelerates this trend toward hybrid externality, combining learning orchestration and on-demand *ADFs* manufacturing.

Given that fashion reflects the change in aesthetic, economic, political, cultural, and social life [10], this trend suggests a prospect of stakeholder capitalization.
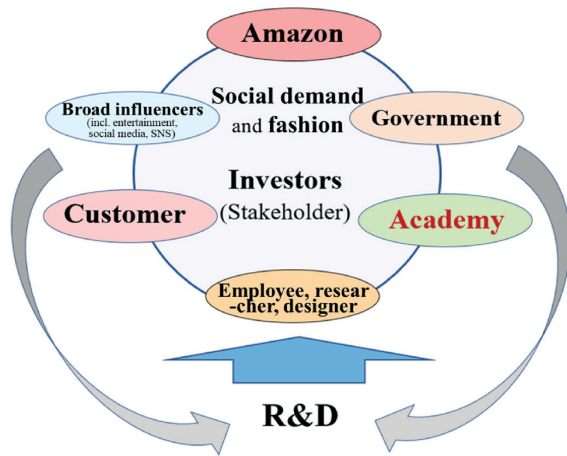
Fig. 10. Broad Stakeholders' Involvement Betting on Amazon's Solid Growth by means of R&D-driven Successive *ADFs* Development.

efficiently as demonstrated in Fig. 12 *D*.[2]

Thus, Amazon has constructed a virtuous cycle among an investor surplus, R&D and stock prices as illustrated in Fig. 13.

Because Amazon has not paid a dividend since its initial public offering (IPO) in 1997, nor has it made any buybacks of its shares since 2012, investors incorporate not only shareholders but also broad stakeholders centered on users.

Therefore, broad involvement of stakeholders, as was demonstrated in Amazon's successive *ADFs* development, stimulates this virtuous cycle and accelerates stakeholder capitalism, which accelerates the accomplishment of neo-open innovation by effective utilization of *SIRs,* as illustrated in Fig. 13.

Thus, with the indigenous nature of the fashion industry embracing broad stakeholders, and also with the art of fashion hitting them, broad stakeholder's involvement betting on a higher R&D with the expectation of future prospects of company involvement in a new fashion industry in the digital economy can be expected.

This corresponds to a new business doctrine toward stakeholder capitalization (Business Roundtable, 2019). A non-contact society after COVID-19 accelerates this direction, as analyzed in the case of Luxury Stores that emerged amidst the COVID-19 backdrop.
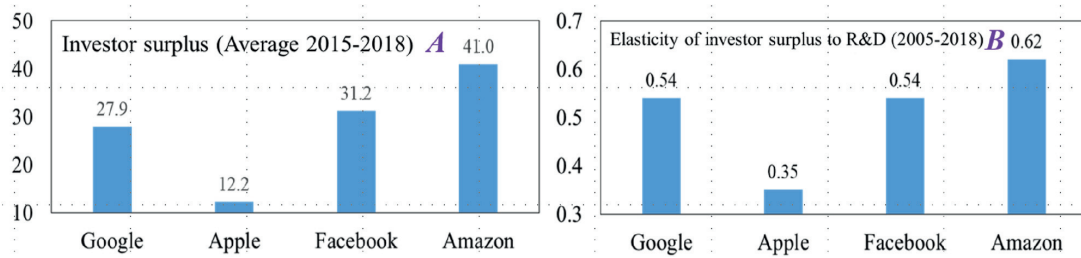

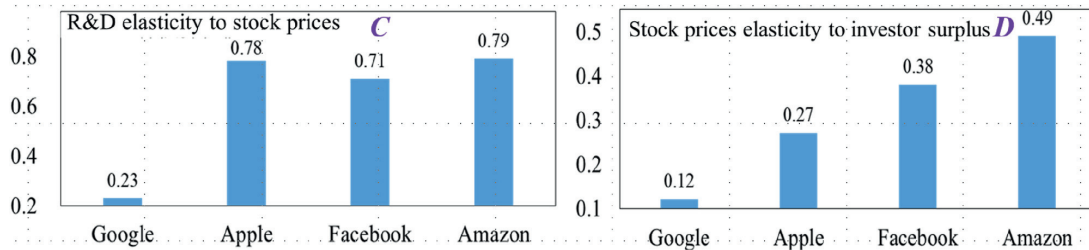**Fig. 11.** Investor surplus and elasticity of investor surplus to R&D in GAFA.

Fig. 12. Elasticity of R&D to stock prices and stock prices to investor surplus **in GAFA** (2005–2018).

4. Stakeholder capitalization

The above analysis on Amazon's R&D-driven *ADF* challenge demonstrates broad stakeholders' involvement betting on the continuation of its solid growth by means of successive *ADF* development, based on its aggressive AI-oriented R&D investment, as illustrated in Fig. 10.

Amazon maintains a high level of an investor surplus which demonstrates that investors are betting on the continuation of its solid growth by means of its aggressive investment in R&D, as demonstrated in Fig. 11 *A* [9]. This surplus induces R&D efficiently, as demonstrated in the highest elasticity of investor surplus to R&D among GAFA (Fig. 11 *B*).

Furthermore, this R&D efficiently induces stock prices as demonstrated in Fig. 12 *C*. Induced stock prices induce an investor surplus

5. Conclusion

In light of the increasing significance of co-evolution between the transformation of R&D that overcomes the dilemma between its expansion and productivity decline, and digital solutions of the advancement of the fashion industry that satisfy people's preferences shift to supra-functionality beyond economic value, this paper analyzed a prospect of this co-evolution.

Prompted by the digital global leader, Amazon, and their recent challenge in developing advanced digital fashion successively with aggressive AI-oriented R&D, an empirical co-evolutional analysis of the

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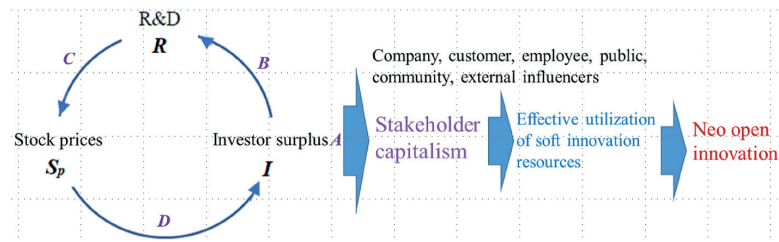[2] These demonstrations are based on Watanabe et al. [9].

Fig. 13. Virtuous cycle among investor surplus, R&D and stock prices leading to neo-open innovation in Amazon.

development trajectories of Amazon's recent advanced digital fashions (*ADFs*) and the fashion industry, with special attention to the role of AI advancement, was conducted. The challenge of the fashion industry toward a non-contact society after COVID-19 was also examined.

Amazon has succeeded in securing timely digital solutions by developing seven *ADFs* successively. This success was enabled by the advancement of AI and Amazon's enthusiastic efforts to be an AI giant. Amazon's business culture as an R&D-based customer–centric company and its subsequent R&D strategy inevitably utilized AI in unique ways, such as inducing multiple hierarchy-level functions for approaching human behavior and thoughts by learning from preceding innovations.

Such institutional systems have enabled Amazon to enjoy the effects of learning orchestration externalities through the course of its successive development of seven *ADFs*. In addition, challenges to luxury fashion brands explored the multichannel approach that allows vendors freedom in managing their luxury brands on Amazon's Marketplace, while paving the way for on-demand manufacturing.

All these challenges led to broad stakeholder's involvement betting on these challenges, expecting the future prospects of Amazon and *ADFs*. A non-contact society after COVID-19 accelerates this trend toward on-demand *ADFs* manufacturing. This corresponds to a new business doctrine toward stakeholder capitalization.

These findings give rise to the following insightful suggestions for this capitalization:

(i) The co-evolutional development between Amazon's *SIRs*-driven innovation and disruptive advancement of fashion should be applied to disruptive business models aiming at overcoming the dilemma between R&D expansion and productivity decline,

(ii) The dynamism enabling this co-evolution should be elucidated and conceptualized,

(iii) The function of fashion in tempting broad stakeholders to bet by investing in it should be elucidated, conceptualized, and then applied to stakeholder capitalization,

(iv) The dynamism of fashion advancement through orchestrating shifts to the digital economy, the sharing economy, and the circular economy should be applied to digital fashion advancement, and

(v) The potential for on-demand manufacturing in the fashion industry should be further developed for broader application.

Future work should focus on further elucidation, conceptualization and operationalization of the functions by which the above orchestration may lead to the transformation of the apparel and the fashion industry, and also to transforming R&D investment in the digital economy toward a non-contact society. Hybrid externality combining learning orchestration and on-demand manufacturing should be generalized.

Acknowledgements

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III

AMAZON'S NEW SUPRA-OMNICHANNEL: REALIZING GROWING SEAMLESS SWITCHING FOR APPAREL DURING COVID-19

by

Watanabe, C., Akhtar, W., Tou, Y., & Neittaanmäki, P., 2021

Amazon's New Supra-Omnichannel: Realizing Growing Seamless Switching for Apparel During COVID-19

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A R T I C L E   I N F O

A B S T R A C T

While COVID-19 has driven a significant drop in sales, the apparel industry has been undergoing a digital solution-oriented transformation.

Preempting its highly profitable potential, Amazon has been expanding its fashion-driven apparel business by developing a series of advanced digital fashions (*ADFs*). *ADFs* intensified Amazon's omnichannel dependence based on seamless switching by utilizing its innovative assets.

With this development, and in response to the increasing necessity for luxury brands to offer extra channels for a non-contact society, Amazon introduced Luxury Stores, a long-lasting digital platform for luxury fashion, in September 2020.

While luxury brands confront "the Internet dilemma," this conundrum can be solved by synchronizing *ADFs*, Luxury Stores, and on-demand manufacturing (ODM).

Taking Amazon's challenge to realize its long-lasting dreams of selling luxury brands and using ODM, this paper attempts to demonstrate the significance of this approach for exploring new frontiers in business models beyond the current omnichannel approach.

An empirical analysis was conducted focusing on the development trajectories of seven *ADFs* and 34 luxury brands that joined Luxury Stores by the end of the first half of 2021 by using a techno-economic analysis, analogical evidence approach, literature review, and subsequent SWOT analysis.

It was demonstrated that by means of timely synchronization of *ADFs*, Luxury Stores and patented ODM, co-evolution among them can be constructed leading to the emergence of a cloud-based fashion platform that enables on-demand personalization and customization. Consequently, big data on customers, vendors, manu-factures, global influencers, and social trends can be collected, which grow and expand Amazon Web Service (AWS). This in turn further accelerates co-evolution among *ADFs*, Luxury Brands, and ODM. Activated co-evolution further advances cloud-based fashion platforms leading to a virtuous cycle between them. Thus, dual-co-evolution of the co-evolution among *ADFs*, luxury brands, and ODM, and cloud-based fashion platform advancement emerged. This dual-co-evolution leads to a supra-omnichannel approach that enables apparel to grow seamless switching and explore new frontiers beyond current business models.

These findings give rise to suggestions for dynamic and resilient strategies toward a non-contact society.

1. Introduction

COVID-19 has significantly affected the apparel industry, leading to a decline in sales.

However, the apparel industry has been undergoing transformations even before COVID-19, initiated by (i) digital solutions to historical demand, (ii) the shift to a sharing economy, and (iii) the shift to a circular economy [1]. Apparel is now the most popular online shopping category worldwide [2].

Amazon anticipated the potential for large profits by expanding its fashion-driven apparel business with the development of a series of advanced digital fashions (*ADFs*), making substantial efforts for an omnichannel approach based on seamless switching. Here, *ADFs* can be defined as a new fast fashion business that leverages digital innovation

assets and the learning effects of preceding development [3].

Amazon has been effectively utilizing learning effects during the process of research and development (R&D) in transforming "routine or periodic alterations" into "significant improvements" [4,5]. Provided that omnichannel thrives in the digitalized environment [6], Amazon's attempt to shift to an omnichannel approach can largely be attributed to learning orchestration externality [3].

In September 2020, Amazon introduced Luxury Stores, a long-lasting digital platform for luxury fashion. This was in response to Covid-19 bringing about an increasingly non-contact society, thereby necessitating the addition of extra channels for luxury brands.

Luxury brands confront "the Internet dilemma" [7,8], which is the reluctance to integrate online technologies into their business model. This makes them hesitant to collaborate with Amazon. However, considering the potential of Amazon's patented on-demand apparel manufacturing (ODM) that enables luxury brands to streamline their supply chain [9]; [10], this conundrum can be expected to be solved by synchronizing *ADFs*, Luxury Stores, and ODM [11].

Inspired by the possibilities created by Amazon's challenge to realize its long-lasting dreams of luxury brands and ODM, this paper attempts to demonstrate the significance of this challenge by examining the plausibility of this approach for exploring new frontiers in business models beyond the current omnichannel approach.

To date, a significant number of studies have analyzed the significance of the omnichannel approach for the advancement of the apparel industry, as well as the significant role of ODM in this advancement.

Brynjolfson et al. [12] suggested that digital technologies facilitate customers switching across various shopping channels, transforming from multichannel to omnichannel, therefore urging stakeholders to rethink their competitive strategies.

Various studies have developed this hypothesis regarding seamless switching ([13–16].

Piotrowicz et al. [15] argued that as the line between online and physical channels is blurred, a new approach to channel integration is emerging – the omnichannel, which aims to deliver a seamless customer experience regardless of the channel. This would be affected by information technology (IT), particularly by the mobile revolution and social networks. The significant role of digital innovation for this switching has been stressed by multiple authors [6,17–22]. Sun et al. [23] pointed out the significance of the digitalized social cognitive perspective of omnichannel service usage. According to Baker et al. [7]; contrary to such seamless switching, luxury brands confront the Internet dilemma, which makes them reluctant to collaborate with Amazon [24]. Kim [25] pointed out that quite a few luxury brands still do not employ the Internet as an active transaction channel. Against such reluctance, Sherburne [10]; Sharma et al. [26]; and Bijmolt et al. [11] argued the significance of the synergy between the advancement of digital fashion and ODM by stressing the integration between customer journey (demand) and product flow (supply) as omnichannel advances. Bijmolt et al. [11] pointed out that in an increasingly omnichannel world, many important interdependencies exist across the stages in the customer journey and product flow, creating significant challenges and opportunities for firms. Peretti et al. [27] pointed out the increasing significance of digitalization for luxury brands, both for firms and customers, and suggested the possible effects of synergy between Amazon's digital-driven fashion and luxury brands. Sherburne [10] expressed the expectation of Amazon's patenting of ODM in exploring an industrial textile ecosystem. Fashion United [9] expected that this embodiment would provide new ways to increase efficiency in apparel manufacturing and encourage brands to streamline their supply chains by internalizing production.

These studies suggest the possibilities of synergy between digital fashion and luxury brands, and also between apparels and ODM. They also inspire the significant effects expected by these synergies.

However, they have remained conceptual ideas within partial systems and none have provided empirical convincing evidence derived

from a system solution that may enable Amazon to realize its long-lasting dreams and subsequent exploration of new frontiers for business models beyond the current omnichannel approach.

In a recent study [3], the authors attempted an empirical co-evolutional analysis of the development trajectories of Amazon's recent *ADFs*, giving special attention to the role of AI advancement toward a non-contact society. They pointed out that Amazon's success in *ADFs* development can be attributed to its business culture as an R&D-based customer–centric company and its subsequent R&D strategy that inevitably utilized AI in unique ways, such as inducing multiple hierarchy-level functions for approaching human behavior and thoughts by learning from earlier innovations. They concluded that such institutional systems have enabled Amazon to enjoy the effects of learning orchestration externalities through the course of its successive development of seven *ADFs* businesses. In addition, they pointed out that challenges to luxury fashion brands led to the exploration of the multichannel approach that allows vendors freedom in managing their luxury brands on Amazon's marketplace, while paving the way for ODM, and suggested the significance of co-evolution among *ADFs*, luxury brands, and ODM.

In light of the increasing expectation for dynamic and resilient strategies toward a non-contact society expected to be realized by a system solution, this paper attempted to find this solution by following up the preceding analysis. This was undertaken using an empirical analysis using a techno-economic analysis centered on diffusion theory, analogical evidence approach,[1] literature review, and subsequent SWOT analysis, focusing on the development trajectories of 34 *ADFs* businesses and ten luxury brands that joined Luxury Stores in 2020.

It was demonstrated that (i) benefits of ODM increase as digital innovation advances, (ii) ODM contributes to transforming the resistance of luxury brands to collaborate with Amazon into a sustainable opportunity to contribute to a non-contact society, (iii) this in turn provides the manufacturing industry with a digital solution, advanced logistics and funding capability, (iv) thus, co-evolution among *ADFs*, luxury brands, and ODM can be constructed, (v) this emerges as a cloud-based fashion platform where *ADFs* and luxury brands are integrated. (vi) This enables on-demand basis personalization and customization, (vii) consequently, big data on customers, vendors, manufactures, global influencers, and social trends can be collected which grow and expand Amazon Web Service's (AWS) function. (viii) Advanced AWS in turn further accelerates co-evolution among *ADFs*, luxury brands, and ODM, (ix) activating co-evolution, further advancing cloud-based fashion platforms leading to a virtuous cycle between them, (x) thus, dual co-evolution between the co-evolution among *ADFs*, luxury brands, ODM, and cloud-based fashion platform advancement emerges. (xi) This dual-coevolution leads to a supra-omnichannel approach that enables apparel growing seamless switching, and (xii) this explores new frontiers beyond the current business model.

These findings give rise to suggestions regarding dynamic and resilient strategies toward a non-contact society.

Organization of this paper is as follows: Section 2 provides an overview of the effects of the socio-economic transformation on the apparel industry. The driving force of the rapid jump of Amazon's apparel business is analyzed in Section 3. Section 4 analyzes the business' new stream leveraging supra-omnichannel. Section 5 summarizes noteworthy findings, policy suggestions, and future research.

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[1] A plausible mechanism was certified comparing with known natural phenomena as a running principle of ecosystem (Section 3) and also the inferior mirage phenomenon (Section 4).

2. Socio-economic transformation affecting the apparel industry

2.1. Effects of COVID-19 on the apparel industry

COVID-19 has significantly affected the apparel industry. Non-essential sectors were hit the hardest in 2020 as consumer confidence fell, with apparel sales declining by 26% in 2020 in the US, as consumers had no events or holidays to purchase new clothes for. However, growth in the demand for loungewear did not follow this downward trend [28].

However, the apparel industry was already undergoing transformations even before the disruption of COVID-19, initiated by (i) digital solutions to historical demands, (ii) the shift to a sharing economy, and (iii) the shift to a circular economy [1]. As of 2018, 57% of global Internet users had purchased clothing online, making apparel the most popular online shopping category worldwide as demonstrated in Fig. 1.

In response to this a global trend, Amazon had already positioned itself well in clothing retail before the pandemic, with a strong third-party network of fashion brands in its marketplace, making full use of its position as a leader in online sales.

Amazon apparel sales consist of first-party sales (sold by Amazon itself) and third-party product sales. While the exact share between them is private, Coresight Research [29] revealed that, as far as number of products are concerned, Amazon depends heavily as it shared 86.3% of number of third-party products in 2018. Amazon appears to be focusing its first-party clothing inventory on higher value categories and most of the private labels tend to be clustered in specific clothing categories [29]. Shoppers feel greater reassurance on issues such as product authenticity, shipping returns charges, and returns policies when they buy direct from Amazon than when they buy from third-party sellers.

Therefore, greater first-party inventory would increase customer satisfaction and strengthen the relationships between Amazon and brands.

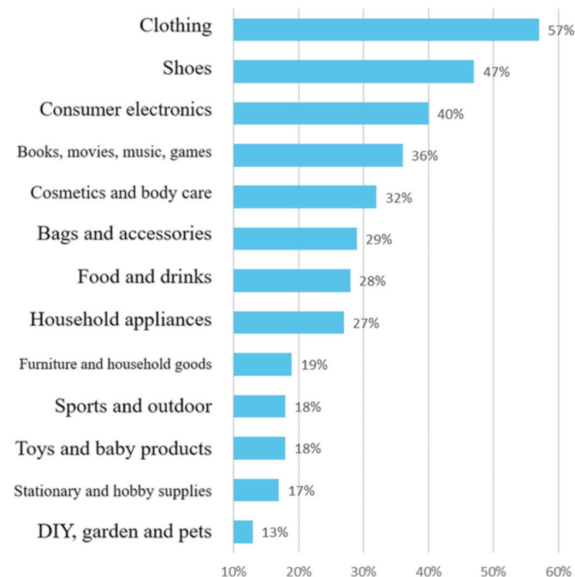With this strategic policy, Amazon depends on a highly segmented approach to its first-party sales, which tend to be concentrated within specific high-value categories and focused on each of its own brands on a particular consumer type or product category. This policy demonstrates the long tail phenomenon in a huge amount of its apparel products both by first and third-party sales (see Fig. A1 in the **Appendix**). However, sales of high-value products are initiated by segmented category of business within first-party sellers. The development of *ADFs* from 2017 is a typical case. Therefore, contrasting the limited number of products, significant contribution to revenues (sales) has been initiated by first-party sellers depending on online sales.[2]

Under such circumstances, COVID-19 had a mixed effect on the apparel market worldwide with demand decreasing and online purchasing increasing [30]. The slowed down economic activity due to COVID-19 across the globe has resulted in a decline in the apparel market demand. The apparel manufacturing industry is experiencing cuts in spending and poor consumer confidence due to fear over coronavirus spread. Due to lockdowns and travel restrictions around the world, people have less desire or need to purchase or wear anything beyond casual clothing. As many companies encouraged remote working due to physical distancing restrictions, the market has witnessed a gradual increase in demand for work-from-home wear. Fashion retailers shifted their sales channels to online platforms, focusing on new trends based on the evolving consumer [30].

Consequently, COVID-19 has accelerated digital solutions in the fashion e-commerce industry. The companies operating in the market are adopting new technologies such as artificial intelligence (AI), barcode scanners, virtual reality outfits, and e-commerce automation tools that offer a highly personalized and relevant consumer experience. Moreover, many fashion companies are launching new apps to sell their products online in order to reach a large consumer base [31]. Amazon's attempt to develop a series of *ADFs* can be considered a pioneering approach to preempt this historical demand, as demonstrated in Fig. 2.
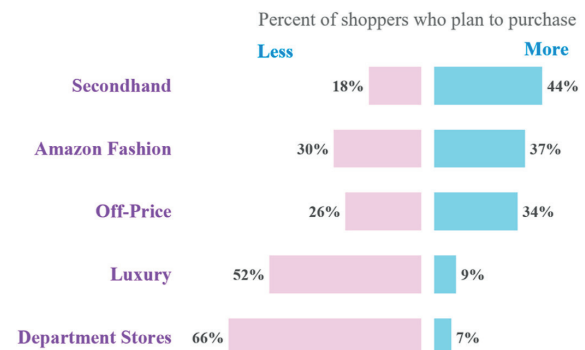

Fig. 2. **Consumers prioritizing value in the US apparel market in 2021**. Where shoppers plan to shift their spend in the next 12 months in 2021. Source: Authors' elaboration based on thredUP [32].

Fig. 1. **Share of products purchased by global internet users in 2018**. Share of Internet users who have purchased selected products online in the past 12 months as of 2018.
Source: Statista [2].

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[2] Amazon shares an extremely high level of online sales than its competitors (see Fig. 3), representing 50% of net sales in 2019. Its apparel sales share in 2019 was estimated at as 18% of net sales (Table A1 in the Appendix), the majority of which depended on online sales. Strong first-seller sales initiatives in developing *ADFs* from 2017 contributed to a significant increase in online store sales, as demonstrated in Fig. A2. While certain apparel sales (including those in Luxury Stores starting from 2020) were conducted in third-party seller services [117], these shares seemed to remain limited (around 2% of net sales) as the third-party seller services share was 19.2% of net sales in 2019 and the percentage of sellers in the clothing and shoes category (including jewelry) in third-party sellers services was 13% (11th out of 28 categories) (Fig. A3). Profitability of this category was 25th out of 28 categories [115].

Fig. 2 demonstrates that consumers prioritizing value in the US apparel market is shifting to correspond to a digital solution represented by Amazon fashion and the circular/sharing economy represented by secondhand toward a non-contact society after COVID-19.

2.2. Amazon's attempt to expand fashion-driven apparel

Amazon has been expanding its fashion-driven apparel business. Fig. 3 demonstrates Amazon's increasing share of apparel sales, as well as all online sales in the US market. Amazon has jumped to the second-largest seller of apparel in the US with 7.9% market share after Walmart (8.6%) in 2017. This increase continued, with Amazon jumping to the top with a 9.5% market share in 2019 exceeding Walmart (6.9%), as demonstrated in Fig. 4.[3] Apparel, including footwear, is now Amazon's most bought category in 2018–19, up from fourth place in 2017–18, surpassing books, beauty, and electronics.

Amazon quietly became the leading apparel retailer in the US in 2019 [33]. The unexpected drive to a non-contact society caused by COVID-19 has accelerated this trend.

3. Driving force of the rapid jump

3.1. Development of Amazon's fashion-driven apparel trajectory

Amazon's apparel sales share in the US jumped up from 3.7% in 2016 to 7.9% in 2017 and 9.5% in 2019 leveraged by the development of *ADFs* started from 2017 without which its share would remain 5% level in 2019 as illustrated in Fig. 5.

To demonstrate this hypothetical view, two development trajectories: sales share without *ADFs* (trajectory A) and sales share leveraged by *ADFs* (trajectory B) were examined using the logistic growth function both by simple logistic growth (*SLG*) and logistic growth function within a dynamic carrying capacity (*LGDCC*), as depicted in equations (1) and (2).[4]

$$\text{SLG} \quad S(t) = \frac{N}{1 + be^{-at}} \quad (1)$$

$$\text{LGDCC} \quad S(t) = \frac{N_k}{1 + be^{-at} + \frac{b_k}{1 - a_k/a}e^{-a_k t}} \quad (2)$$

where $S(t)$: apparel sales share at time t; N and N_k; carrying capacity; a, b, a_k, b_k; coefficients.

As far as the development trajectory depends on the *SLG* trajectory, its sales share $S(t)$ saturates with the fixed carrying capacity N. which
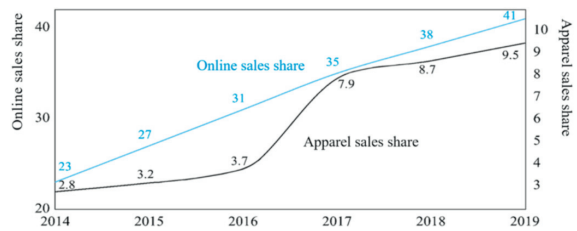
Fig. 3. Trends in Amazon's apparel sales share 2014–19 (%).
Sources: Lieber [34]; Statista [35]; Keyes [36]; Richter [37]; Wichser et al. [38]; PYMNTS [39]. Sabanoglu [40]; eMarketer [41].
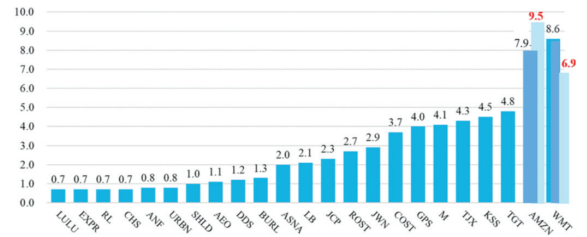
Fig. 4. Apparel sales share in the US in 2017 (%).Brown figures on the light blue bars indicate sales share in 2019. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)
Source: Authors' elaboration based on Segura [42] and PYMNTS [39].
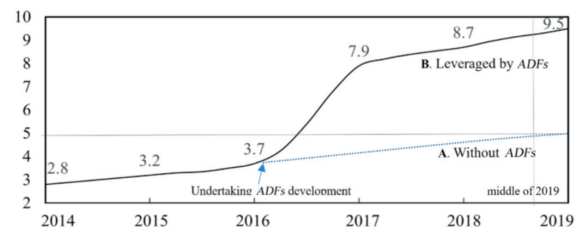
Fig. 5. Trends in Amazon's apparel sales share in the US 2014–19(%).
Sources: Lieber [34]; Statista [35]; Keyes [36]; PYMNTS [39]; Sabanoglu [40].

inevitably results in the dilemma between advancement of time and productivity decline [43]. However, since *LGDCC* incorporates dynamic carrying capacity $N(t)$ that creates new carrying capacity during the diffusion process, it maintains sustainable growth depending on self-propagating development [44,45] (see the details of theoretical bases and logic behind this application in Appendix 2).

The result of the analysis is summarized in Table 1. Trajectory A (without *ADFs*) was analyzed by taking the period between January 2014 and August 2016, a period before undertaking *ADFs* development, while trajectory B (leveraged by *ADFs*) took a period between January 2014 and December 2019 that reflects the effects of the development of *ADFs*.

Looking at Table 1, we note that while trajectory B demonstrates *LGDCC*-driven development with sustainable growth depending on self-propagating development leading to a 9.5% share level in 2019, trajectory A demonstrates *SLG*-driven development remaining at a 5%

Table 1
Development trajectory of Amazon's sales share in the US.

	N	a	b	a_k	b_k	adj. R^2
Trajectory A (2014.1–2016.8)	9.32 (2.04) *	0.016 (4.36)	2.81 (1.52) **			0.994
Trajectory B (2014.1–2019.12)	12.20 (7.01)	0.053 (3.76)	10.37 (2.49)	0.15 (1.82) *	14.81 (1.27) **	0.951

The figures in parentheses indicate the t-statistics: all are significant at the 1% level except * 5% and ** 10%.

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[3] CNBC estimated that this share increased to 11–12% in 2020 [118].
[4] Monthly trend was used by disaggregating annual data to monthly data by using the Denton-Cholette temporal disaggregation method. See Table A2 in Appendix 1 for monthly data used.

share level in 2019.[5]

Provided that *LGDCC*-driven sustainable growth can be attributed to self-propagating development [44,45], the above analysis prompts a hypothetical view that a rapid jump in Amazon's apparel sales share in the US leveraged by *ADFs* can be attributed to its self-propagating dynamism.

3.2. Inertia of transformation from multichannel to omnichannel

3.2.1. Transformation to omnichannel approach

Business dynamics are changing, and manufacturers must keep up with the increasing customer demand for personalized shopping experiences. From anticipating pre-purchase experiences to tracking post-purchase activities, the quest for improving the customer experience is almost endless [46,47].

Customers expect a seamless, personalized experience everywhere they shop which blurs the line between the internet and reality and accelerates the transformation from solo-channel customer experience to multichannel and omnichannel as illustrated in Fig. 6.

While multilateral channels such as physical stores, e-commerce, mobile applications and social media channels are used for a multichannel approach, these channels have stayed co-existing and no switching between these channels functions for a multichannel approach.

Contrary to such an approach, the omnichannel approach depends on seamless switching across all available channels and these channels co-evolve each other (mutually inspiring one another, leading to a virtuous cycle). Advancement of the digital economy has enabled this co-evolution. Brynjolfson et al. [12] postulated that digital technologies facilitate customers to switch across various shopping channels, evaluate the quality of products or services, and make purchase decisions. Omnichannel thrives in the digitalized environment [6]. Foregoing analysis on the development trajectory of ADF cultivated in the digitalized environment suggests that their omnichannel function grows with the increase in seamless switching, as the trajectory depends on self-propagating development.

In light of the increasing significance of the omnichannel approach corresponding to the advance of the digital economy, a significant number of studies have been undertaken to identify the unique nature of the omnichannel approach.

Brynjolfsson et al. [12] identified strategies for omnichannel retail and claimed that omnichannel retailing can be defined as a business model in which different channels are fully integrated to provide a seamless experience throughout a customer's journey. Verhoef et al. [16] have critically analyzed multichannel retail studies and demon-

strated that the synergetic management of the numerous available channels and customer touch points can be expected in such a way that the customer experience across channels and the performance over channels is optimized. Cummins et al. [14] suggested that omnichannel retailing refers to retailing that involves a synergetic integration of channels to create a unified brand experience for customers, regardless of the channel or stage they are in during the purchasing process. Bernon et al. [13] mentioned a synchronized operating model in which a firm can align all channels with not only the presentation of a single face to customers but also a consistent way of doing business. Hubner et al. [48] studied the multichannel transformation to an omnichannel fulfillment and identified channel integration and expansion strategies. They suggested that channel integration creates synergies, whereas expansion improves the service options for customers. Luo et al. [19] stressed that digital technologies are a major force driving the retail industry's transformation toward omnichannel retail. Saghiri et al. [6] and Shen et al. [21] supported this view. Kranzbühler et al. [18] identified that customer experience encompassing customers' cognitive, emotional, social, sensory and value responses to the organization's offerings over time, including pre-and post-consumption. Von-Briel et al. [22] defined omnichannel retail as referring to the integration of retail channels like stores, online, and mobile into a single, seamless customer experience. Similarly, Shen et al. [21] claimed that omnichannel aims to coordinate the fragmented service processes and technologies in various channels to deliver a consistent and integrated cross-channel experience for customers.

Weiner et al. [49] have addressed the online-offline business model synergies and co-existence of multichannel in an omnichannel environment. They have recommended further research and clarification on the complex interplay between online and offline business models that co-exist within an organization. Sun et al. [23] pointed out the significance of the digitalized social cognitive perspective of omnichannel service usage.

On the basis of this pioneering research, the core function governing the omnichannel approach can be identified as seamless switching that is an integration of all available channels (multi-channels) seamlessly (consistent availability seeking) for sustainable performance optimization in co-evolutionary, rather than a simple co-existence of multilateral channels.

3.2.2. Running principle of ecosystem

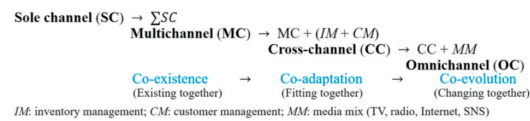This identification corresponds to a running principle of ecosystem. With an understanding that (i) ecology is the science of the relationships between living organisms and their environment, (ii) human ecology is about the relationships between people and their environment, and (iii) in human ecology, the environment is perceived as an ecosystem, masterpiece of the system, Marten [50] classified the state of ecosystem into co-existence, co-adaptation and co-evolution. While co-existence is existing together, co-adaptation and co-evolution are fitting and changing.

Given the positive feedback between people and the environment against indispensable obsoleting features, Watanabe [51,52] and Watanabe et al. [53] postulated a contrasting consequence between co-existence and co-evolution suggestive to the consequence of multichannel (simple combination of multilateral channels) and omnichannel approaches (synergetic management of all channels) as illustrated in Fig. 7.

While an omnichannel approach leads to self-propagating development based on synergetic management of all channels that activates co-evolution among multiple channels, a multichannel approach based on the simple combination of multilateral channels that keeps the co-existence of these channels results in diminishing future.

Sole channel (SC) → ∑SC
Multichannel (MC) → MC + (*IM* + *CM*)
Cross-channel (CC) → CC + *MM*
Omnichannel (OC)

Co-existence → Co-adaptation → Co-evolution
(Existing together) (Fitting together) (Changing together)

IM: inventory management; *CM*: customer management; *MM*: media mix (TV, radio, Internet, SNS)

	Multichannel	Omnichannel
Channel scope	Phys. store, e-com., mobile app.,	Phys. store, e-com., mobile app., social media
Channel integration	No switching between channels	Seamless switching among all channels
Channel characteristics	Co-existence resulting in diminish	Co-evolution leading to self-propagation
Channel goals	Sales per channel, experience per channel	All channels work together to offer a holistic customer experience

Fig. 6. Scheme of transformation from multichannel to omnichannel approach.

3.2.3. Emergence of service-oriented manufacturing

By means of seamless switching, the omnichannel approach enables a firm to increase its number of services and attractive assortment (*N*)

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[5] *SLG* demonstrates decline of the growth rate after termination period t_0 when its value is $N/2$. t_0 can be depicted as $t_0 = \ln b/a$. In this case, $t_0 = 64.6$ (middle of 2019) and $N/2 = 4.7$ (see Fig. 5).
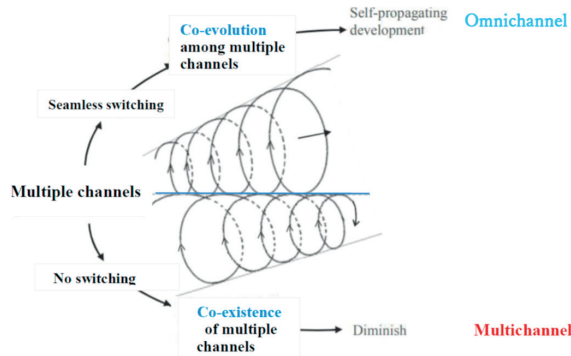
Fig. 7. Contrasting the consequences between multichannel and omnichannel.

[11,47], leading to an increase in its profits (*P*) and productivity (*S/L*) [6,16]). This can be attributed to the self-propagating function (*S^n*) as demonstrated earlier by Amazon's development trajectory. Here, *S*, *L*, and *n* denote sales, number of employees and the multiplier of network elasticity, respectively.

In their preceding analysis on the performance of Japan's top five leading electric and electronic mega retail firms (EEMRs), authors demonstrated that a virtuous cycle exists between *S/L*, *N* and *P* based on the success in customer's involvement, depending on self-propagating development. They also explored the prospect of service-oriented manufacturing in which retails firms play a similar function to ODM [54]. In service-oriented manufacturing, tangible products and intangible services are integrated into one product service system to provide comprehensive solutions for customers where each firm focuses on core businesses, outsources non-core businesses, and provides producer services for one another to achieve rapid innovation and improve efficiency [55,56]. This corresponds with Amazon's R&D-driven customer-centric business model that transforms routine or periodic alterations into significant improvements during the R&D process [4,43].

Transformation to the omnichannel approach leverages this dynamism, as illustrated in Fig. 8, and paves the way for ODM [9].

3.3. Amazon's initiatives

Amazon's initiatives both in developing a series of *ADFs* and going deeper into the luxury market can be considered as efforts to increase the effects of an omnichannel approach.

3.3.1. Series of ADFs development

3.3.1.1. Cultivation of the digital environment. Co-evolution in the digital economy can be leveraged by a self-propagating function indigenous to
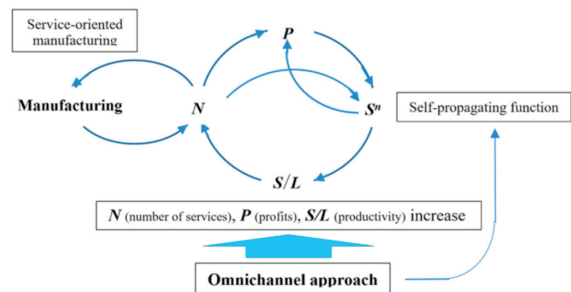
ICT [52]. The rapid jump in Amazon's apparel share in the US market based on the *LGDCC* trajectory corresponding to undertaking the series of *ADFs* from 2017 demonstrates the shift from a multichannel approach to an omnichannel approach. While a certain extent of omnichannel approaches have been deployed prior to ADF development, including "Fashion website" (2007), "Smart Lockers" (2011), "Amazon Flow app" (2012), "Amazon Physical Popup Stores" (2014), "University/college pickup points (2015) and "Amazon, Kohl, and Best Buy collaboration" (2017), they are hardly satisfactory in shedding Amazon's perception as an uncool brand seller that will not satisfy customers' desire to try before purchase.

Thus, Amazon made substantial efforts to employ an omnichannel approach to improve their reputation as selling uncool brands seller have been undertaken together with developing *ADFs*.

While Amazon has been effectively utilizing learning effects during the process of transformation of routine or periodic alterations into significant improvement [4], provided that omnichannel thrives in the digitalized environment [6], Amazon's attempt to the shift to an omnichannel approach has been enabled by its intensive R&D investment centered on digitalization. Fig. 9 and Table 2 analyze the contribution of learning effects and R&D investment to Amazon's apparel sales share in the US market over the period 2014 to 2019 by utilizing quarterly data. Looking at Table 2, we note that while Amazon's increase in this share depends on learning effects for the whole period examined (dummy periods D_1, D_2, and D_3), its rapid jump in 2017 (similarly, D_2) largely depends on R&D investment centered on AWS (Amazon Web Service), BD (big data), AI (artificial intelligence) encompassing ML (machine learning), DL (deep learning), CV (computer vision) and IR (image recognition), as well as AR (augmented reality), BR (blended reality), DM (data mining), GAN (generative adversarial networks) and QR (quick response).

This suggests that Amazon undertook intensive R&D for cultivating the digitalized environment for undertaking *ADFs* starting from Prime Wardrobe, which emerged in 2017, and AI Algo (2017), Echo Look (2017), and AR Mirror (2018), Amazon then utilized learning orchestration effects thereon for the developing of succeeding *ADFs* as Personal Shopper (2019), Style Snap (2019), and The Drop (2019) [3].

Business-model innovation is essential for the omnichannel shopper. Omnichannel customers are hungry for innovation and are more likely to experiment with new technologies and engagement models. As the number of omnichannel shoppers grow, the degree and pace of innovation and experimentation will need to grow to serve them [57]. This corresponds to $N \rightarrow S^n$ (self-propagating function increases as services increase) in Fig. 8. Innovative direct-to-consumer apparel firms are gaining real-time insights into what customers want and responding to trends faster than ever [57]. Since omnichannel service can satisfy customers' demands for smooth and convenient experiences, they naturally expect satisfactory outcomes from omnichannel service usage. At the same time, omnichannel urges customers to develop certain abilities [23].
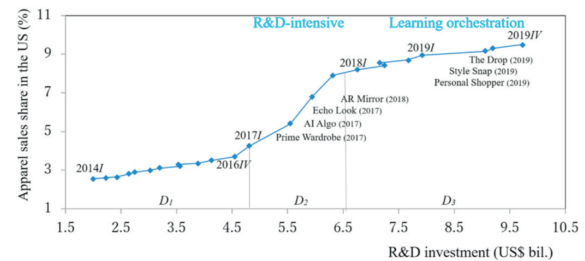

Fig. 8. Prospect of service-oriented manufacturing.

Fig. 9. Correlation between Amazon's R&D investment and apparel share in the US market (2014–19 quarterly).

Table 2
R&D Contribution to Shift to Omnichannel Approach in Amazon (2014-2019).

$$S(t) = Ae^{\lambda t}R(t)^{\alpha}$$

$$\ln S(t) = \ln A + \lambda\, t\ + \alpha \ln R(t)$$

$$\ln S(t) = 1.75 + 0.03\, D_1\, t + 0.13\, D_2\, t + 0.02\, D_3\, t$$

$$+\ 0.85\, D_2 \ln R(t) - 0.85\, D_1 - 3.38\, D_2$$

$S(t)$: apparel sales share in the US, A: scale factor, λ: learning coefficient, t: time trend, $R(t)$: R&D investment, α: R&D elasticity to $S(t)$, D: dummy variables; D_1: 2014I-2016IV = 1, others = 0; D_2: 2017I-2017IV = 1, others = 0; D_3: 2018I-2019IV= 1, others = 0 (I: 1st quarter, IV: 4th quarter).
Backward elimination method with 5% criteria was+ used.
The figures in parentheses indicate the t-statistics: all are significant at the 1% level.

3.3.1.2. Increased density of omnichannel dependence. With an identical notion of the omnichannel approach, Amazon has attempted to fully perform its comparative advantage through learning orchestration based on its innovative technology assets as AWS, AI, and big data and used a variety of omnichannels as illustrated in Fig. 10. Through this attempt, Amazon has improved the curation system for developing customers' abilities.

In line with this strategy, Amazon has been securing a digital solution by developing *ADFs* successively based on learning orchestration externality [3] and increased density of omnichannel dependence as *ADFs* proceeds as demonstrated in Table 3. For example, The Drop, which emerged in 2019, taps global influencers to co-design street-inspired collections sold over a 30-h window. The collections are manufactured in line with demand, leading to developing a testbed function for on-demand manufacturing. This has been enabled by accomplishing seamless switching among physical stores, the website, mobile channels, social media, and an extensive media mix. With AI advancements and the omnichannel experience, apparel can be manufactured to order without mass producing a product and holding it in inventory. This paves the way for ODM and further reinforces seamless switching among an increasing variety of channels [9].

Table 4 summarizes seamless switching in seven- *ADFs* businesses.

Since omnichannel service can satisfy customers' demands for smooth and convenient experiences, they naturally expect satisfactory outcomes from omnichannel service usage. At the same time,
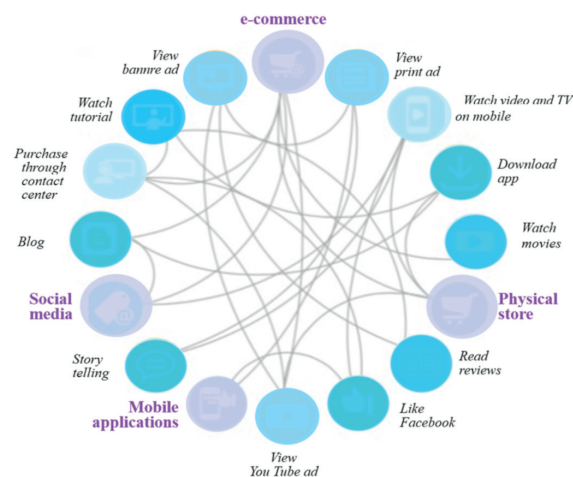
omnichannel urges customers to develop their abilities for searching, learning, and absorbing trends in the global fashion community [23].

Table 4 demonstrates Amazon's successive *ADFs* developments in line with:

(i) effective utilization of innovative assets as AWS, AI, big data, and a variety of omni-channels thereon [59,60]),
(ii) maximizing learning orchestration externality [3,61–63];
(iii) improving the curation system function for developing customers' abilities [64,65] as initiated by Echo Look in training Amazon's machine learning algorithms through customers' photos and short videos captured by its smart camera device [66];
(iv) intensifying the density of omnichannel dependence by enriching functions as *ADFs* advances, as demonstrated in Table 5 [67,68], and
(v) developing a testbed function for ODM [67,69]; Amazon.com, 2021). Here, testbed incorporates systems functions such as as predictability, observability, and trialability [70].

3.3.1.3. Contribution of ADFs development. Consequently, the development of a series of *ADFs* has contributed to intensifying the density of qualified omnichannel dependence based on high-level curation systems equipped with learning orchestration of innovative technologies as AWS, AI, and big data. This development has led to increasing in Amazon's sales share of apparel and high prospecting business, and contributed to its sales increase, as demonstrated earlier (Fig. 5 and Table 1, as well as Fig. 9 and Table 2). It has also paved a realistic way for ODM. In addition, it cannot be overlooked that the development of a series of *ADFs* has leveraged Amazon to advance deeper into the luxury market.

3.3.2. Advancing further into the luxury market

3.3.2.1. New digital platform for luxury fashion. Advancing further into the luxury market is Amazon's long-lasting dream. However, Amazon's previous attempts to court luxury brands have been met with resistance [71]. These brands want to avoid being associated with discount and counterfeit products [72,73]. Brands have been reluctant to collaborate with Amazon due to its solo-channel approach of selling basic apparel using its own control over branding, pricing, and discounts [3,74]. Amazon introduced a new digital platform for luxury fashion, Luxury Stores in September 2020 by collaborating with renowned luxury fashion designers and brands in attempting to overcome these structural impediments, in line with its development of successive *ADFs* businesses, and also in response to the increasing requirement from brands to look for extra channels that address a non-contact society. Taking into account the structural impediments that make brands reluctant to collaborate with Amazon, Amazon allowed brands to make decisions about their inventory, selection, timing, and pricing, which in turn

Fig. 10. Scheme of digital customer journey- Physical store, e-commerce, mobile app., social media, and media mix.
Source: Authors' elaboration based on Coelewij [58].

Table 3
Trend in omnichannel density in *ADFs*.

	Physical store (PS)	e-commerce (e-com.)	Mobile application (m-app.)	Social media (SM)	Media mix (MM)
Prime Wardrobe	Not depending (*ND*) (mimics PS by bringing sensory experience and flexible returns at homes)	Subscription-based online clothing service, access to premium brands, try at home before purchase.	m-app. is designed to collect and store data, real time info, and purchase any time anywhere, customized messages.	Branded content campaign, product tagging on SM, experience sharing, brand awareness, product reviews, partnership with content creators.	m-TV, SMS, YouTube ad, video, m-video, blog, purchase through contact center, reviews, tutorial, print ad
AI Algo	*ND*	Algorithmic fashion design solution.	*ND*	Learning from trends on SM.	YouTube ad, m-video, blog, purchase through contact center, reviews, tutorial, print ad
Echo Look	*ND*	Online fashion recommendation service through photos and short videos.	Companion apps that recommend styles collect and store data, sharing photos with others, real time info and purchase any time anywhere, customized messages.	Branded content campaign, experience sharing with other consumers, brand awareness, product reviews, and partnerships with digital content creators.	YouTube ad, m-video, blog, purchase through contact center, reviews, tutorials, print ad
AR Mirror	*ND* (mimics PS through AR/VR experience at homes)	Device based on AR/VR for Prime members.	*ND*	Promotions, experience sharing with other consumers, brand awareness, product reviews, partnerships with content creators.	YouTube ad, m-video, blog, purchase through contact center, reviews, tutorials, print ad
Style Snap	*ND*	Image based style inspiration search for prime members.	m-app. sharing with others, real time info and purchase any time anywhere, customized messages.	Promotions, brand awareness, reviews, experience sharing with other consumers, partnerships with digital content creators.	YouTube ad, m-video, blog, purchase through contact center, reviews, tutorial, Facebook
The Drop	*ND*	Fashion influencers designed clothes for Prime members.	Mobile app, real time info and purchase any time anywhere, customized messages.	Influencers designs, collaboration with influencers on social media, promotions, experience sharing with other consumers, brand awareness, reviews.	YouTube ad, m-video, blog, purchase through contact center, reviews, tutorial, banner, Facebook

Media mix encompasses TV, radio, e-mail, phones, call centers, and short messages service (SMS).

abled broader luxury brand participation with close integration with manufacturers [71,73,75].

However, this is a trade-off between multichannel and omnichannel approaches as this challenge incorporates trade-offs between exclusive and wide availability, as well as owning and ease. Luxury brands have to figure out how to maintain their high-class reputation while being available to many around the world. This requires Amazon to provide an answer to a previously impossible conundrum [75]. Luxury Stores is expected to make this answer viable; therefore, luxury brands are expected to have their own exclusive interactive experiences while having the availability of Amazon's non-contact-oriented channels. Once accomplished, both luxury brands and Amazon enjoy seamless switching.

Starting with Oscar De La Renta (September 2020), followed by Roland Mouret (September), Altuzarra (October), Clé de Peau (October), Car Shoe (October), Révive Skin Care (October), La Perla (November), Elie Saab (December), Mark Cross (December), and The Conservatory (December) Amazon has endeavored to expand Luxury Stores by inviting ten pioneering brands by the end of 2020. Success of this challenge depended on the construction of the co-evolution between traditional business models in luxury brands and Amazon's successive efforts for a more sophisticated omnichannel approach [75]. Table 6 reviews the current state and prospect of the omnichannel approach in ten pioneering luxury brands that joined Amazon's Luxury Stores in 2020.

Table 6 demonstrates the pioneering state and future prospects of Amazon's Luxury Stores with ten brands as follows:

(i) Currently, Amazon and ten brands continue co-existing regarding their respective functions and hardly perform seamless switching by integrating both functions [24,25,71].

(ii) However, all incorporate the potential to transform co-existence to co-evolution that activates multi-channels with seamless switching by maximizing co-evolutionary effects [77,78].

(iii) This transformation contributes to paving the way to Amazon's ODM [46,79].

3.3.2.2. Acceleration of innovative technology solutions. While seamless switching expects the consistent availability of products and services on all available channels, luxury brands confront the Internet dilemma [7]. They seek to maintain brand image, sustain personal links with customers, and retain an exclusive aura while providing products and services to online customers [24]. Kim [25] pointed out that quite a few luxury brands still do not employ the Internet as an active transaction channel. The untransferable in-store experience and luxurious atmospherics of physical stores are considered the main reason that makes luxury brands hesitant to go online as retailers. In addition, the uncertainty of product authenticity is a critical issue that prevents customers from purchasing luxury goods online [80]. With these hesitations, luxury brands may overlook opportunities that the digital platform can bring such as financial strength and brand awareness [25]. Parisi [71] argued out that Amazon has to strike a delicate balance between being exclusive enough to court luxury brands but not so exclusive and small-scale that the brands see no value in joining.

However, by selling luxury goods on their own e-commerce sites, luxury stores can help luxury customers reduce perceived risks of online shopping and thus increase sales [25]. Kluge et al. [81] stressed that online accessibility of luxury goods does not negatively affect brand desirability for customers. Instead, online accessibility positively affect customer perceptions of convenience and willingness to buy. According to Gendre [77] "If Amazon can continue to develop innovative technology solutions, it has a real opportunity to increase online revenue share in the luxury sector." Dalpiaz [78] pointed out that "Now, it's important to do what it takes to reach customers where they are and offer what they need. It's possible for luxury brands, via Amazon,

without losing their luster."

Taking this invaluable opportunity during COVID-19 when apparel demand confronts stagnation, by making full use of learning orchestration externality accumulated through *ADFs* development, Amazon's Luxury Stores attempts to solve the structural impediment of the Internet dilemma by providing an answer to a previously impossible challenge through a "store within a store" that gives brands the power to manage their inventory and customer relationships by themselves [82].

Consequently, Amazon has succeeded to invite additional 24 luxury brands, in addition to the ten pioneering brands, to join Luxury Stores by the end of the first half of 2021 [83].

Germany based Mytheresa is a major competitor of Amazon's Luxury Stores and considers Amazon as threat. Its curated offerings come from a network of over 200 luxury brands. However, It doesn't have as flexible services and advanced technological infrastructure as Amazon has. It is in fact Amazon's customers that use AWS for cloud computing, online sales management and other innovative technologies [82,84]. While it took 15 years for Mythersea to attract 200 brands, Amazon attracted 34 brands in less than one year. This demonstrates the system efficiency of Amazon's Luxury Stores. It is estimated that Amazon could bring 180 luxury brands to Luxury Stores in less than three years [73].

Table 6–2 summarizes the additional 24 luxury brands that joined Luxury Stores by the end of the first half of 2021. This demonstrates that all can be attributed to effects of learning orchestration externalities from *ADFs* in overcoming the Internet dilemma. In addition, they suggest the possibility of co-evolution among *ADFs*, luxury brands, and ODM.

3.3.2.3. Synchronization of Amazon's assets. Amazon's success in advancing into the luxury market depends on maximizing substantial seamless switching effects [79] in the triggering scheme of co-evolution among *ADFs*, luxury brands, and ODM under the increasing dependence on ODM in a non-contact society by finding the right hybrid set of skills, technologies, and the right partner [46]. As manufacturers begin to see the business benefits, they will start to adopt a more comprehensive approach to their omnichannel strategy [46].

The newly appointed president of Amazon fashion, Muge Edirik[6] Dogan has been using her skills and experience in retail, technology, and innovation to attract luxury brands to compete with rival platforms [85].

She is expected to solve the above concerns by synchronizing Amazon's assets, *ADFs*, Luxury Stores, and ODM system, which was patented in 2017.

Table 7 demonstrates the significance of this synchronization through SWOT analyses of ADF and Luxury Stores.

Table 7 demonstrates the significance of the synchronization of *ADFs*, luxury brands, and ODM by supporting findings obtained in Tables 4 and 6 and also suggesting the opportunity of ODM for the apparel industry.

4. New stream leveraging supra-omnichannel in Amazon's apparel business

4.1. Three-dimensional approach for a fashion-driven apparel leader

The ambitious goal to be a fashion-driven apparel leader has led Amazon to focus on the following a three-dimensional approach consisting of: (i) satisfaction of customers' dream to have their own

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[6] In this chasing game, while a inferior mirages in the distance ahead move together with the same size, given the certain obsolescence rate ρ indispensable to new innovation, moving with the same size implies growing by this rate. $S[(1 + g)^t](1 - \rho)^t = S \quad (1 + g)^t = 1/(1 - \rho)^t \quad then \ g \approx \rho$ where S: size of the inferior mirage, g: growth rate, ρ: rate of obsolescence of innovation, and t: time trend.

Table 4
Way of seamless switching in *ADFs*.

	Way of Seamless Switching
Prime Wardrobe	**Subscription clothing box with a try at home before purchase:** See online try offline service→ subscription-clothing box→ try at home before purchase experience →personalization (online product matches) enabled by **BD** analytics i.e., **BD** collection through website visits, past histories and profiles→ **AWS**→ **BD** processing and experimentation → **ML** algorithms development→ customer taste, buying patterns and preference identified and structured → seamless fashion catalogue browsing and ordering → enables customers to renew their fashion collection with free trials at home → order via m-app. or e-com. free shipping/return →24/7 (seven days trial period) customer service (cs) →multi- channel presence, i.e., Amazon contact center, blogs, email, YouTube and MM.
AI Algo	**AI fashion designer: ML** algorithmic approach→ **GAN** to understand human tasks → Amazon trained **GAN** to fashion designer→ spots, reacts and redesign fashion trends by learning from images on web → data set of trendy images on SM and MM (input data) → similar images produced by generative model (output) → real-time process→ **DM**→ style identification→ demand prediction of trends before manufacturing → produced on demand → based on context predict why the customer is seeking support, speeding the response.
	Recommendations provision: Provide recommendations for problem-solving, both from the perspective of recommending a particular journey, but also providing recommendations to the customer and support staff on how to address the problem, improving support effectiveness → through continuous learning, refine these journeys and recommendations leading to optimizing the experience.
Echo Look	**Virtual try-on service:** Integrated with companion recommendations and rating apps (Style Check, outfit Compare) → virtual fashion wardrobe creation (look book app) at home as in PS. → enable fashion image sharing on social networks →**ML** curates photos into categories → human designers provide final recommendations.
	AWS computing platform for profiles mapping: Smart speaker with depth-sensing camera for profiles mapping → powered by **AI**-based interactive voice service (Alexa) → lives in Amazon cloud →**ML** enables continuous skills learning → virtual advisor to virtual fashion advisor supported by **AWS** computing platform.
	Omnichannel data integration and management: Outfit images contain customers' behavioral data (lifestyle, fashion sense, and buying behavior), → personalized recommendation→ algorithm training→ order via m-app., e-com. or Alexa delivered at home with free shipping and returns, 24/7cs. → multichannel presence i.e., Amazon contact center, blogs, SMS, email notifications, YouTube tutorials, and MM→ fully integrated retail experience → device stopped functioning in 2020 → corresponding apps are in operation for recommendations.
AR Mirror	**AR based virtual try on service:** Echo Look extension→ **BR** view → removes the hassle of changing rooms in PS → create seamless PS experience online along with fun, enjoyment, and time spent in PS. Customers envision virtual outfits at physical locations→ new outfits emerge based on touch screen, voice and body movements→ closes the gap between online and offline (show rooming and web rooming concepts) → Mass customization and personalization→ could be integrated with other ADF and fashion catalogue.
	Smart mirror with depth-sensing camera for profiles mapping: CV to create human avatars with realistic movements → used for outfit modeling → **ML** provides self-learning and self-adapting features to the mirror → updates and more responsive in delivering experiential consumption, more certain product evaluation and decision making → a sophisticated data collection tool. → Integrated retail experience enables seamless switching between channels.
	Context-relevant information: AR brings inventory directly to the customer home and can help boost customer confidence, reduce shopping cart abandonment, and limit returns → link to the Amazon's Web page → order via AR Mirror device (IoT), to be delivered to the home with free shipping and returns, 24/7cs. → Amazon patent → commercially unavailable.
Personal Shopper	**Multi channels exploitation:** Styles are selected by humans (customers and designers) and **AI** by means of e-com., m-app. and SM as key sales channels → enables a customer to renew their fashion collection with free trials at home→ order via m-app. or e-com. With free shipping and return → 24/7cs. → multichannel presence i.e., Amazon contact center, blogs, SMS, email notifications, YouTube tutorials, and MM.
	Mass customization and personalization: Prime Wardrobe extension with curation function learning through data analytics, AI, customer input, and human designers supported by AWS→ closes the gap between offline and online channels with a try at home before purchase → **ML** carries learning assets, **BD** both structured data (preference, size, fit, color) and unstructured data (images, videos, special requests, SM) as well as Amazon fashion inventory → data analytics for interpretation and structuring of structured data → human expertise for interpretation of unstructured data→ data sets assist human designers for final curation, and delivery→ **BD** continuously trains **ML** for determining personalization and latest trends that support curation function and service improvement.
	Highly engaging clothing box service: Created by customers, **AI**, and human designers on monthly basis → highly engaging service (customers are always curious in finding what they have created) → curation function satisfy customers increasing desire of individuality.
Style Snap	**Curation with lifestyle influencers learning from SM:** Photo-based fashion shopping service by landing page via selecting camera icon → upload a photo →**AI** photo analysis → **IR** to retrieve similar items from a fashion catalogue supported by **AWS** → **DL** and **CV** initiated voice and text free fashion search → faster and easier online shopping experiences in real-time → recommendations based on brands, price, and reviews → continuous curation thereon.
	Inducing advanced influencer program: Fashion influencers tag their SM fashion images or add to their storefronts→ notifications to followers→ they upload screenshots on Style Snap → AI analyzes the photo and match it with influencer's shared images for similar recommendations and matching → induce influencers to further develop their followers by receiving a commission on SM.
	Photo-based matching recommendations: Customers use typical filters for Prime eligibility, size, fit, etc. → within the catalog, the branded **QR** codes drive customers directly to the Amazon website → customers scan fashion items **QR** → gain more product information, its availability on other channels or other recommendations from Amazon catalogue → recommended items are consistently available at Amazon catalogue customer can order via Prime Wardrobe, e-com, and m-app. → delivered to home with free shipping and return 24/7cs. → seamless switching among multi-channels i.e., Amazon contact center, blogs, SMS, email notifications, YouTube tutorials, and MM.
The Drop	**Curation with international fashion influencers:** International fashion influencers learning from SM fashion influencers → minimal and exclusive editions → new capsule collections in every few weeks →production starts as soon as collection ends →available for 30 h → limited inventory→ produced in small batches → enables on-demand manufacturing→ delivery in 2–3 weeks.
	Direct relations between influencers and customers: Most of the influencers are SM active → fashion customers explore multiple channels, particularly by SM to seek fashion information→ SM enables influencers to create direct relationships → share their contents by MM (blogs, reviews, banner, videos, YouTube) and inspire customers in decision making→ their credibility, design expertise, specific channel contents, and direct relations allow customers to trust and follow them.
	Global fashion data acquisition through worldwide collaboration and co-creation with renowned influencers: Shed uncool image → deeper into Luxury fashion as well as towards on-demand manufacturing → expertise and knowledge of influencers enable Amazon and its **AI** system to learn evolving global fashion cultures →global fashion data acquisition → every influencer representing "The Drop" has significant number (millions) of SM and MM followers.
	Testbed for on-demand manufacturing: ML algorithms training→ designing personalized and dynamic services → accurate recommendations → testbed for future on-demand manufacturing factory → order via m-app., e-com. or phone call → deliverer to home with free shipping and return 24/7cs. → seamless switching among multi-channels i.e., Amazon contact center, blogs, email notifications, YouTube, influencers SM and MM.

R&D - BD: Big data, AWS: Amazon web service, ML: Machine learning, AI: Artificial intelligence, GAN: Generative adversarial networks, AR: Augmented reality, CV: Computer vision, IR: Image recognition (subset of CV), DL: Deep learning, QR: Quick response, DM: datamining, BR: Blended reality.
Channels - PS: Physical store, e-com.: e-commerce, m-app.: Mobile application, SM: social media, MM: media mix.

Table 5
Development of key functions in *ADFs*.

Prime Wardrob	Subscription clothing box with try at home before purchase
AI Algo	AI fashion designer
	Recommendations provision
Echo Look	Virtual try on service
	AWS computing platform for profiles mapping
	Omnichannel data integration and management
AR Mirror	AR-based virtual try-on service
	Smart mirror with depth-sensing camera for profiles mapping
	Context-relevant information
Personal	Multi channels exploitation
Shopper	Mass customization and personalization
	Highly engaging clothing box service
Style Snap	Curation with lifestyle influencers learning from SM
	Inducing advanced influencer program
	Photo-based matching recommendations
The Drop	Curation with international fashion influencers
	Direct relations between influencers and customers
	Global fashion data acquisition and co-creation with renowned influencers
	Testbed for on-demand manufacturing

initiatives, (ii) shedding uncool label and increasing curation function, and (iii) deepening into the luxury market.

(1) Satisfaction of customers' dream by accelerating SNBN program

Amazon has accelerated the SNBN (see now buy now) program to let shoppers create by themselves [5]. This corresponds with the increasing trend of prosumers (consumers as producers) in response to the increasing anger of consumers to have been retained non-producers [86, 87] against their dream to enjoy an exciting story with their own initiatives as heroes/heroines of a drama [52].

(2) Shedding uncool label and increasing curation function

Amazon has attempted to shed its uncool label and increase the curation function to improve customers' abilities by developing a series of *ADFs* leading to tapping global influencers to co-design 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.

(3) Advancing into the luxury market

Amazon has attempted to advance into the luxury market through opening to a multichannel approach by allowing luxury brands to make decisions about their inventory, selection, timing, and pricing.

While this attempt started from the co-existence of luxury brands' traditional channels and Amazon's own channels, the ultimate goal is to transform this co-existence into co-evolution.

4.2. Synchronization of three-dimensional streams

Synchronization of these three-dimensional streams is expected to pave the way to long-lasting ODM for the apparel business together with shedding Amazon's uncool label and advancing further into the luxury market, as illustrated in Fig. 11. The first stream, satisfaction of customers' dream to have their own initiatives, encourages ODM from the motivation-side. The second stream, shedding the uncool label and increasing the curation function, encourages ODM from demand-side. The third stream, advancing into the luxury market, encourages ODM from the supply-side.

4.3. Breakthrough to on-demand manufacturing for the apparel business

(1) Features of ODM

Less uncertainty, shorter lead-time, higher flexibility, minimum investment and inventory [88,89].

(2) Merits of ODM

Customization, individuality, exclusivity, sustainability, less wastage, reduced energy and pollution, faster supply chains, and reduced inventory [90,91].

(3) Necessary requirements for ODM
  (i) Ability to comprehend variations in volume, variety, and processes [90,92].
  (ii) Capital and technology for an automated system, investments in AI, standardization and rapid supply of materials for manufacturing, real-time supply chain visibility, a platform for customer-supplier interaction, talented workforce, collaborations, intelligent decision support system, and high-speed Internet such as 5G technology to handle intelligent machines and robotics [88].
  (iii) 5G will further accelerate automated processes and allow machines to update themselves, transfer big data, and initiate a new process based on customers' demand [93].
(4) Structural impediments to realize ODM

Design and technological requirements for every order, access to materials as every order is unique, uncertain lead times, irregular supply of customer orders, uncertain production planning and control, setting delivery priorities, cost of customization, and multiple orders from multiple customers can lead to production errors [94].

(5) Effects on broad stakeholders

Satisfy customers' dream to be heroes/heroines of a drama (corresponding to an increase in prosumers).

(6) Contribution to the apparel industry

ODM contributes the following benefits to the apparel industry:

  (i) Enables brands to focus more on finding new customers and their data instead of dictating fashion trends to the world [95].
  (ii) Eliminates intermediaries such as dealers, wholesalers, and marketing firms [96],
  (iii) Enables apparel producers to make products close to the customer, without inventories, long lead times, and forecasts.
  (iv) Customers and suppliers can communicate in real time for customized products [97],
  (v) Virtuous circle of agile production and rapid response to quickly evolving customers' demands can be constructed [98].
(7) Amazon's aim to develop ODM for apparel

Amazon is taking steps to develop the tools that deliver real-time consumer insights and can be leveraged for just-in-time delivery. In light of the significance of ODM for this attempt, with its comparative advantage in data and automation technology, Amazon applied a patent for an on-demand apparel manufacturing system based on data and automation in December 2015 and was granted this patent in April 2017 [99].

In this patented system, orders are received through multiple channels used by customers, based on data and automation. Computers then collect orders and arrange them for production. The manufacturing system is based on textile printers, cutters and computers. The computing environment increases production efficiency and real time customization, allowing new manufactures with advanced technologies to enter the market with very low minimum order quantities [100].

The acquisition of this patent steps up Amazon's fashion game (CB

Table 6
Development of luxury stores.

Brands	Time of launch	Label	Prospect of omnichannel
Oscar De La Renta	Sep. 2020	USA	1. With ready-to-wear and on-demand fashion from 2013, it offers personalized shopping with fitting solutions by using True Fit technology. First official partner on Luxury Stores. 2. Integration with Amazon is expected to increase visibility, digital-merchandising solutions to personalize the brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. Provides customization and remodeling services. In addition, customers and brand's designers curate bridal dresses. These services correspond to on-demand apparel manufacturing.
Roland Mouret	Sep. 2020	UK	1. With ready-to-wear and on-demand fashion with online and PS, e-com. Collaboration with Shopify. SEO (search engine optimization) strategies for increased sales were initiated. 2. Both co-created "Utopia" for virtual try-on with virtual backgrounds, "No Show" movie, enabling integration of digital content with e-com. Such storytelling strategies would enhance customer's luxury experience. Amazon provides digital-merchandising solutions to personalize the brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. It also offers customized dresses, and the "Utopia" strategy enables mass customization and personalization, leading to on-demand manufacturing.
Altuzarra	Oct. 2020	USA	1. While ready-to-wear both PS and online, collaboration with a multi-brand department store is a significant sales channel at present. 2. In collaboration with Amazon, storytelling strategies via movies will be used for an enhanced luxury experience that combines digital content with e-com. Fashion collections are presented to Luxury Stores with three short films and curated product vignettes. Amazon provides digital-merchandising solutions to personalize the brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. These strategies and curation function in creating product vignettes represent personalization pave the way to on-demand manufacturing.
Cle de Peau	Oct. 2020	Japan	1. Since cosmetics are major products with luxury brands of Japan's Shiseido group, Cle de Peau doesn't sell outfits. With online and PS presence, major sales channels are outlets, boutiques, departmental stores, and several e-com. Channels. 2. Integration with Amazon is expected to increase visibility, digital-merchandising solutions to personalize brands' content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. Digital-merchandising solutions contribute to Amazon's on-demand apparel manufacturing.
Car Shoe	Oct. 2020	Italy	1. With both online and PS presence, it sells leather shoes, not outfits. Major sales channels are outlets, boutiques, departmental stores, and e-com. Collaborated with Adobe to analyze customers' preference data in designing digital marketing campaigns, personalization, and customization. 2. Collaboration with Amazon's Luxury Stores provides access to customers across the world with SM, MM, and email campaigns, Storytelling through a short movie on Amazon fashion social media channels with a tag line "City or Country." Amazon also provides digital-merchandising solutions to personalize brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. It belongs to the leading luxury brand Prada that uses "Made to Measure" technology that enables customers to curate outfits with the brand's designers. This personalization and customization approach leads to on-demand apparel manufacturing.
Revive Skin Care	Oct. 2020	USA	1. Since cosmetics constitute a significant product, revive skincare doesn't sell outfits. Sales channels include web, several e-com., mobile, SM, own stores including revive skincare and boutique, and departmental stores. It also provides AI-enabled selfie-based customized skincare recommendations to individual customers representing an omnichannel approach in cosmetics. 2. Its founder won a Nobel prize for inventing medicine for burn victims, which became the foundation for the company. Integration with Amazon is expected to increase visibility, digital-merchandising solutions to personalize brands' content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching in broader apparel businesses. 3. AI-based customized recommendations contribute to Amazon's on-demand apparel manufacturing.
La Perla	Nov. 2020	Italy	1. With both online and PS presence, major sales channels are outlets, boutiques, departmental stores, and several e-com. channels. Collaborates with SM influencers and bloggers, meet and greet events with brand's own designers, and Candid videos that capture in natural, spontaneous, or unposed manner. 2. Collaboration with Amazon's Luxury Stores provides access to customers across the world with SM, MM, and email campaigns, storytelling through short movie at Netflix series. Amazon also offers digital-merchandising solutions for personalizing the brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. Better solution for La Perla problems, the satisfaction of individual customers' needs, urges Amazon's on-demand apparel manufacturing.
Elie Saab	Dec. 2020	Lebanon	1. With both online and PS presence, major sales channels are departmental stores and outlets. Collaboration with e-com. platforms, Net a Porter and Ounass. 2. Collaboration with Amazon's Luxury Stores provides access to customers across the world with SM, MM, and email campaigns, storytelling through auto play imagery, and in motion graphics. Amazon also offers digital-merchandising solutions to personalize the brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. Its customized dresses and digital-merchandising solutions urge Amazon's on-demand apparel manufacturing.
Mark Cross	Dec. 2020	USA	1. Since luxury leather accessories i.e., handbags and wallets are major products, it does not sell outfits. With both online and PS presence, major sales channels are outlets, boutiques, departmental stores, and e-com. 2. Collaboration with Amazon's Luxury Stores provides access to customers across the world with SM, MM, and email campaigns. Joined Luxury Stores with new gifting suits in time for holidays strategy, leveraging storytelling elements and curated offerings. Amazon also provides digital-merchandising solutions to personalize the brand's content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3. Curated offerings urge Amazon's on-demand apparel manufacturing.
The Conservatory	Dec. 2020	USA	1. Multi-brand store representing fashion, wellbeing, and lifestyle products. Both PS and online presence, for e-com. collaborated with Farfetch. Allow customers to try items on but not make any purchases. Uses universal cart technology for cash less payments. Some of its stores act as showrooms to boost online sales.

Table 6 (*continued*)

Brands	Time of launch	Label	Prospect of omnichannel
			2. Collaboration with Amazon's Luxury Stores provides access to customers across the world with SM, MM, and email campaigns. Amazon also provides digital-merchandising solutions to personalize the brand's content, international presence, virtual store-fronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching. 3 It's eco-friendly approach and creativity representing ageless outfits urges Amazon's on-demand apparel manufacturing.

2 Development of Luxury Stores (2) – 24 Luxury Brands joined by June 2021

Brands	Time of launch	Label	Prospect of omnichannel
Aquazzura	2021	Italy	1. Women's footwear brand with timeless classic styling. Acquazzuras' "Wild Thing" shoe designs led to international success. With PS, online, and e-com. presence. Collaboration with Shoe Spa that provides repair, restoration, and revitalizing services. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Digital merchandising solutions and customized offerings lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Charlotte Chesnais	Apr. 2021	France	1. Luxury jewelry designer brand that specializes in crafting handmade and timeless designs. With PS, online and e-com. presence. Its creativity represents both jewelry and sculpture i.e., wearable art. It also collaborates with other leading designers. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Digital merchandising solutions and customized offerings lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Christopher Kane	May 2021	UK	1. Luxury apparel brand offers ready-to-wear, customized, and on-demand apparel. With online, PS, and e-com. presence, its patent leather embroidered dresses lead to international success. Collaborated with Far fetch white label e-com. platform. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Its customized services, and rush order features lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Costa Brazil	Dec. 2020	USA	1. Eco-friendly beauty and skincare products inspired by Brazilian nature and Amazon rain forests where beauty is viewed and felt. With online, PS, and e-com. presence, it also collaborates with multi-brand retailers. Acquired by biotech company Amyris provided Costa Brazil resources for global business expansion. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Digital merchandising solutions lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
CVC Stones	2021	USA	1. Since jewelry is a major product, CVC Stones doesn't sell apparel. With online, PS, and e-com. presence, it specializes in hand-crafted diamond and gold jewelry. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Digital merchandising solutions lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Deveaux New York	2021	USA	1. Ready-to-wear luxury apparel brand. With online, PS, and e-com. presence, it also collaborates with multi-brand retailers. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Digital merchandising solutions lead to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
Dundas	2021	UK	1 Luxury apparel, jewelry, and accessories brand famous for celebrity designer. With online, PS, and e-com. presence, its major sales channels are outlets, boutiques, and different e-com. platforms. It follows the non-season structure of timeless capsule collections. 2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching. 3. Virtual try-on, and digital merchandising solutions lead to Amazon's ODM, thereby co-evolution among *s,* luxury brands, and ODM can be expected.
Epara	Dec. 2020	UK	1. Based on skincare products, Epara does not sell apparel. With online, PS, and e-com. presence, its major sales channels are outlets, boutiques, and several e-com. platforms such as, The Conservatory. Epara finds its roots in Nigerian dialect, the very first luxury skincare brand specifically created for women of color. Its online presence is limited.

[101] leading to accelerating the above three streams and enhancing the feasibility of ODM for apparel through synchronizing of these streams.

4.4. Co-evolution among ADF businesses, luxury brands and ODM

Benefits of ODM increase as digital innovation advances, leading to providing a sustainability base, particularly to luxury brands working toward a non-contact society where customers are moving from physical channels to digital channels.

Thus, advanced ODM steadily contributes to transforming the resistance of luxury brands to collaborate with Amazon into a sustainable opportunity against a non-contact society. This, in turn, provides manufacturing industry digital solutions, advanced logistics and funding capabilities initiated by Amazon. Thus, co-evolution among *ADFs*,

Table 6 (*continued*)

2 Development of Luxury Stores (2) – 24 Luxury Brands joined by June 2021

Brands	Time of launch	Label	Prospect of omnichannel
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Fabrizio Viti	May. 2021	UK	1. Specializes in creating timeless women's footwear and handbags with the ambition of classical elegance with a real attitude. With online, PS, and e-com. presence, it does not sell apparel.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
For Restless Sleepers	2021	Italy	1. Offers luxury ready-to-wear apparel. With online, PS, and e-com. presence, it also collaborates with multi-brand retailers and e-com. platforms. The brand storytelling reflects the conversion of sleepwear into luxury for restless hours while staying home during a pandemic.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Heraux	Dec. 2020	USA	1. Luxury skincare brand that specializes in stem cell biology R&D its core HX-1 technology. With online, PS, and e-com. presence, it doesn't sell apparel. It specializes in skin inflammation solutions.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Jonathan Cohen	2021	USA	1. Women's ready-to-wear luxury apparel brand. With online, PS and e-com. presence, its apparel and accessories represent the transformation and imaginative creation.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. It also provides customization and curation services that lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
La Bouche Rouge	Apr. 2021	France	1. Women's luxury cosmetics brand. With online, PS, and e-com. presence, the brand is reintroducing the cosmetics industry to traditional hand-made and French craftsmanship. It focuses on the use of recycled and upcycled materials.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Its luxurious, and refillable leather cases made from sustainable upcycled materials lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
L/Uniform	Apr. 2021	France	1 L/Uniform is a luxury accessories manufacturer, ranging from ready to use and customization services i.e., on demand printing. With online, PS, and e-com. presence, bags, and accessories are major products made of canvas fabric and leather.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. The use of sustainable textile materials and customization services lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Lumira	Dec. 2020	Australia	1. Luxury niche fragrance brand with online, PS, and e-com. presence.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Marina Moscone	2021	USA	1. Luxury women's ready-to-wear apparel brand reflecting the philosophy of timeless fashion. With online, SM, MM, and e-com. presence.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. It also provides customization and curation services that lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
MATEO New York	2021	USA	1. Specializes in men's jewelry representing Jamaican heritage. With online, PS, and e.com. presence, products are sold in well-known retailers such as, Net A Porter, Matches Fashion, Browns, Far Fetch, 1stDibs etc.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. It also provides customization and curation services that lead to Amazon's ODM, thereby co-evolution among *ADFs,* luxury brands, and ODM can be expected.
Missoni	May. 2021	Italy	1 Luxury apparel brand offers ready to wear, and customized apparel. With online, PS and e-com. presence, it also collaborates with multi brand retailers.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.

Table 6 (*continued*)

2 Development of Luxury Stores (2) – 24 Luxury Brands joined by June 2021

Brands	Time of launch	Label	Prospect of omnichannel
			3. The use of sustainable textile materials, and customization services lead to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
Nomad NOE	Dec. 2020	USA	1. Luxury fragrance brand that specializes in fragrance oils and candles. With online, PS, and e.com. presence it also collaborates with multi-brand retailers.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. The use of sustainable textile materials and customization services lead to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
Rodarte	2021	USA	1. Luxury ready to wear apparel and accessories brand. It also provides customization services. With online, PS, and e-com. presence, it also collaborates with multi-brand retailers.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. It also provides customization and curation services lead to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
ROSE 1845	Dec. 2020	USA	1. Luxury fragrance brand. It does not sell apparel. With online, PS, and e-com. presence, it collaborates with multiband retailers. It represents the craft of Paris with the storytelling of Los Angeles.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Satisfaction of individual customers' needs leads to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
Royal Fern	Dec. 2020	Germany	1. Plant powdered luxury skincare brand. With online, PS, and e-com. presence, it does not sell apparel.
			2. By utilizing *ADFs* experience, Amazon will provide increased visibility, digital-merchandising solutions to personalize brands' content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching in broader apparel businesses.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
The Harmonist	2021	France	1. The harmonist is a fragrance brand. It does not sell apparel. With online, PS, and e-com. presence, it collaborates with multiband retailers. It represents the craft of Paris with the storytelling of Los Angeles.
			2. By utilizing *ADFs* experiences, Amazon will provide customers with a fully integrated online experience, digital merchandising tools with 360-visualization technology, global presence, virtual storefronts, and free and fast delivery 24/7 cs. leading to seamless switching.
			3. Satisfaction of individual customers' needs leads to Amazon's ODM, thereby co-evolution among *ADFs*, luxury brands, and ODM can be expected.
Votary	Dec. 2020	UK	Luxury skincare brand. With online, PS, and e-com. presence, it does not sell apparel.
			2. By utilizing *ADFs* experience, Amazon will provide increased visibility, digital-merchandising solutions to personalize brands' content, international presence, virtual storefronts creation, multiple touchpoints, and free and fast delivery 24/7cs. leading to seamless switching in broader apparel businesses.
			3. Amazon's digital merchandising solutions and satisfaction of customer's needs lead to Amazon's ODM, thereby co-evolution among ADF, luxury brands, and ODM can be expected.

PS: Physical store, e-com.: e-commerce, SM: social media, MM: media mix.
360-degree view technology: Amazon introduced view in 360 technology in 2018 to millions of sellers around the world. This technology improved product visualization that resulted in improved revenues, improved customers satisfaction, and reduced product returns [76].

luxury brands, and ODM can be constructed, as illustrated in the right-hand side of Fig. 12.

This co-evolution enables Amazon to find an answer to a previously impossible conundrum to solve "the Internet dilemma" [7] as reviewed earlier. The solution that emerges is a cloud-based fashion platform where *ADFs*, luxury brands, and all sales channels are integrated in one place. This enables personalization and customization by way of seamless switching on an on-demand basis. Consequently, big data on customers, vendors, manufactures, global influencers, and social trends can be collected, which advance AWS's function by enjoying learning orchestration externality. AWS, as computational science infrastructure, grows and expands by learning digital advancement initiated by the preceding endeavors [3,102,103]. Advanced AWS, in turn, further accelerates co-evolution among *ADFs*, luxury brands, and ODM. Activated co-evolution further advances cloud-based fashion platforms leading to a virtuous cycle between them. Thus, dual co-evolution between the foregoing co-evolution among *ADFs*, luxury brands and ODM, and cloud-based fashion platform advancement is emerged as illustrated in the left-hand side of Fig. 12.

Through the course of this dual-co-evolution, a "chasing game" between luxury brands' exclusivity seeking and Amazon's mass-customization seeking will continue, similar to an inferior mirage as

an increasing number of customers seek exclusive value [32,104]. Inferior mirage is a phenomenon in which it looks like there are superior mirages in the distance ahead under the scorching sun due to different refractive indices [105,106]. In trying to get closer, it looks like the mirages are moving together and cannot be caught up no matter how much the effort to chase them intensifies, as illustrated in Fig. 13.

This chasing game leads to a supra-omnichannel approach that enables apparel to grow seamless switching. Blanckenberg [108] pointed out that "Already the most significant e-commerce niche, the online apparel industry is growing at an incredible rate. This growth means online clothing stores need to constantly evolve in terms of trend shifts, technology and market changes, and emerging markets."

Seamless switching among multi-channels grows both quantitively and qualitatively as this chasing game activates.[6] This growing seamless switching is anticipated by the analysis in section 3 on the *ADFs'* AI-driven development trajectory demonstrating self-propagating development (Table 1). With growing and expanding function, AWS plays a core role in this dynamism [103]. The result is like running a small laboratory for Amazon [3].

By means of SWOT analysis, Table 8 demonstrates the significance of growing seamless switching expected to be realized by synchronizing *ADFs*, luxury brands, and ODM as follows:
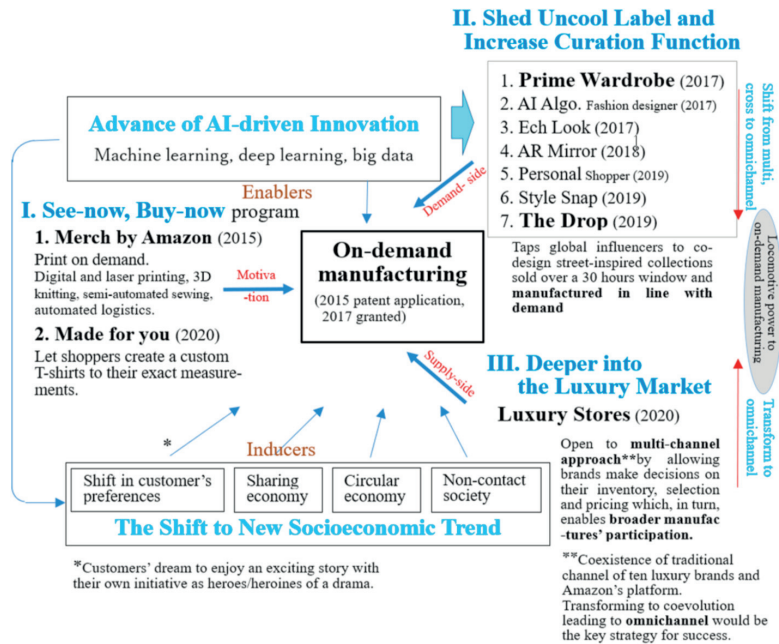
Fig. 11. Amazon's three-dimensional streams toward on-demand manufacturing.

Table 7
SWOT analyses of Amazon's *ADFs* and Luxury Stores.

7–1 *ADFs*	
Strengths	**Weaknesses**
1. Effective development and utilization of core assets such as AWS, AI, big data, and omnichannel approach. 2. Maximizing learning orchestration externality. 3. Improving curation system function for developing customer's ability. 4. Intensifying density of omnichannel dependence by enriching functions as ADF advance. 5. Developing a function of a testbed for Luxury Stores and ODM. 6. Amazon Prime with free shipping and returns, 24/7cs. 7. Advancement in customization and personalization technologies and improvements in AR/VR, virtual try-on, and virtual personal assistants.	1. Only for Amazon Prime subscribers. 2. Limited involvement of luxury brands. 3. Dependence on growing third-party sellers.
Opportunities	**Threats**
1. Co-evolution with involving luxury brands. 2. Self-learning technologies as a frontier of innovations. 3. On-demand apparel manufacturing. 4. Development of ML algorithms for trends, patterns, and design search. 5. Flexible supply chain.	1. Stagnation of apparel demand in a non-contact society 2. Rapidly evolving data analytics techniques. 3. Pioneer competitors such as Stitch fix and Trunk Club. 4. Saturation of new growth.

| 7–2 Luxury Stores in 2020	
Strengths	**Weaknesses**
1. Non contact sales. 2. Exploration of sales and distribution routes. 3. Strategic alliances and partnerships with luxury brands. 4. Mass customization and personalization. 5. Fast delivery with free shipping and returns policy. 6. Amazon Prime with free shipping and returns, 24/7cs. 7. Presentation of Luxury Stores in a protected environment. 8. Product visualization in 360-degree view.	1. Co-exist without seamless switching. 2. Absence of fashion physical stores. 3. Counterfeits and mistrust due to improper regulation of unauthorized third-party sellers. 4. Absence of higher end luxury brands.
Opportunities	**Threats**
1. Potential to transform from co-existence to co-evolution. 2. Effective utilization of sophisticated merchandising tools, customers database and AWS for customer preferences analysis and learning. 3. **ML based brand registry and transparency systems for overcoming counterfeit misuse, and mistrust issues.** 4. **On demand apparel manufacturing.** 5. Digital tangibilization of luxury. 6. Personalized product assortment and content delivery.	1. Increase in counterfeit issues caused by the third-party sellers. 2. Growing price competition and other luxury focused e-com platforms such as Farfetch etc. 3. Resistance against Amazon's control over brands inventories, prices, and commissions.
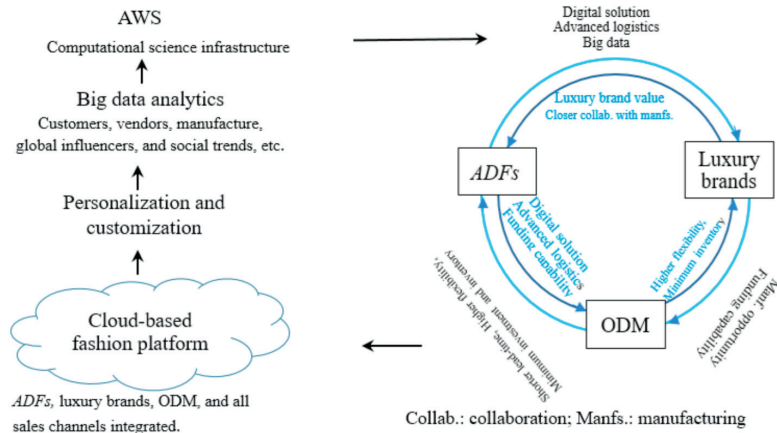
Fig. 12. Dual co-evolution among *ADFs*, luxury brands, ODM co-evolution, and cloud-based fashion platform advancement.

Table 8
SWOT analysis -after synchronization of *ADFs*, luxury stores and ODM.

Strengths	Weaknesses
1. Synergies among *ADFs*, luxury brands, and ODM. 2. Seamless switching among a growing variety of channels. 3. Digital solution to the historical demand, shifting to sharing economy and circular economy. 4. Design-driven thinking leads to design-driven innovations. 5. Digital tools to identify the best and worst selling items. 6. Data collection and analysis through multiple on and offline touch points.	1. Untimely countermeasures to shedding Amazon's image of brand cannibalization.
Opportunities	**Threats**
1. Cloud –based fashion platform, big data analytics, and AWS. 2. **On-demand basis personalization and customization.** 3. **Learning orchestration externality that advances AWS.** 4. Dual co-evolution between cloud-based fashion platform, and co-evolution among ADF, luxury brands, and ODM. 5. Supra-omnichannel approach that enables growing seamless switching. 6. Explore new frontiers tr explores new frontiers beyond current business models. 7. Decisions based on BD analytics. 8. Open innovation with new resources for more innovations.	1. Unexpected shift in customers' preferences. 2. Emergence of new luxury brand platforms beyond foresight.

(i) Through the synchronization, seamless switching among growing variety of channels can be expected [11,15,16] leading to a digital solution to the historical demand, shifting to a sharing economy, and circular economy [26,109,110].

(ii) While this synchronization depends on the construction of co-evolution among *ADFs*, luxury brands, and ODM, untimely countermeasures to shedding Amazon's image of brand cannibalization can be its structural weakness [27,111].

(iii) However, this weakness can be a springboard for constructing dual co-evolution between cloud-based fashion platforms and co-

evolution among *ADFs*, luxury brands, and ODM which induces further innovation toward growing seamless switching that explores new frontiers beyond current business models [9,10,75, 112].

(iv) It should be noted that unexpected shifts in customers' preferences and the emergence of new luxury brand platforms beyond foresight could be fatal threats in the fashion business [26,113].

5. Conclusion

In light of the increasing shift to explore a new frontier beyond current business models toward a non-contact society after COVID-19, and Amazon's ambitious attempt to pursue this exploration in digital fashion (including luxury brands) by utilizing its innovative assets, this paper attempted to demonstrate the significance and credibility of this endeavor by explaining its dynamism.

An empirical analysis was conducted focusing on the development trajectories of Amazon's development of a series of seven *ADFs* businesses over the period 2017–19 as well as 34 luxury brands that joined its Luxury Stores in 2020/2021, together with possible application of its patented ODM by using techno-economic analysis, an analogical evidence approach, literature review, and SWOT analysis.

While COVID-19 has caused a significant decline in sales, the apparel industry was undergoing digital solution-oriented transformations even before the crisis. Preempting its highly profitable potential, Amazon has been expanding its fashion-driven apparel business by developing series
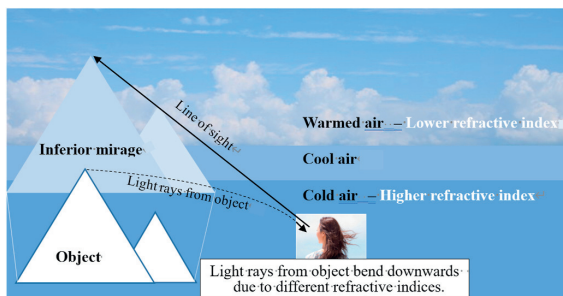

Fig. 13. Scheme of a chasing game in the inferior mirage.
Source: Authors' elaboration based on Brittain [107].

of *ADFs* businesses that intensified omnichannel dependence based on seamless switching by utilizing its innovative assets such as AWS, AI, big data, and maximizing learning orchestration externality.

With this development, and in response to the increasing necessity for luxury brands to provide extra channels for a non-contact society, Amazon introduced a long-lasting digital platform for luxury fashion, Luxury Stores in September 2020.

While seamless switching expects the consistent availability of products and services on all available channels, luxury brands confront "the Internet dilemma," which is the reluctance to integrate online technologies into their business model, leading to the reluctance to collaborate with Amazon.

Benefits of ODM increase as digital innovation advances leading to providing a sustainability base, particularly to luxury brands toward a non-contact society. Thus, ODM contributes to transforming the reluctance of luxury brands into a sustainable opportunity to operate in a non-contact society. This in turn provides manufacturing industry digital solutions, advanced logistics, and funding capabilities.

Thus, co-evolution among *ADFs*, luxury brands, and ODM can be constructed. This co-evolution led to the emergence of a cloud-based fashion platform where *ADFs* and luxury brands are integrated in one place, enabling on-demand basis personalization and customization by way of seamless switching.

Consequently, big data on customers, vendors, manufacturers, global influencers, and social trends can be collected, which advance AWS's function by enjoying learning orchestration externality. AWS, as computational science infrastructure, grows and expands by learning. This in turn further accelerates co-evolution among *ADFs,* luxury brands, and ODM.

Activated co-evolution further advances cloud-based fashion platforms, leading to a virtuous cycle between them. Thus, dual co-evolution between the co-evolution among *ADFs*, luxury brands, and ODM, and cloud-based fashion platform advancement is emerged.

This dual-co-evolution leads to a supra-omnichannel approach that enables apparel growing seamless switching and explores new frontiers beyond current business models. The development trajectory of *ADFs* with self-propagating growth supports this expectation to growing seamless switching.

These findings give rise to the following insights for exploring a new

frontier beyond current business models toward a non-contact society after COVID-19:

(i) Taking COVID-19 as a springboard for the apparel industry to transform and advance digital fashion, luxury brands, and ODM should be accelerated by complementing their respective strengths and using the effects of learning orchestration externality.

(ii) Synchronization should be endeavored for co-evolution among them.

(iii) The supra-omnichannel approach should be broadly applied to other product and service categories.

(iv) Growing seamless switching should be further developed in the broad fields expecting to embrace the novel concept of R&D that embeds a growth characteristic during an R&D process.

(v) Resilient business strategies for sustainable growth in a new normal state beyond COVID-19 should be sought by incorporating a growing seamless switching function.

Limitations of this research include focusing solely on Amazon with a limited number of statistical data and indirect evidence to analogical evidence approaches.

Following the further advancement of Amazon's Luxury Stores and ODM, future research should focus on in-depth explanation, conceptualization and operationalization of the functions that the above dynamism leads to explore new frontiers for the apparel industry beyond current business models.

Comparative analysis of the similarity and disparity of the supra-omnichannel approach that enables growing seamless switching in other industries should be also undertaken with a priority basis.

Acknowledgements

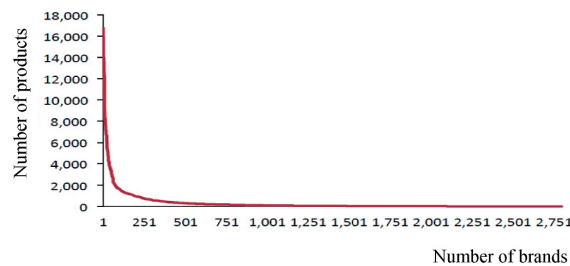### Appendix

Appendix 1. Data Construction

Fig. A1. Correlation between Number of Brands and Number of Clothing Products Listed in Amazon Fashion (2018). Source: Coresight Research [29].

Table A1
Trend in Amazon's Sales by Product Group (2014–2019)

	Online stores	Physical stores	Third-party seller services	Subscription services	AWS	Other	Net sales	Apparel sales
2014	68.5 (77.0)	–	11.8 (13.3)	2.8 (3.1)	4.6 (5.2)	1.3 (1.5)	**89.0**	10.7 (12.0)
2015	76.9 (71.9)	–	16.1 (15.0)	4.5 (4.2)	7.9 (7.4)	1.7 (1.6)	**107.0**	12.0 (11.2)
2016	91.4 (67.2)	–	23.0 (16.9)	6.4 (4.7)	12.2 (9.0)	3.0 (2.2)	**136.0**	17.8 (13.1)
2017	108.4 (60.9)	5.8 (3.3)	31.9 (17.9)	9.7 (5.5)	17.5 (9.8)	4.7 (2.6)	**177.9**	39.3 (22.1)
2018	123.0 (52.8)	17.2 (7.4)	42.7 (18.3)	14.2 (6.1)	25.7 (11.0)	10.1 (4.3)	**232.9**	44.8 (19.2)
2019	141.2 (50.3)	17.2 (6.1)	53.8 (19.2)	19.2 (6.8)	35.0 (12.5)	14.1 (5.0)	**280.5**	50.7 (18.1)
2020	197.4 (51.1)	16.2 (4.2)	80.5 (20.8)	25.2 (6.5)	45.4 (11.8)	21.5 (5.6)	**386.1**	60.1 (15.6)

Figures in parentheses indicate the share (%).
Apparel sales were estimated as follows.
[(Apparel sales in the US) × (Amazon's apparel share in the US)] × [(Amazon's global market)/(US market sales)].
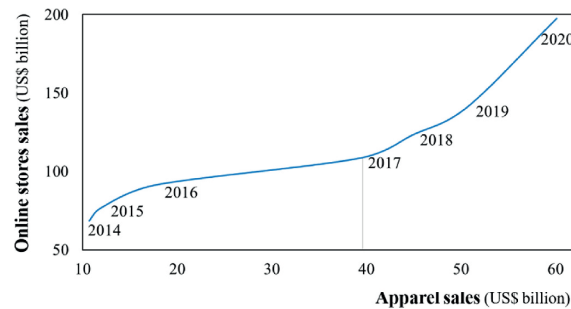Original sources: Statista [114].

Fig. A2. Correlation between Apparel Sales and Online Store Sales in Amazon (2014–2020).
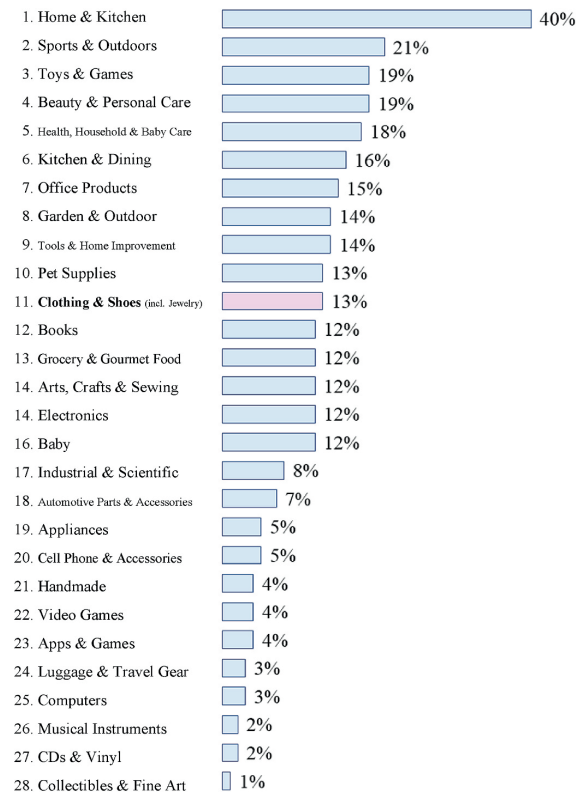Source: Same as Table A2.

Fig. A3. Popularity of Product Categories in Amazon's Third-party Seller Services (2020) - % of sellers listed in the third-party seller services. *Sellers could select multiple categories.
Source: Authors' elaboration based on Jungle Scout [115].

Table A2
Trend in Amazon's Apparel Sales Share in the US (Jan. 2014–Dec. 2019)

1	201401	2.43
2	201402	2.47
3	201403	2.5
4	201404	2.53
5	201405	2.57
6	201406	2.6
7	201407	2.62
8	201408	2.63
9	201409	2.65
10	201410	2.7
11	201411	2.75
12	201412	2.8
13	201501	2.83
14	201502	2.86
15	201503	2.9
16	201504	2.93
17	201505	2.97
18	201506	3
19	201507	3.03
20	201508	3.07
21	201509	3.1
22	201510	3.13
23	201511	3.17
24	201512	3.2
25	201601	3.23
26	201602	3.27
27	201603	3.3
28	201604	3.32
29	201605	3.33
30	201606	3.35
31	201607	3.4
32	201608	3.45
33	201609	3.5
34	201610	3.57
35	201611	3.63
36	201612	3.7
37	201701	3.88
38	201702	4.07
39	201703	4.25
40	201704	4.63
41	201705	5.02
42	201706	5.4
43	201707	5.87
44	201708	6.33
45	201709	6.8
46	201710	7.17
47	201711	7.53
48	201712	7.9
49	201801	8
50	201802	8.1
51	201803	8.2
52	201804	8.27
53	201805	8.33
54	201806	8.4
55	201807	8.45
56	201808	8.5
57	201809	8.55
58	201810	8.6
59	201811	8.65
60	201812	8.7
61	201901	8.78
62	201902	8.87
63	201903	8.95
64	201904	9.02
65	201905	9.08
66	201906	9.15
67	201907	9.2
68	201908	9.25
69	201909	9.3
70	201910	9.37
71	201911	9.43
72	201912	9.5

Original sources: Lieber [34]; Statista [35]; Keyes [36]; PYMNTS [39]; Sabanoglu [40].
Annual data were disaggregated to monthly data by

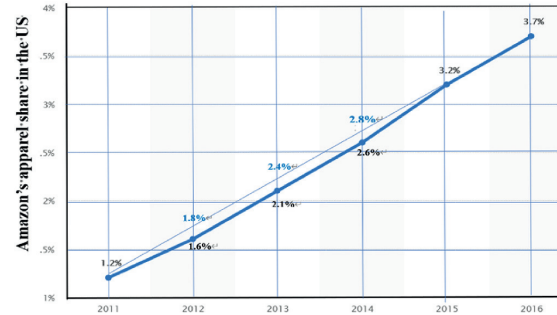using the Denton-Cholette temporal disaggregation method.

Fig. A4. US Amazon Share of Total Apparel Sales from 2011 to 2016. Estimates of the earlier stage before A*DFs* (2011–2016) were based on Lieber [34] and Sabanoglu [40]. Bold line is based on Sabanoglu [40] ,[7] while thin line is authors' modified estimate for 2012–2014 based on Lieber [34] .[8]

Appendix 2. Development Trajectory of Amazon's Fashion-driven Apparel

ICT in which network externalities function to alter the correlation between innovations and institutional systems - which creates new features of the innovation leading to exponential increase. Schelling [116] portrayed an array of logistically developing and diffusing social mechanisms stimulated by these interactions. The advancement of the digital innovation centered on Internet and AI further stimulates these interactions and accelerates ICT's logistically developing and diffusing feature, which is typically traced by the sigmoid curve [44].

Given the logistic growth nature of Amazon's AI-driven digital fashion development, its development trajectory, proxied by apparel sales share in the US, $S(t)$, can be depicted by the following epidemic function that leads to a simple logistic growth function (*SLG*):

$$\frac{dS}{dt} = aS\left(1 - \frac{S}{N}\right) \tag{A1}$$

$$\text{SLG} = S(t) = \frac{N}{1 + be^{-at}} \tag{A2}$$

where t: time; N: carrying capacity; a: velocity of diffusion; b: coefficient indicating the initial level of diffusion.

As far as the development trajectory depends on the *SLG* trajectory, its digital value, $S(t)$, saturates with the fixed upper limit N. However, once the trajectory shifts to logistic growth within a dynamic carrying capacity (*LGDCC*), its digital value, $S(t)$, can continue to increase, as it creates a new carrying capacity during the process of development.

In particular innovation which creates new carrying capacity $N(t)$ during the diffusion process, equation (A1) is developed as follows:

$$\frac{dS(t)}{dt} = a\,S\left(t\right)\left(1 - \frac{S(t)}{N(t)}\right) \tag{A3}$$

Equation (A3) develops the following *LGDCC* function (A4) which incorporates self-propagating function as carrying capacity increases corresponding to $S(t)$ increase as depicted in equation (A5) [44]:

$$S(t) = \frac{N_k}{1 + be^{-aR} + \frac{b_k}{1 - a_k/a}e^{-a_k R}} \tag{A4}$$

where N_k: ultimate carrying capacity; a, b, a_k, and b_k: coefficients.

Dynamic carrying capacity $N(t)$ in this *LGDCC* is depicted as follows:

$$N(t) = S\left(t\right)\left(\frac{1}{1 - \frac{1}{a}\frac{\triangle S(t)}{S(t)}}\right) \quad \triangle S(t) = \frac{dS(t)}{dt} \tag{A5}$$

While Amazon's apparel sales have been leveraged by advanced digital fashion development (ADF) by creating new functionality as enhancing carrying capacity, this trajectory (trajectory B in Fig. 5) can be traced by *LGDCC*, this trajectory would have been remained *SLG* without ADF (trajectory A in Fig. 5).

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[7] 1.6% in 2012, doubled by 2015 reaching 3.2%, and accounted for 3.7% in 2016.

[8] In 2011, Amazon debuted the membership-based flash-sale site MyHabit, a move to directly compete with Gilt Groupe, introduced the contemporary menswear website in the fall of 2013. That same year, photo studio in Brooklyn opened, The Amazon Fashion project was in full swing — because despite all of his high-profile launches and acquisitions, Bezos realized that building out a dedicated fashion space on Amazon was the only way to truly maximize profits. Amazon's clothing and accessories sales nearly quadrupled from $4.3 bil. in 2011 to $16.4 bil. in 2015.

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IV

A NEW PERSPECTIVE OF INNOVATION TOWARD A NON-CONTACT SOCIETY: AMAZON'S INITIATIVE IN PIONEERING GROWING SEAMLESS SWITCHING

by

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A new perspective of innovation toward a non-contact society - Amazon's initiative in pioneering growing seamless switching

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A B S T R A C T

This paper elucidates the inside of the black box of Amazon's unique research and development (R&D) dynamism that made it the world's top R&D leader by transforming "routine or periodic alterations" into "significant improvement" during the R&D process. This dynamism also succeeded in transforming the COVID-19 pandemic period into a springboard for new innovation, leading to Amazon's notable growth notwithstanding the pandemic.

An empirical analysis using a techno-economic approach focusing on Amazon's endeavor to develop a series of advanced digital fashions (ADFs) and online-based luxury brands (neo-luxury) before and during the COVID-19 pandemic was conducted.

Amazon became a global apparel leader based on learning orchestration externality through developing a series of ADFs that emerged co-evolution with neo-luxury corresponding to the cultural shift to a new age of meaning. The focal driver of design-driven innovation is meaning, and meaning-seeking innovation emerges as a self-propagating generative function.

Amazon has been advancing Amazon Web Services (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 in one place.

Given the common key function, the self-propagating generative function, AWS, and neo-luxury resonate and induce co-evolution between them. This co-evolution emerges as growing seamless switching. Thus, a new perspective of innovation toward a non-contact society can be explored.

This paper aims to reveal a theoretical and empirical demonstration of this dynamism, which gives rise to insights for pioneering a new frontier beyond current business models toward a non-contact society after the COVID-19 pandemic ends.

1. Introduction

Amazon has become a global research and development (R&D) leader by demonstrating leading world-class R&D investment and experiencing subsequent jumps in market value. The COVID-19 pandemic accelerated this steep increase by transforming the crisis into a springboard for new innovation. All of this can be attributed to Amazon's unique R&D model. In light of the increasing concern about this mystery, the goal of this paper is to elucidate the inside of the black box of this unique R&D dynamism.

To date, a significant number of studies have attempted to analyze

Amazon's notable performance and unique business model [1–4]. However, many of the drivers of this dynamism have remained veiled.

In previous studies, scholars endeavored to clarify Amazon's orchestration of techno-financing systems that led to stakeholder capitalization and identified the following notable dynamism [5–8]:

(i) Amazon attempts to make customer-centric R&D-driven advancement the basis of the platform's business model.
(ii) With this business model, Amazon has strived for pioneering innovation and company-wide experimentation to achieve empire growth and a subsequent big data collection system.

(iii) This leads to notable interaction with users for user-driven innovation based on an architecture of participation, as well as high-level assimilation capacity based on rapidly increasing R&D investment.

(iv) This enables Amazon to harness the power of users who seek soft innovation resources (SIRs),[1] which functions as a virtuous cycle leading to the transformation of "routine or periodic alterations" into "significant improvement" during the R&D process.

(v) These systems are considered a source that enables Amazon to deploy successful neo-open innovation, which leads to its outstanding accomplishments in R&D and increases in sales by overcoming the dilemma between them.

(vi) This deployment has been enabled by fusing a unique R&D system and a sophisticated financing system centered on cash conversion cycle-driven free cash flow management.

(vii) With this orchestration of R&D and financing, Amazon leverages the expectations of a wide range of stakeholders by providing supra-functionality beyond the economic value that corresponds to a shift in consumer preferences and takes the initiative of stakeholder capitalism in which stakeholders bet on the platform's prospects driven by aggressive R&D.

(viii) Consequently, a notable virtuous cycle is constructed: *user-driven innovation → advancement of the Internet → awakening, and inducement of SIRs in a marketplace → increase in gross R&D → solid growth → activation of self-propagating function → emergence of supra-functionality beyond economic value → acceleration of user-driven innovation.*

Inspired by these findings, the authors further identified that the key enabler of this virtuous cycle is Amazon's unique identical R&D model that transforms "routine or periodic alterations" into "significant improvement" during its R&D process and that this unique transformation-seeking R&D model plays a significant role in generating a spinoff co-evolution that creates a "great co-evolution" with digital innovation and shifts to new socioeconomic trends such as the sharing economy, the circular economy, and a non-contact society. This "great co-evolution" induces disruptive business models that cause the emergence of disruptive innovation by harnessing the vigor of activated SIRs [9].

Given the pivotal role of this unique R&D model, intending to further conceptualize and operationalize this model, the authors conducted an in-depth analysis of the development trajectory of Amazon's artificial intelligence (AI)-driven advanced digital fashions (ADFs) and luxury brands, as Amazon has been expanding its fashion-driven apparel business on a priority basis by preempting its highly profitable potential [10]. They postulated that the dual co-evolution between ADFs and luxury brands' co-evolution and the AWS-initiated cloud-based fashion platform leads to a supra-omnichannel approach that enables growing seamless switching of apparel [11]. Because of this postulate, growing seamless switching is expected to innovate new frontiers beyond current business models and give rise to insights for pioneering a new frontier beyond current business models toward a non-contact society after the COVID-19 pandemic ends, further theoretical and empirical demonstration of this switching dynamism was performed in this paper.

Using techno-economic analysis and intensive literature reviews, an empirical analysis was conducted focusing on the development trajectories of Amazon's series of ADFs and luxury brands before and during the COVID-19 pandemic. Special attention was paid to the structural change in external circumstances affecting the management of the development trajectories derived from the unexpected COVID-19 pandemic.

The authors identified that because of learning orchestration externality Amazon increased its apparel sales while maintaining balanced growth in online sales dependence. This can be attributed to Amazon's homeostasis management strategy, which is essential for its customer-centric business principle. This principle urges Amazon to seek not only economic value but also socio-political balance, including a rich assortment despite low profitability to satisfy a variety of consumer demands and protect weak suppliers.

The unexpected COVID-19 pandemic has effected a structural change by stagnating apparel demand while leveraging demand for online-based luxury brands in corresponding to the cultural shift to the age of new meaning.

We are reminded of the significance of design-driven innovation that stressed the significance of a third strategy of having a vision and driving new meaning by delivering the vision to customers, in addition to technology-push and market-pull innovation [12]. Design thinking includes a series of iterative activities [13], in which the output of each process is fed back to the previous processes [14]. Given that design is a means of speculation about a future vision [15], the future vision leads to new innovation with feedback about the current action; thus, a self-propagating generative function can emerge.

This dynamism prompted the authors to postulate that online-based luxury brands that correspond to a cultural shift to the age of new meaning incorporate self-propagating generative functions.

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 in one place [16–18].

Given the common key function (the self-propagating generative function) that AWS and neo-luxury share, both resonate [19] and induce co-evolution between them. Due to this co-evolution, growing seamless switching emerges.

Thus, the authors investigated this topic and the paper show that Amazon succeeded in AI-driven innovation. AI advancement removed the limitations of scale, scope, and learning that enabled effective utilization of learning orchestration externality, which leveraged an iterative design process. Through this process, learning effects were fed back to the input and evolved design artifacts that had a vision and drove new meaning by delivering the vision to customers and reinforced the emergence of sustainable innovation, leading to self-propagating development. This resonated with AWS advancement that incorporates a self-propagating generative function and led to sustainable growth with expanding omnichannel; thus, a supra-omnichannel with growing seamless switching can emerge.

In addition to these findings, this paper contributes to the literature by revealing the inside of the black box of Amazon's unique business model, on which the majority of information has been kept private. Consequently, broken logic can be linked, plausible logic can be constructed, and a new demonstration can be expected.

These findings give rise to suggestions regarding a new perspective of innovation toward a non-contact society.

The paper is organized as follows: Section 2 provides an overview of Amazon's development of ADFs. Section 3 analyzes the contribution of apparel to Amazon's position as a global digital leader and its limit. Section 4 examines structural change toward a non-contact society. Section 5 proposes harnessing the vigor of meaning by shedding light on design-driven innovation. Section 6 summarizes notable findings, policy suggestions, and future research.

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[1] SIRs are latent innovation resources in the digital economy that can be awoken and activated by deploying an information and communication technology (ICT)-driven disruptive business model with the consolidated challenge for social demand. The activation possibility of SIRs can be attributed to ICT's native self-propagating nature.SIRs are considered condensates and crystals of the advancement of the Internet and consist of Internet-based resources that have either been sleeping, been untapped, or are the results of multisided interactions in the markets where consumers are looking for functionality beyond economic value.

2. New challenge to Advanced Digital Fashion Development

2.1. Trajectory management

2.1.1. Optimal balance between assortment and higher value

2.1.1.1. Higher value by first-party initiative.
Given the prospective future of the fast fashion industry with a high level of elasticity of income and apparel, as illustrated in Fig. 1, Amazon attempted to increase sales of the fashion industry by its own initiative.

However, this strategy was not successful in increasing revenues (sales). Part of the problem was the e-commerce brand's image. Despite conquering most of retail and selling a lot of clothes, Amazon has consistently struggled to sell fashion. The company's quest to dominate the fashion industry has faced several historical obstacles, 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 [10].

After this experience, Amazon focused on changing its image to that of a cool brand. The company focused its first-party clothing inventory on higher-value categories, and most of the private labels tend to be clustered in specific clothing categories [20].

A series of ADFs have been developed since 2017 on a priority basis, as shown in Table 1. Based on this approach, in contrast to the limited number of products, a significant contribution to sales has been initiated by first-party sellers dependent on online sales, as shown in Fig. 2. Thus, Amazon has been able to shed its uncool image and increase its sales significantly by maintaining its online sales leader position.

In addition to enjoying AI-driven sophisticated services, shoppers feel greater reassurance regarding product authenticity, shipping charges for returns, and return policies than when buying from third-party sellers. Thus, larger first-party inventory would increase customer satisfaction. Furthermore, the growth of online clothing stores' leverage constantly evolves in terms of trend shifts, technology and market changes, and emerging new markets [23].

2.1.1.2. Five socio-political dimensions beyond economic value.
Although such an advantage of first-party sellers through online sales growth, a certain number of third-party seller sales is indispensable to maintain a variety of apparel products for demanding customers and to strengthen the close relationship with brands. Therefore, careful attention to the balance between apparel sales growth and dependence on online sales is critical for Amazon to be a customer-centric apparel leader. Although first-party sellers' sales based on online sales are essential for Amazon to increase its own sales, excessive unbalanced dependence on online sales may lose third-party sellers sales that are essential for various products and brands, resulting in a disruption in a resilient supply base that is indispensable to a customer-centric apparel leader.

As a customer-centric global leader, Amazon has been navigating its business model corresponding to the new socio-economic trends. A chronology of the bases of its business model is summarized in Table 2.

With this business strategy, Amazon has been not only seeking to increase economic values but also paying careful attention to balancing the following five socio-political dimensions beyond economic value.

(i) Sufficient assortment for customers' diverse demand

Ramaseshan et al. [24] suggested that innovative tools should be introduced to the firm's business strategies to sustain customer satisfaction and gain long-lasting clientele. For example, to improve the rapid delivery system, Amazon is investing in its logistics technology in developing new delivery channels. This enables a seamless customer experience that raises customers' expectations for instant gratification [25]. Hence, Amazon maintains an intense focus on customer satisfaction and requires participants in the Amazon Marketplace to do the same [26].

(ii) Maintain good relationships with brands

Attracting luxury fashion brands to its platform was Amazon's long-awaited ambition, but the company failed due to its solo-channel approach, selling basic apparel with control over branding, pricing, and discounts. Due to these impediments, luxury fashion brands have been reluctant to collaborate with Amazon [21].

Therefore, maintaining good relationships with as many brands as possible is fundamentally important to attract luxury fashion brands to Amazon's platform.

(iii) Protect weak suppliers

Amazon's apparel offerings continue to be dominated by products offered for sale by third-party merchants. As Amazon builds its fashion offerings through partnerships with brands and the expansion of its private-label offering, one might expect the share of clothing offered by these third-party sellers to decrease. However, items listed by third parties now account for a more significant share of the offering [20]. More than half of the items Amazon sells online come from small businesses. The service lets small businesses offer Prime two-day shipping while the company handles packaging, shipping, and customer service (Rogers, 2017). Amazon is conscious about the policy remedy to combat third-party complaints about product cannibalization (e.g. Ref. [27], and stakeholder capitalism proposed by Business Roundtable in 2019 [8].

(iv) Avoid a monopoly

In response to allegations that Amazon illegally manipulates the e-commerce market to its advantage by penalizing third-party sellers that offer products at lower prices on other platforms [28], Amazon claims that its platform and third-party sellers benefit each other. The fact that third parties have the opportunity to sell alongside a retailer's products is the very competition that most benefits consumers and have made the marketplace model so successful for third-party sellers [29].

(v) Foster sources of customer data and influencers

Amazon maintains a direct relationship with consumers and compiles massive amounts of consumer data. This data poses the risk of
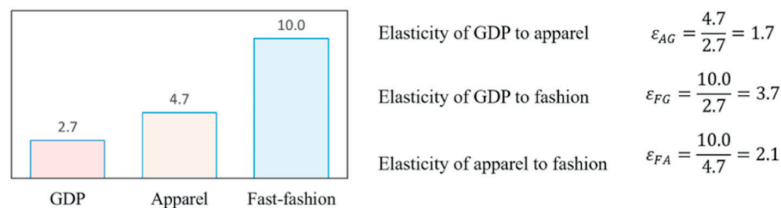

	Elasticity of GDP to apparel	$\varepsilon_{AG} = \dfrac{4.7}{2.7} = 1.7$
	Elasticity of GDP to fashion	$\varepsilon_{FG} = \dfrac{10.0}{2.7} = 3.7$
	Elasticity of apparel to fashion	$\varepsilon_{FA} = \dfrac{10.0}{4.7} = 2.1$

Fig. 1. Comparison of the Growth Rate of the Gross Domestic Product (GDP), Apparel, and the Fashion Industry in the World (2011–2015), % *p.a.*
Source: Watanabe et al. [10].

Table 1
Series of advanced digital fashions (*ADFs*) development in amazon.

Advanced Digital Fashion	Functionality	Lessons from preceding innovation	Assets obtained that transferred to/motivated followers	Core function of AI
1. **Prime Wardrobe** (2017)	Enables customers to try several items at home before purchase.	3D body modeling AI (ML), IoT, VR/AR, mobile devices.	Foundation of the business model to understand customers' need and style preferences.	ML
2. **AI Algo. Fashion designer** (2017)	Provides new items by copying all possible fashion trends.	ML and DL based Generative Adversarial Networks (GAN).	Prospect of machines' capability to design fashion without human supervision.	ML, DL
3. **Echo Look** (2017)	Captures images and short videos of customers wearing the outfits.	Echo, Outfit Compare (share photos), Style Check (second opinion).	Enhanced the skills of ML algorithms in designing and recommending customized outfits. Trained Alexa to become a style assistant	ML, CV, SL, DL
4. **AR Mirror** (2018)	Provides real-time customized recommendation by using virtual clothing.	CV-based Body Labs software.	Accumulated in-depth customer's data, such as 3D visual measurements of body shapes and sophisticated curation ability.	CV, AR, VR
5. **Personal Shopper** (2019)	Provides the subscription-based personalized curated clothing box.	sophisticated curation ability accumulated through series of *ADFs* development.	Secured big customer data on their preferences and improved algorithmic fashion recommendation system thereby. Improved customer loyalty and provided convenience, comfort, and customized fashion.	ML
6. **Style Snap** (2019)	Provides photo-based matching recommendations in real time.	Influencer program.	Enabled to process large data and find best possible matches.	CV, DL
7. **The Drop** (2019)	Allows renowned life-style influencers to co-design with Amazon's designers.	Social media fashion influencers.	Explored a new business model utilizing external innovation resources by co-designing with external designers.	ML

ML: machine learning; *DL*: deep learning; *CV*: computer vision; *SL*: statistical learning; *AR*: augmented reality; *VR*: virtual reality.
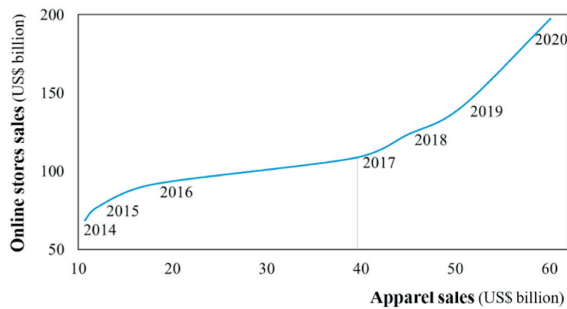Source: Watanabe et al. [21].

Fig. 2. Correlation between Amazon's apparel sales and online store sales (2014–2020).
Source: Statista [22].

Table 2
Chronology of the bases of business model in amazon.

1994	Founded as a one-sided online book retailer
1999	Evolved into multi-sided platformer
1999	Amazon Marketplace: Allow third-party to sell their products on Amazon's platform
2009	Introduced private-label brands (PB)
2013	Earth's most customer-centric company -The lowest environmental impact
2019	Critic of the consolidation of economic power (e.g., Elizabeth Warren) – Care to weak
2019	Stakeholder capitalization (Business Roundtable) – Balanced attention to stakeholders

going off and making products in-house at a lower cost if suppliers do not meet Amazon's toughening standards [30]. This could be the answer to sellers' product cannibalization complaints. Many of Amazon's suppliers will eventually capitulate and deepen their discounts to ensure that they remain an Amazon supplier. This desire to remain with Amazon again circles back to its use of metadata [31]. In addition, influencers have become indispensable to advancing fast fashion. Amazon has been making every effort to foster influencer marketing with Amazon Influencer Program and other social media influencers,

etc. Thus, iterative activities in the third-party market should be maintained.

2.1.2. Homeostasis for optimal ADF development

2.1.2.1. Development trajectory for a cool image. Taking into account the significance of an optimal balance between apparel sales growth and dependence on online sales, Fig. 3 illustrates trends in Amazon's apparel sales share together with its online sales share in the U.S. market over the 2014–2019 period.

Fig. 3 shows that although Amazon steadily increased its apparel sales share in the U.S. market in parallel with the platform's online sales share, the apparel share has increased substantially since 2017. This increase can be attributed to the development of ADFs starting in 2017, with which Amazon has dramatically increased its apparel sales by shedding its uncool image.

Although this success can be attributed to the first-party sellers' online sales initiative, careful attention should have been taken to avoid excessive dependence on online sales that may disrupt third-party sellers that are essential for maintaining the optimal balance among the five socio-political dimensions above.

2.1.2.2. Balance between apparel sales growth and dependence on online sales. To examine the balance between apparel sales growth and dependence on online sales for Amazon to be a customer-centric apparel
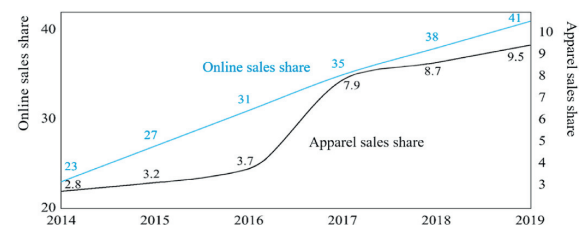

Fig. 3. Trends in Amazon's apparel sales share in the U.S. Market (2014–2019), **percentage**.
Sources: Lieber [32]; Statista [33]; Keyes [34]; Richter [35]; Wichser et al. [36]; PYMNTS [37]. Sabanoglu [38]; eMarketer [39].

leader, the ratio of the apparel sales share, and the online sales share (relative apparel intensity: RAI η) in the U.S. market is traced in Fig. 4.

The RAI (η) can be depicted as follows:

$$\eta = (\text{Apparel sales share}) \Big/ (\text{Online sales share}) = \frac{\frac{A_{Am}}{A_U}}{\frac{O_{Am}}{O_U}} = \frac{\frac{A_{Am}}{O_{Am}}}{\frac{A_U}{O_U}} = \frac{\frac{A_{Am}}{A_U}}{\frac{O_{Am}}{W_U}} \times \frac{O_U}{W_U} = (\text{Apparel intensity ratio}) \times (\text{U.S. online sales share}) \tag{1}$$

A_{Am}: Amazon apparel sales; A_U: US apparel sales; O_{Am}: Amazon online sales; O_U: US online sales; W_U: US wholesales.

Looking at Fig. 4, we note that although this ratio (RAI) was maintained at the same level (0.12) before 2016, it doubled to 0.23 in 2017, and has been maintained since then.

This notable phenomenon can be attributed to Amazon's strategy to be a customer-centric global apparel leader:

(i) The doubling of the ratio is a consequence of Amazon shedding its uncool image through a series of AI-driven ADFs developed during the years 2017–2019 as mentioned in Table 1.

(ii) Maintenance of the same RAI level is a consequence of consistent efforts to maintain an optimal balance between apparel sales growth and dependence on online sales for maintaining an optimal balance with socio-political dimensions.

Maintaining various apparel products and brands while developing high-value products with AI-driven ADFs depending on online sales is Amazon's fundamental strategy to be a customer-centric global apparel leader [40]. To satisfy these requirements, the RAI (η) should be stable (its growth rate *is* $\Delta\eta/\eta \approx 0$). (See the details of the mathematical proof in Appendix 2).

2.1.2.3. Homeostasis. The RAI indicates the state of homeostasis in an ecosystem. Homeostasis is a self-regulating process by which biological systems maintain stability while adjusting to changing external conditions [41] and incorporates the following profound implications for sustainable growth in a dynamically changing environment.

(i) **Function for adaptation and survival**: This concept explains how an organism can maintain more or less constant internal conditions that allow it to adapt and survive in the face of a changing and often hostile external environment [41].

(ii) **Self-regulation for balance**: This can be applied to systems in which the presence of conscious and deliberative minds, individually and in social groups, permits the creation of supplementary regulatory mechanisms aimed at achieving balanced and
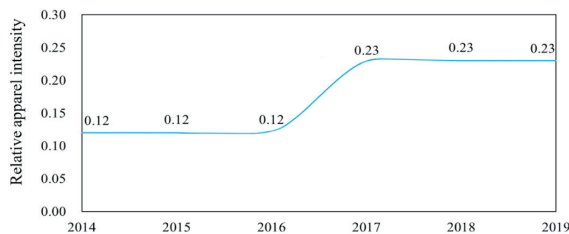
thus survivable life states but are more likely to fail than fully automated mechanisms [42].

(iii) **Changeable to a higher level**: This is not static and unvarying, but a dynamic process that can change internal conditions as required to survive external challenges.

(iv) **Complex interaction**: Homeostatic regulation is not merely the product of a single negative feedback cycle but reflects the complex interaction of multiple feedback systems that can be modified by higher control centers.

(v) **Redundancy and flexibility**: This hierarchical control and feedback redundancy results in a finer level of control and greater flexibility that enables the organism to adapt to changing environmental conditions [41].

In line with such ecosystem principles [43], Amazon has been creating customer-centric "[s]pecies survival and evolution systems" [5]. The rapid increase by AI-driven ADFs leading to shedding of Amazon's uncool image in 2017 is based on principle (iii) while regulating excessive online sales dependence for balancing high-value products initiated by online sales–based first-party sellers' sales and a variety of products and luxury brands initiated by third-party sellers' sales is based on principle (ii). All can be attributed to Amazon's flexible business model, as suggested in principle (iv).

Based on principle (ii), Amazon has been managing the pace of apparel sales share growth corresponding to the growth rate of the online sales share, as shown in Fig. 5.

2.2. Enablers of the rapid increase

2.2.1. Harnessing the vigor of soft innovation resources: neo-open innovation

As reviewed, the rapid increase in Amazon's apparel sales share since 2017 is a consequence of shedding its uncool image by developing a series of AI-driven ADFs that can be considered a dynamic process of changing internal conditions as required to survive external challenges. This can be enabled by harnessing the vigor of soft innovation resources (SIRs), as illustrated in Fig. 6, and pioneered neo-open innovation [44].

2.2.2. Learning orchestration externality in the age of AI

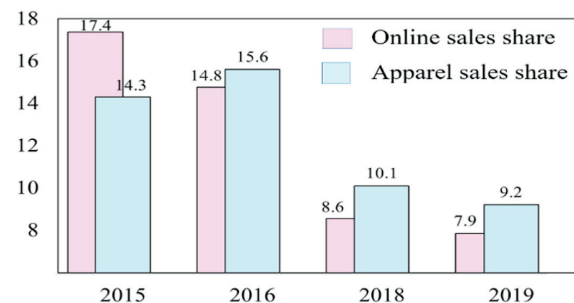Amazon, as an R&D-driven customer-centric firm [5,6], has fully

Fig. 4. Trend in Amazon's relative apparel intensity in the US (2014–2019).

Fig. 5. Growth Rates of Amazon's Apparel Sales Share and Online Sales Share in the US (% *p.a*).
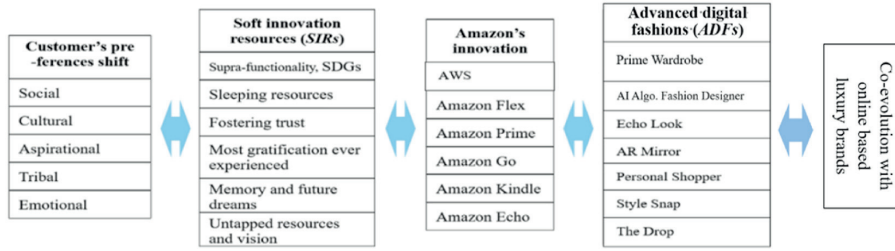
Fig. 6. Co-evolution between Amazon's SIRs-induced innovation and advanced digital fashion development.
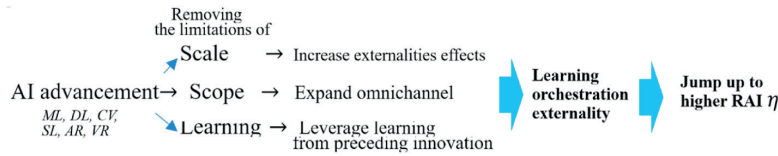

Fig. 7. Scheme of emerging learning orchestration externalities in Amazon's AI-driven advanced digital fashion development.

utilized AI to develop ADFs, as shown in Table 1.

AI can offer better performance in terms of customer-centricity, creativity, and rate of innovation, on which Amazon has focused its business strategy by removing the typical limitations in scale, scope, and learning [45]. This enabled Amazon to effectively utilize learning effects from the preceding innovation, enjoying externality effects by expanding omnichannel, and attaining higher RAI, as illustrated in Fig. 7.

Fig. 8 and Table 3 demonstrate these effects [11].

3. Contribution to becoming the global digital leader and its limit

3.1. Contribution to Amazon's growth to Be the global digital leader

3.1.1. Amazon's conspicuous sales growth

Trends in sales among GAFA (Google, Apple, Facebook, and Amazon) are compared in Fig. 9, which shows that Amazon has outperformed its competitors since the late 2010s. This outperforming sales increase has contributed to the further advancement of Amazon's unique cash conversion cycle (CCC), leading to the construction of a virtuous cycle with a sales increase [6].

3.1.2. Contribution of apparel to growth

This outperforming sales increase can largely be attributed to the rapid growth of apparel, as shown in Fig. 10. Although Amazon's apparel sales share remained 11–13% of total sales in 2014–2016, this share accounted for 15–20% after ADFs were developed in 2017 and increased to Amazon's top sales category in 2017.

3.1.3. Contribution of Amazon Web Services (AWS) to the growth

In addition to apparel, AWS has shown significant growth compared to apparel, as illustrated in Fig. 11. This suggests AWS contributes significantly to ADFs regarding its AI-driven advancement [21] and contributed to the growth above.

3.2. AWS's role

3.2.1. Contribution of two key players: apparel and AWS

Apparel and AWS have been two key players contributing to Amazon's sales increase, as shown in Fig. 12.

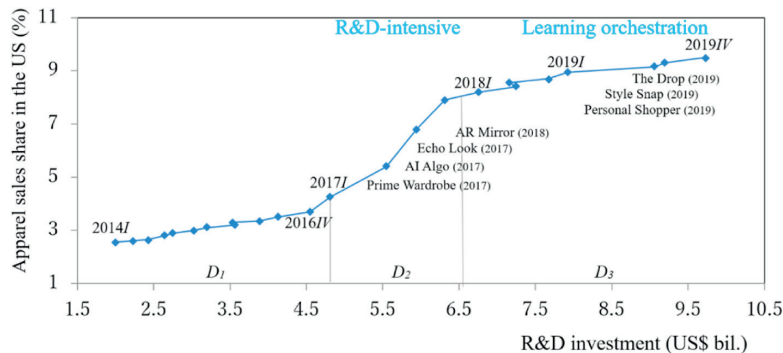AWS showed the highest growth rate over the period 2015–2020, as shown in Fig. 13.

Fig. 8. Correlation between Amazon's R&D Investment and Apparel Share in the U.S. Market (2014–2019 quarterly).

Table 3

R&D contribution to shift to omnichannel approach in amazon (2014–2019).

$S(t) = Ae^{\lambda t}R(t)^{\alpha}$ $\quad$ $\ln S(t) = \ln A + \lambda t + \alpha \ln R(t)$						
$\ln S(t) = 1.75 + 0.03D_1 t + 0.13D_2 t + 0.02D_3 t + 0.85D_2 \ln R(t) - 0.85D_1 - 3.38D_2$						
$\quad$ (49.38) $\quad$ (35.98) $\qquad$ (5.81) $\quad$ (12.30) $\qquad$ (3.31) $\qquad\qquad\qquad$ (-23.70) $\;$ (-24.16)						
$adj.R^2$ $\;$ 0.999 $\quad$ DW2.46						

$S(t)$: apparel sales share in the US, A: scale factor, λ: learning coefficient, t: time trend, $R(t)$: R&D investment, α: R&D elasticity to $S(t)$, D: dummy variables; D_1: 2014I–2016IV = 1, others = 0; D_2: 2017I–2017IV = 1, others = 0; D_3: 2018I–2019IV = 1, others = 0 (I: 1st quarter, IV: 4th quarter).

Backward elimination method with 5% criteria is used.

The figures in parentheses indicate the t-statistics: all are significant at the 1% level.
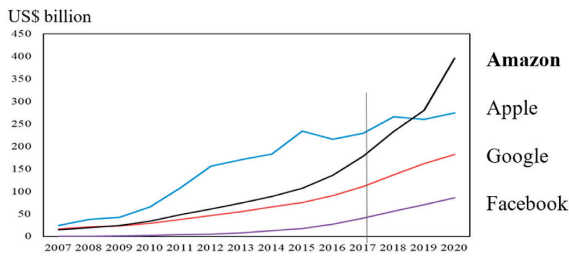

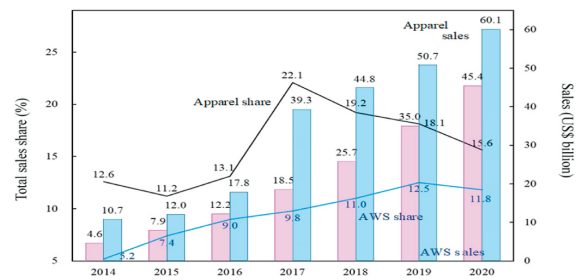**Fig. 9.** Trend in sales in GAFA (2007–2020).
Source: US SEC [46].

Fig. 10. Correlation between Amazon's apparel sales and whole sales (2014–2020).

Fig. 11. Trend in Amazon's net sales and sales of apparel and AWS (2014–2020).

Fig. 12. Trends in Amazon's apparel and AWS sales, and their share **out of total sales** (2014–2020).

Fig. 13. Growth Rate in Amazon's Sales (2015–2020 average: % *p.a*).

3.2.2. AWS as an R&D-driven science infrastructure

3.2.2.1. Amazon as an R&D-centric firm. Amazon has been continuing intensive R&D investment, exceeding its competitors since 2015, and accounting for 1.5 times higher investment than Google in 2020, as shown in Fig. 14.

3.2.2.2. AWS as a crystal of R&D. The AWS envisioned in 2002 and opened to external customers in 2006 demonstrates an extremely high correlation with R&D, with a high level of elasticity of R&D (1.44) through the course of 2008 and 2020, as illustrated in Fig. 15 and Table 4. This can be considered the crystal of R&D.

3.2.2.3. Innovative advanced composite cloud infrastructure with generative function. AWS, as an innovative advanced composite cloud infrastructure, incorporates the following unique functions:
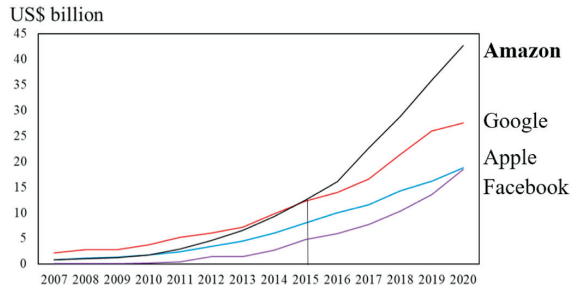
US$ billion

Fig. 14. Trend in R&D investment in GAFA (2007–2020).
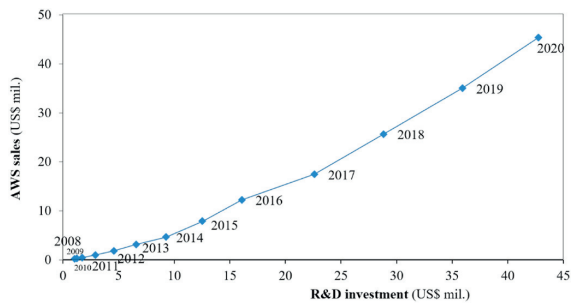Source: US SEC [46].

Fig. 15. Correlation between R&D and AWS (2008–2020).
Source: US SEC [46].

Table 4
Correlation between R&D and AWS in amazon (2008–2020).

ln $AWS =$	- 4.64 +	1.44 ln $R\&D$	*adj. R^2* 0.999	*DW* 2.53
	(-56.78)	(159.46)		

The figures in parentheses indicate the t-statistics: all are significant at the 1% level.

   (i) Incorporates computational, network, storage, database, and management facilities.
  (ii) Connects all stakeholders in the supply chain.
 (iii) Thus, combines different business systems into a single cloud-based solution.
 (iv) Accelerates the digital transformation of the combined systems.
  (v) Through this iterative process, its function is developed, and its generative function is incorporated. Its function self-propagates as iterative actions increase.
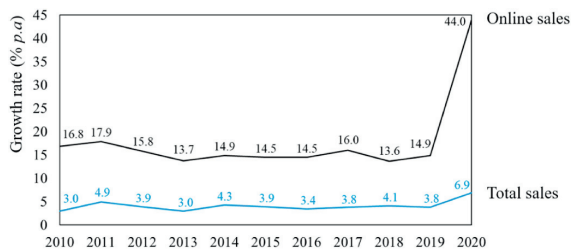

Fig. 16. Trend in growth rate of online sales and total sales in the US (2010–2020).
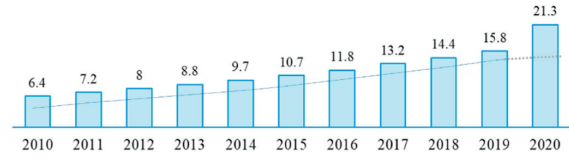Source: Digital Commerce 360 [48].

Fig. 17. Trend in Online Sales Penetration in the US (2010–2020), % of online sales out of total sales.
Source: Digital Commerce 360 [48].

3.3. Limits to growth

Although AWS, as the crystal of R&D, made a significant contribution to ADFs for its AI-driven advancement and contributed to Amazon's notable growth, an unexpected paradigm change toward a non-contact society due to COVID-19 has revealed the limits of sustainable growth for the model.

Confronting such circumstances, a crucial point depends on whether to transform such a crisis into a springboard to the new innovation that explores new frontiers. The next section examines this possibility.

4. Structural change toward a non-contact society

4.1. Demand segmentation and breakthrough of the internet dilemma

4.1.1. Fall and rise of online sales

Wischser et al. [36] recognized that "the possibility that online sales growth has hit a natural inflection point" in logistics growth should be considered. Consequently, the growth rate of online sales was considered to decrease over time.

However, an unexpected shift to a non-contact society due to COVID-19 has changed the share of online sales (e-commerce) of total retail from "slowly increased" in 2018 and 2019 to "spiked" in 2020 [47], as illustrated in Figs. 16 and 17.

4.1.2. Selective growth of online sales by expansion of its scope: long-lasting effects of the COVID-19 pandemic

The COVID-19 pandemic has had the following significant impacts on online sales.

   (i) Lockdowns and social distancing measures affect retailers with physical stores more than online retailers and may ultimately accelerate the ongoing shift from brick-and-mortar to online retailing [49].
  (ii) Despite persistent cross-country differences, the COVID-19 pandemic has enhanced dynamism in the e-commerce landscape across countries and has expanded the scope of e-
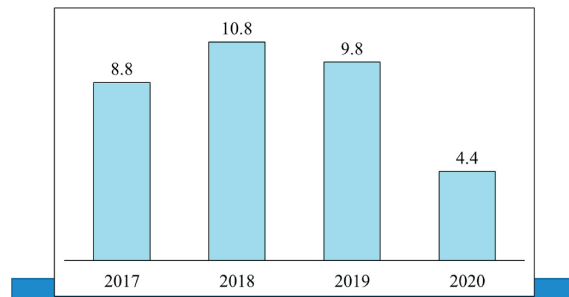

Fig. 18. Increase in Amazon's Retail e-Commerce Share in the US (2017–2020), % p.a.
Sources: Statista [22]; eMarketer [39].

commerce, including through new firms, consumer segments (e. g., elderly), and products (e.g., groceries; [47]).

(iii) The effect of the COVID-19 pandemic on e-commerce is not uniform across product categories or sellers. A surge in demand was generally observed for "essential retail goods" (e.g., consumer electronics, grocery, food, and pharmacy), while demand dropped for "non-essential retail goods" (e.g., luxury goods, home appliances, home furnishings, travel accessories, apparel; [49,50]).

(iv) In contrast to such demand segmentation, non-contact shopping has steadily broken through the Internet dilemma that has been impeding online shopping. Luxury brands are typical cases [51, 52].

(v) Although some demand shifts may be temporary, some of these changes in the e-commerce landscape will likely be long-term, in light of the possibility of new waves of the epidemic, the convenience of the new purchasing habits, learning costs, and the incentive for firms to capitalize on investments in new sales channels [47] leading to broader omnichannel.

(vi) Thus, the COVID-19 pandemic is likely to have long-lasting effects on e-commerce with its expanding scope and the continued

and "non-essential" (e.g., travel, formal apparel). Amazon is no exception, as shown in Fig. 19.

4.2. Structural change revealing limit to ADFs and challenge to neo-luxury

The COVID-19 pandemic has reminded us of the following new normal state as a non-contact society:

(i) Demand drops for non-essential retail goods, including apparel.
(ii) Demand for overcoming the Internet dilemma for luxury brands increases.

This prompted Amazon to explore a new business model.

Amazon satisfied increasing demand for fast fashion by developing a series of ADFs based on AI-driven learning orchestration externalities, as shown in Table 1.

This success can be attributed to evolving to disruptive digital fashion as demonstrated by the doubled relative apparel intensity (RAI η) as follows:

$$\text{Amazon's apparel intensity} = \text{Relative apparel intensity} \times \text{Apparel share} / \text{Online sales share in the US}$$

shift from brick-and-mortar stores. The development of a new expanding scope is crucial for sustainable e-commerce growth. The expansion of luxury brands by overcoming the Internet dilemma is a typical scope.

4.1.3. Impacts on Amazon's online sales strategy

Under such circumstances, Amazon lost its grip on its continuously increasing share of online sales in 2020. As illustrated in Fig. 18, the annual growth rate of the share of online shares decreased from 9.8% in 2019 to 4.4% in 2020, as other online retailers grew in 2020.

The COVID-19 pandemic pushed many more consumers online, as shown in Figs. 16 and 17. Although online sales have shown a saturating trend in recent years [36], COVID-19 has caused them to surge by segmenting "essential retail goods" (e.g., consumer electronics, pharmacy)

$$\frac{A_{Am}}{O_{Am}} = \eta \times \frac{A_U}{W_U} \bigg/ \frac{O_U}{W_U} \quad \eta = 0.12 \ (\text{before } 2016), 0.23 \ (\text{after } 2017) \quad (2)$$

A_{Am}: Amazon apparel sales; A_U: US apparel sales; O_{Am}: Amazon online sales; O_U: US online sales; W_U: US wholesales.

However, as the apparel share (A_U/W_U) decreases and online sales (O_U/W_U) share increases in a non-contact society, RAI should be increased to sustain apparel intensity that has contributed to Amazon's sales increase.

The increase in luxury brands intensity because of co-evolution between ADFs and luxury brands is indispensable as follows:

$$\begin{aligned}\text{Relative apparel intensity} = (\text{Amazon's apparel intensity} &\quad / \text{Apparel intensity in the US}) \times (\text{Online sales share in the US}) \\ &= (\text{Amazon's luxury brands intensity} \times \text{Apparel and luxury brands ratio}) / (\text{Apparel intensity}) \\ &\times (\text{Online sales share}).\end{aligned}$$
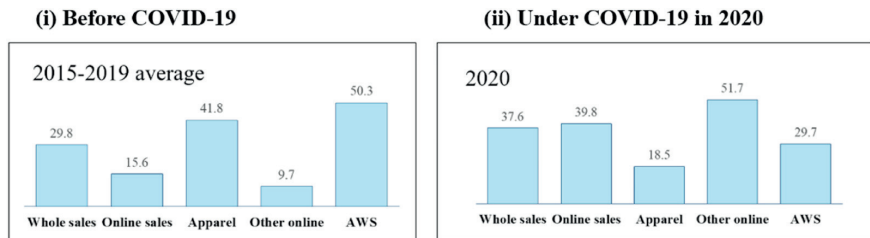

Fig. 19. Growth Rate in Amazon's Sales by Period (% *p.a*). All apparel is included in online sales.
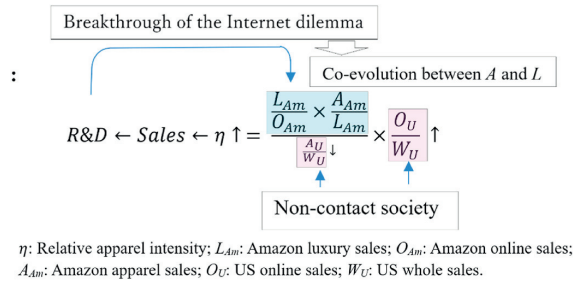Source: Statista [22].

Fig. 20. Dynamism leveraging Co-evolution between ADFs and luxury brands development.

$$\eta = \frac{\frac{A_{Am}}{O_{Am}}}{\frac{A_U}{W_U}} \times \frac{O_U}{W_U} = \frac{\frac{L_{Am}}{O_{Am}} \times \frac{A_{Am}}{L_{Am}}}{\frac{A_U}{W_U}} \times \frac{O_U}{W_U} \qquad (3)$$

L_{Am}: Amazon luxury brands sales.

As the apparel intensity (A_U/W_U) decreases, and the online sales share (O_U/W_U) increases, the luxury brands intensity (L_{Am}/O_{Am}) increases by overcoming the Internet dilemma through co-evolution between ADFs and luxury brands (O_{Am} and L_{Am} increase) and can lead to an RAI increase.

Thus, Amazon launched Amazon Luxury Stores in September 2020.

Advancing deeper into the luxury market is Amazon's long-held dream. However, Amazon's previous attempts to court luxury brands were met with resistance [53]. These brands want to avoid being associated with discount goods and counterfeit products [54]. They have been reluctant to collaborate with Amazon due to its solo-channel approach of selling basic apparel with control over branding, pricing, and discounts [21]. Taking these structural impediments, in line with the successive ADF development, and in response to increasing requirements from brands to look for extra channels that correspond to a non-contact society, Amazon introduced a new digital platform for luxury fashion, Luxury Stores, in September 2020 by collaborating with renowned luxury fashion designers and brands.

Given the unique potential of luxury brands as prospective SIRs [53], this endeavor is expected to pioneer a new perspective of innovation.

4.3. Perspective of neo-luxury: moving toward the new age of meaning

4.3.1. Significance of neo-luxury for sustainable growth in a non-contact society

With this expectation, Fig. 20 illustrates the dynamism of the new perspective of innovation explored by overcoming the Internet dilemma
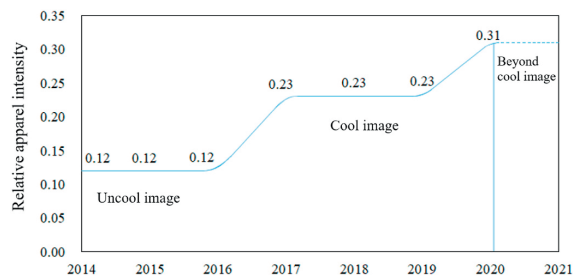

Fig. 21. Amazon's relative apparel intensity beyond its cool image.* $\frac{A_{Am}}{A_U}$ (2020) = 0.12 [55], $\frac{O_{Am}}{O_U}$ (2020) = 0.39 [39], $\frac{A_{Am}}{A_U}/\frac{O_{Am}}{O_U}$ = 0.31.
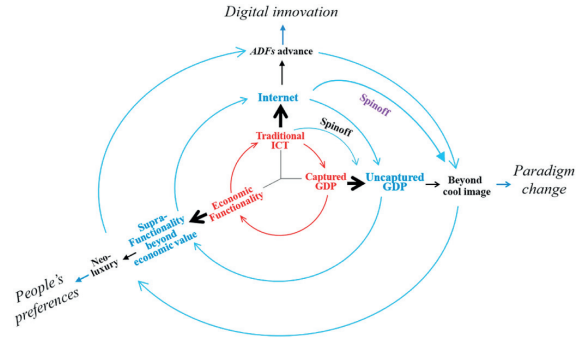

Fig. 22. Co-evolutionary development of neo-luxury.

of luxury brands through co-evolution between luxury brands and ADFs (the blue area of the figure). This solution leads to an increase in RAI (η) as a non-contact society results in decreasing apparel intensity (A_U/W_U) and increasing online sales intensity (O_U/W_U), both of which contribute to an increase in RAI (the pink area of the figure). Increased RAI leads to a sales increase that induces an R&D increase leading to overcoming the Internet dilemma, essential for luxury brands' dependence on online sales (L_{Am}/O_{Am}), and further advancement of ADFs (A_{Am}).

In line with this dynamism, Amazon invited 34 luxury brands to sell in its Luxury Stores by the first half of 2021. Consequently, Amazon is expected to shift to a new phase beyond the platform's current cool image with a higher RAI, as illustrated in Fig. 21.

4.3.2. Developing neo-luxury by overcoming the internet dilemma

The analysis above suggests the significance of the development of online-based luxury brands, neo-luxury, by overcoming the Internet dilemma that has impeded online-based luxury brand sales. This solution can be expected through co-evolution with the advancement in ADFs and a paradigm shift beyond a cool image, as illustrated in Fig. 22.

This co-evolution can be considered a new spinoff from the preceding co-evolution among digital innovation, paradigm change, and changes in consumers' preferences [56].
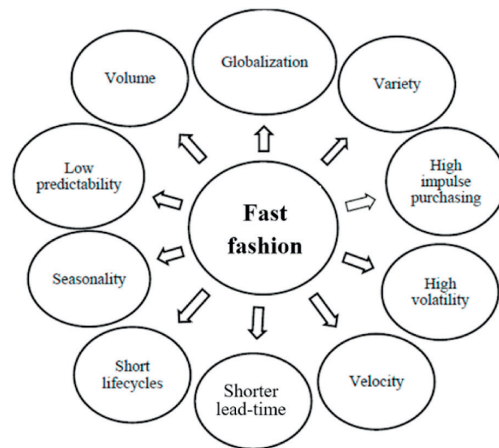

Fig. 23. Key features of the fashion industry in the digital economy.
Source: Authors' elaboration based on Ciarniene et al. [58].

5. Harnessing the vigor of meaning: shedding light on design-driven innovation

5.1. Redefining Global Luxury

5.1.1. Cultural shifts amidst digital innovation

Fashion reflects changes in aesthetics, economics, politics, culture, and society. Society changes fashion and apparel boosts this change [57]. Individuals and society use fashion to communicate their tastes and lifestyles. The common tastes and lifestyles of society collectively form and represent the taste and lifestyle of that society [58]. These new emerging lifestyles are interpreted by fashion designers into fashion concepts and then translated into fashion commodities [59].

The fundamental impediment of the fashion industry is that the time it takes to source materials, convert them into products, and move them into the marketplace is invariably longer than the time the customer is prepared to wait.

The contemporary fashion industry has become extremely global and dynamic, in addition, to quickly changing, trendy, and inexpensive but luxurious. These trends have transformed the industry into fast fashion. The primary requirement of fast fashion is to quickly produce a product cost-efficiently to respond to fast-changing consumer tastes in as near-real-time as possible.

The importance of time as a competitive weapon has been recognized in this fashion. Thus, the ability to meet the demands of customers for ever-shorter delivery times and to ensure that supply can be synchronized to meet the peaks and troughs of demand is critical. Consequently, key features of the fashion industry in the digital economy centered on fast fashion can be identified as volatility, velocity, variety, complexity, and dynamism, as illustrated in Fig. 23.

While most mass-market companies immediately exploited Internet-based technologies in an attempt to improve their marketing and communication strategies, luxury brands were hesitant [60]. Consequently, luxury brands were faced with the Internet dilemma [61,62]. However, contrary to the common belief about consumers' reluctance to shop online for luxury goods, a recent industry report showed shifting shopping behavior trends among luxury shoppers [51,52,63]. The COVID-19 pandemic has accelerated this shift.

Fig. 24. Key cultural shifts redefining the face of global luxury.
Source: Authors' elaboration based on Olbert [64].

5.1.2. Moving toward the new age of meaning

Although the requirements above are from the demand side, dramatic advancement of the Internet in the supply side leverages us to move toward the new age of meaning, where authenticity, sustainability, sense, and shared experiences are becoming the most valuable social currencies [64]. Aiming at securing these currencies, luxury brands are challenged by new digital channels that force them to reinvent the shopping experience without compromising their brand excellence [65]. Modern luxury consumers have become "highly digital, social and mobile," with 75% already owning several digital devices. They are known for putting less value on owning physical high-end items, focusing instead on the authentic and special experiences that luxury companies offer. Luxury brands rely not only on offering the highest differentiated products and services but also on delivering experiential value [66].

Adopting technology and embracing a digital presence through platforms and initiatives, the luxury industry today is tackling the challenge of designing an unparalleled user experience (UX) online [67].

Innovation that elevates the sensorial online experience is an important consideration for luxury fashion firms [60].

Luxury brands use several methods to create their myths: the personality and story of the creator, the difficulty in accessing the brand, the history and authenticity of the brand, and the individual stories that charge the brand with symbolic meaning [61]. Today, the concept of luxury is no longer strictly related to the economic value of the offering or the individual's spending capacity. It is now more frequently related to a lifestyle connected to emotional and experiential values and a more intrinsically ethical or social idea of value [68].

Consequently, the meaning becomes far more important for luxury brands than for any other brand. This is because, in luxury, the gap between the functional value of a product and the symbolic value of a brand is the greatest in comparison to any other market category. Luxury, in essence, is all about the meaning, which inevitably leads to five key cultural shifts, as illustrated in Fig. 24 [64].

While this cultural shift corresponds to the shift in people's preferences from economic functionality to supra-functionality beyond economic value in the digital economy, as illustrated in Fig. 25 [56], these shifts extend further beyond the shift from economic functionality to supra-functionality beyond economic value and draw special attention to design-driven innovation that highlights the role of meaning for innovation inducement.

Design-driven innovation focuses on the innovation of product meanings that address utilitarian values as well as intangible values, such as experiential, emotional, and socio-cultural values. In other words, design-driven innovation focuses on the purpose a product has for a customer [69].

5.1.3. New perspective of innovation

Inspired by these insights triggered by the unexpected COVID-19 pandemic, understanding that we are moving toward the new age of meaning that seeks luxury, and that meaning is a focus of design-driven innovation, the following dynamism based on a specular design concept that proposes new value from the perspective of the future is analyzed next, as illustrated in Fig. 26.

This concept is based on the postulate that the output envisioned in the future process is feedback on the previous process. Thus, growing seamless switching can be expected by the emergence of a generative function in a self-propagating way. This pioneer a new perspective of innovation toward a non-contact society.

5.2. Generative innovation

5.2.1. Design-driven innovation

Verganti [12] stressed that in addition to technology-push and market-pull innovation, a third strategy of having a vision and driving new meaning by delivering the vision to customers is becoming important as a bold new way of competing. Thus, Verganti postulated
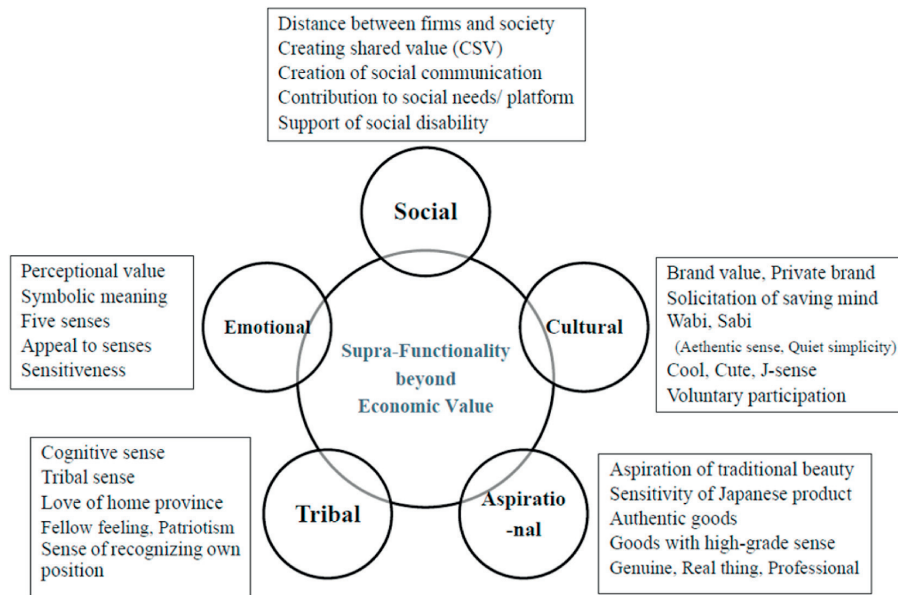
Fig. 25. Basic concept of supra-functionality beyond economic value.
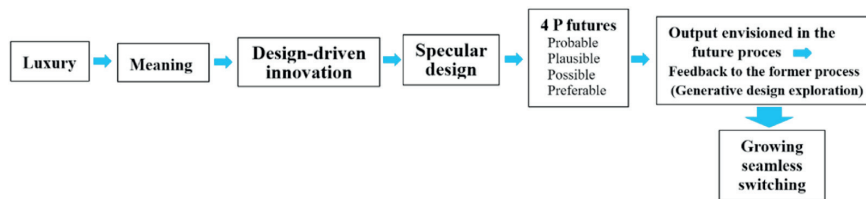Source: Watanabe et al. [56].

Fig. 26. The scheme in exploring new perspective of innovation.
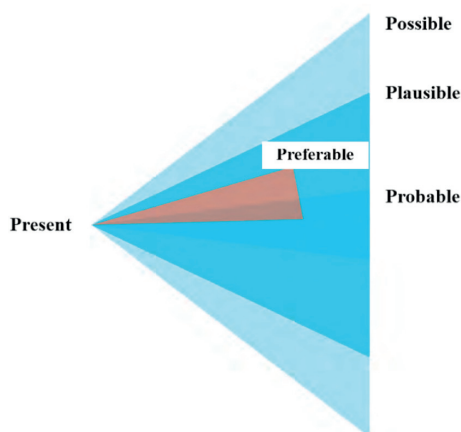
Fig. 27. PPPP for predicting the future.
Source: Dunne et al. [15].

the significance of design-driven innovation.

Considering that online-based luxury brands' business advancement (neo-luxury) will pioneer a new perspective of innovation toward a non-contact society and that meaning will take focal inducement for this innovation, this approach should be further developed.

5.2.2. Speculative design and PPPP

Dunne et al. [15] developed this concept by proposing a speculative design concept. They claimed that while designers often focus on making technology easy to use, sexy, and consumable, design is a means of speculating about how things could be—to imagine possible futures. This is not the usual sort of predicting or forecasting, spotting trends, and extrapolating; these kinds of predictions have been proven wrong. Instead, Dunne et al. posed "what if" questions that are intended to open debate and discussion about the kind of future people want by proposing PPPP (**p**ossible, **p**lausible, **p**robable, and **p**referable futures), as illustrated in Fig. 27.

This approach explores how to acquire thinking for innovation that can propose new value from the perspective of the future by understanding that there is no future in the extension of the past.

Amazon's own software and hardware companies (Lab 126 and Body Labs) are constantly working on future concepts.

5.2.3. Generative design exploration

Verganti [13] noted that design thinking includes a series of iterative

Fig. 28. Scheme of generative design exploration.
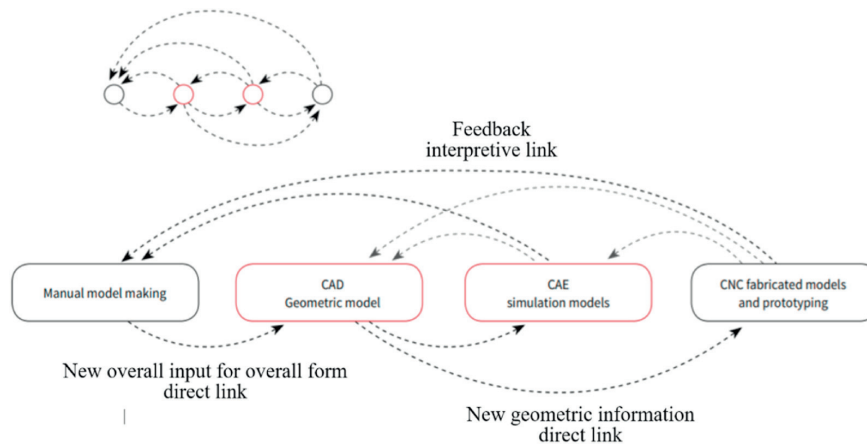Source: Authors' elaboration based on Meibodi [14].
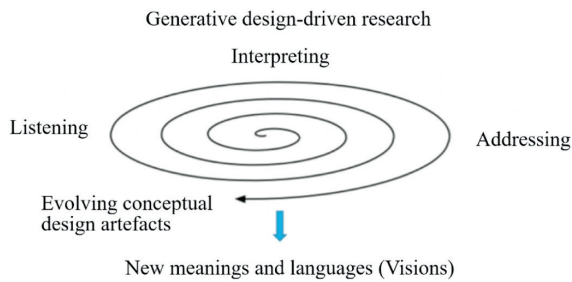

Fig. 29. The generative design-driven innovation processes (GDDI) model.
Source: Kristiansen et al. [71].

activities: an initial exploratory set of activities focused on data gathering to identify user needs, design criteria, and problem definition, followed by the generation of ideas, which are then prototyped and tested.

Design thinking is an iterative process in which we seek to understand the user, challenge assumptions, and redefine problems in an attempt to identify alternative strategies and solutions that might not be instantly apparent with our initial level of understanding [70].

Meibodi [14] proposed an iterative design process that involves a program that will generate a certain number of outputs that meet certain constraints and a designer who will fine-tune the specific output or change the input values. In this iterative process, the output of each process is fed back to the previous processes in the chain as input, as illustrated in Fig. 28.

As generative design exploration inspires that the output of each process is fed back to the previous processes, given speculative design and subsequent PPPP futures, it can be suggested that in a future vision, PPPP leads to innovation through feedback about the current action.

Amazon's computational experts' beta-tested ADFs related to digital products—apps and services (Personal Shopper, Echo Look, Style Snap, and Luxury Stores)—on a selected group of users (i.e., invite-only) and asked for feedback before actual products were released. Echo Look's beta version was introduced in 2017, and the final version that incorporated users' feedback was introduced in 2018. Then, incremental improvements were made based on users' feedback.

5.2.4. Generative design-driven innovation

Following these investigations, Kristiansen et al. [71]; based on their empirical analysis, postulated that design-driven innovation incorporates a generative design-driven innovation (GDDI) process that emerges the generative function in a self-propagating way, as illustrated in Fig. 29.

This postulate supports the authors' preceding concept of a supra-omnichannel that leads to growing seamless switching [11] and paves the way to a pioneering new perspective of innovation toward a non-contact society.

5.3. Dynamism Leading to growing seamless switching

5.3.1. Supra-omnichannel realizing growing seamless switching

Given the breakthrough in overcoming the Internet dilemma that has impeded the advancement of online-based luxury brands, this advancement, neo-luxury, can be expected to leverage meaning-seeking innovation leading to a supra-omnichannel with growing seamless switching and a new perspective of innovation, as illustrated in Fig. 30.

5.3.2. Overcoming the internet dilemma

The dynamism above is subject to a breakthrough in overcoming the Internet dilemma for transforming luxury brands into neo-luxury (online-based luxury brands). Two systems, on-demand manufacturing (ODM) and AWS play a pivotal role.

5.3.2.1. Amazon's ODM attempt for apparel. Amazon is taking steps to develop tools that deliver real-time consumer insights and can be leveraged for just-in-time delivery. In light of the significance of ODM for this attempt, with its comparative advantage in data and automation technology, Amazon applied for a patent for an on-demand apparel manufacturing system based on data and automation in December 2015, and the patent was granted in April 2017 [72].

The acquisition of this patent steps up Amazon's fashion game [73], leading to acceleration of the three-dimensional approach, Amazon's fundamental strategy for a fashion-driven apparel leader, consisting of
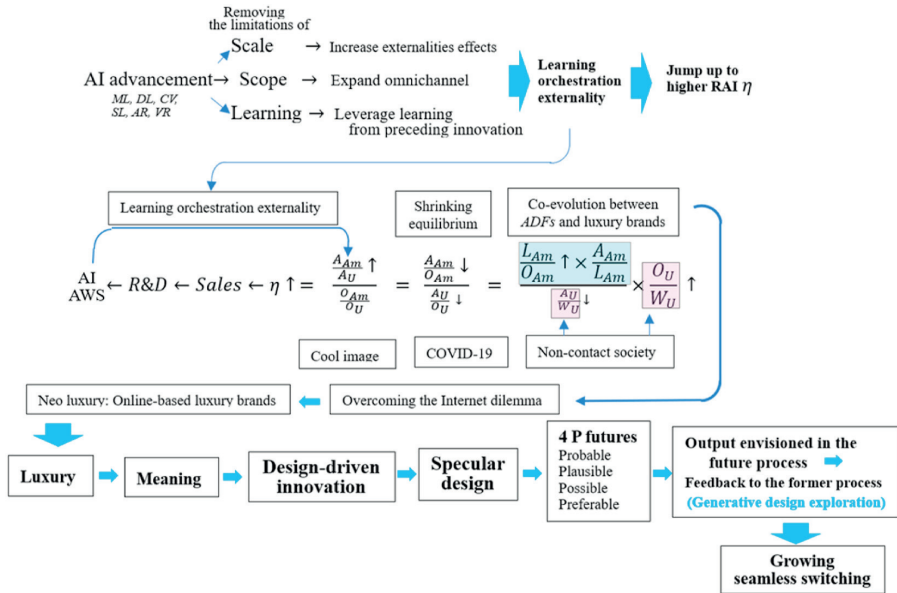
Fig. 30. Dynamism leading to a supra-omnichannel with growing seamless switching.

Fig. 31. Dual Co-evolution among ADFs, luxury brands, ODM Co-evolution, and cloud-based fashion platform advancement.

(i) satisfying customers' dream to have their own initiatives, (ii) shedding the uncool label and increasing the curation function, and (iii) moving more deeply into the luxury market. This acquisition also has enhanced the feasibility of ODM for apparel through the synchronizing of these approaches [11].

The benefits of ODM increase as digital innovation advances, leading to providing a sustainability base, particularly to luxury brands working toward a non-contact society where customers are moving from physical channels to digital channels.

Thus, advanced ODM steadily contributes to transforming luxury brands' resistance to collaborating with Amazon into a sustainable opportunity toward the creation of a non-contact society. This, in turn,

Table 5
Development trajectory of Amazon's sales share in the US by *LGDCC* (2014.1–2019.12).

$$S(t) = \frac{N_k}{1 + be^{-at} + \dfrac{b_k}{1 - a_k/a}e^{-a_k t}}$$

N	a	b	a_k	b_k	adj. R^2
12.20	0.05	10.37	0.15 (1.82)	14.81 (1.27)	0.951
(7.01)	(3.76)	(2.49)	*	**	

The figures in parentheses indicate the t-statistics: all are significant at the 1% level except * 5% and ** 10%.
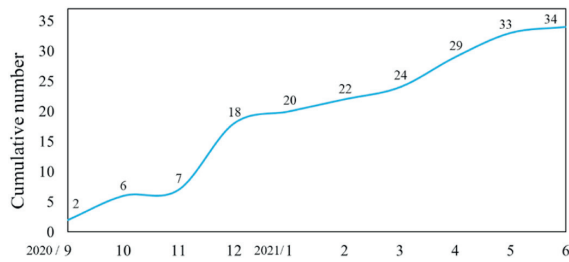
Fig. 32. Trend in cumulative number of luxury brands that joined luxury stores (september 2020–June 2021).

provides the manufacturing industry with digital solutions, advanced logistics, and funding capabilities initiated by Amazon. Thus, co-evolution among ADFs, luxury brands, and ODM can be constructed, as illustrated on the right side of Fig. 31.

5.3.2.2. Transformative role of AWS. AWS is an innovative advanced composite cloud infrastructure. Its five unique functions are reviewed previously in section (3.2 (3)). With these functions, a cloud-based fashion platform is constructed by integrating ADFs, luxury brands, ODM, and all sales channels in one place, as co-evolution among ADFs, luxury brands, and ODM emerges.

AWS offers all the technologies that online retailers need to manage growth instantly. With technologies like automatic scaling compute resources, networking, storage, content distribution, and a payment card industry (PCI)-compliant environment, retailers can always provide great customer experiences and capitalize on growth opportunities [18]. The AWS cloud allows organizations to arrange advanced real-time services and accomplish significant profits and productivity improvements. It assists online retailers with website hosting, cloud storage, and database management and in delivering digital content, e-mails, and other functionalities to customers [17]. Thus, personalization and customization can be leveraged.

The digital technology landscape in the retail industry is expanding beyond traditional enterprise resource planning (ERP), customer relationship management (CRM), and supply chain management. To compete in this landscape, retailers are using new technologies, such as analytics, big data, and social media, to identify individual customer preferences and behaviors to offer a personalized shopping experience, while many retailers are suffering from data management issues [16].

Retailers have prioritized investments in delivering an integrated experience online but have lacked the tools to track, measure, and engage consumers in stores. With new advancements in cloud capabilities and the power of real-time data, retailers now have the opportunity to rapidly experiment and scale solutions that elevate the customer experience [74].

Through the course of iterative activities among stakeholders integrated with the platform, big data on customers, vendors, manufacturers, global influencers, and social trends are compiled. With these iterative activities, AWS further develops and expands its cloud-based platform, leading to a virtuous cycle, as illustrated on the left side of Fig. 31.

5.3.3. Growing seamless switching

5.3.3.1. Dual Co-evolution induced by resonance. AWS incorporates a

self-propagating generative function. This function also emerges in neo-luxury through the generative design exploration process, as reviewed in Section 5.2.4. With this common function, AWS and neo-luxury resonate[2] and induce co-evolution between them.

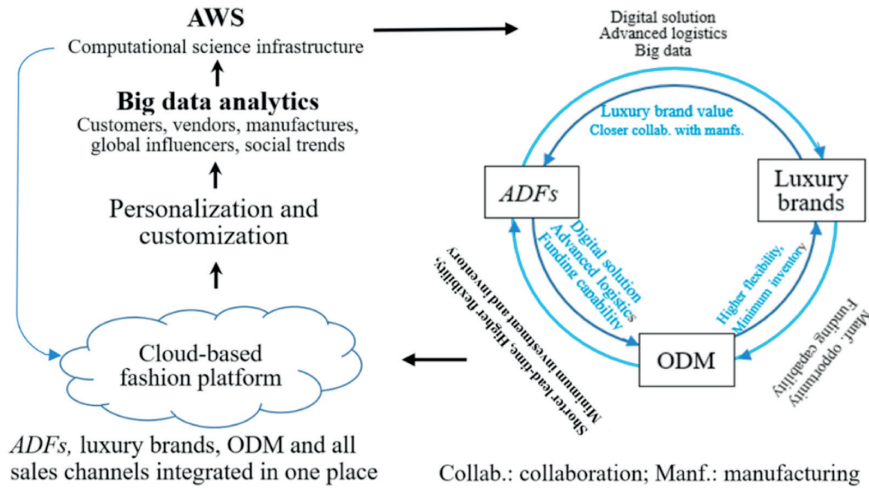Thus, dual co-evolution among ADFs, luxury brands, ODM co-evolution, and cloud-based fashion platform advancement emerges, as illustrated in Fig. 31.

This dual co-evolution emerges as growing seamless switching, which is illustrated in Fig. 30, and pioneers a new perspective of innovation toward a non-contact society.

5.3.3.2. Self-propagating generative function. ICT is self-propagating, which can be traced by the logistic growth function within a dynamic carrying capacity (LGDCC; [75]). Amazon's apparel development trajectory fits LGDCC, as shown in Table 5 [11]. Provided that LGDCC-driven sustainable growth can be attributed to the self-propagating development, this demonstrates that Amazon's apparel development trajectory depends on self-propagating development with growing seamless switching.

Contrary to the drop in apparel demand due to the COVID-19 pandemic, online-based luxury brands (neo-luxury) have been gaining momentum, as shown in Fig. 32. Thirty-four luxury brands joined Luxury Stores by the first half of 2021 [11]. The cumulative number of these neo-luxury firms is traced in Fig. 32. This figure demonstrates that a significant number of neo-luxury brands joined Luxury Stores several months after it launched in September 2020, and a sustainable increase has been maintained since then.

With the breakthrough in overcoming the Internet dilemma, neo-luxury is expected to incorporate a self-propagating generative function, as analyzed. Table 6 displays the notable generative function in luxury brands available in Luxury Stores.[3]

5.3.3.3. Growing seamless switching. Co-evolution among ADFs, luxury brands, and ODM is expected not only to maintain ADFs' self-propagating function but also to activate a self-propagating generic function in ADFs and luxury brands. Given AWS's indigenous self-propagating generic function, dual co-evolution with the AWS-driven cloud-based fashion platform is expected to further activate the self-propagating generic function.

This leads to a supra-omnichannel with growing seamless switching and pioneers a new perspective of innovation toward a non-contact society.

6. Conclusion

In light of the future of the fast fashion industry and noting the structural change in the fundamentals of this industry due to the unexpected COVID-19 pandemic, the drop in apparel demand and a sharp hike in online-based luxury brands, this paper analyzed Amazon's pioneering response to these critical issues, which is expected to provide insights for pioneering a new frontier beyond current business models toward a non-contact society after the COVID-19 pandemic ends.

Based on a theoretical and empirical demonstration of Amazon's endeavor against a new trend in the COVID-19 pandemic, this paper attempted to elucidate the inside of the black box of Amazon's unique R&D dynamism that made the platform the world's top R&D leader by transforming "routine or periodic alterations" into "significant improvement" during the R&D process and transformed the COVID-19

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[2] Authors in the preceding research [19] demonstrated the significant resonance between industries with similar core functions that smartly complement comparative advantageous and disadvantageous technologies through effective utilization of spillover technology.

[3] From June 2021 to December 2021, the cumulative number of luxury brands available in Luxury Stores have increased from thirty four to fifty.

Table 6

Noteworthy generative function in luxury brands joined in luxury stores.

Brands	Time of launch	Label	Features of generative function
Oscar de la Renta	Sep. 2020	USA	Early adoption of digital tools such as Livestream fashion shows digital storytelling, Oscar de la Renta socialized with clients for meaningful designs and feedback [76]. Collaboration with external designers, timeless collections, and customization services focused on celebrities [77].
Roland Mouret	Sep. 2020	UK	Roland Mouret uses Adwords Customer Match. Women feedback for design innovations, collaboration with the Banana Republic for luxury democratization [78]. Seeks inspiration from renowned artists such as Matisse for meaningful designs, experimentation with **"See Now, Buy Now"** trend before the rest of the fashion industry [79] and sustainable approach of materials innovation such as Switch-to- BLUE® hanger campaign [80].
Cle de Peau	Oct.2020	Japan	Prioritizes **customization and experiential** beauty, collaboration with artists for Brilliant **Cell design concept**, beauty, and science [81]. Based on the concept of the **fruitful fusion of knowledge and people**, its **new way of researching** i.e., internal, external and collaborations will give birth to revolutionary products and services, and create **beauty experiences** that **go well beyond traditional cosmetics** to inspire the global audience, and bring about the **new value** and brand-new lifestyles [82].
Elie Saab	Dec. 2020	Lebanon	Given the Internet dilemma, Elie Saab product lines such as haute couture, ready-to-wear, Le Parfum, and accessories, **remain distinguishable on their websit**. This eliminates the risk of brand **status dilution** [83]. The Elie Saab group and "**Brand Beyond Beauty**" collaboration will focus joint resources to bring new perspectives to Elie Saab Parfums and achieve stronger positions in brick and mortar and online channels [84].
The Conservatory	Dec. 2020	USA	Creative retail concepts of The Conservatory solve issues of inventory and cashless payments. It uses **universal cart technology for cash-less payments**, innovative **check-in systems**, and the business model is based on a sense of **exclusivity** [85]. **Emphasizes mainly on physical store** (PS), and e-com. is powered by Farfetch. Customers visit PS, and then sales associates open online accounts for the specific customers. This enables customers to explores its hidden e-com. Website [86].
L/Uniform	Apr. 2021	France	According to its founder with **background in econometrics** "I am not a designer neither I design for fashion- I design for daily use" that represents **practicality and time management** [87]. Provides personalization, customization with on-demand printing.
La Bouche Rouge	Apr. 2021	France	The eco-luxury beauty brand **introduces sustainbale materials for the future if luxury and beauty industry**. Products with zero micro-plastics and customizable, and refillable cases quickly became a cult favorite. It uses recycled metal and upcycled leather [88]. **Raised 2.5 million euros** for redeveloping its digital strategy as a part **of its omnichannel reach in order to better highlight its commitment to craftsmanship**, nature, and to further its development in key markets such as China [89].
Missoni	May. 2021	Italy	The adoption of digitalization and **influencer marketing**. In the apparel industry, the knitwear sector is more fertile for experimentation and innovation [90]. Missoni collaborates with **academic institutions and other designers** for design thinking, creativity, and innovation in **Italian knitwear production**. Students use **historical archives** of Italian craftsmanship for **design and material innovation** [91].
Fabrizio Viti	May. 2021	UK	Fabrizio Viti provides design solutions to luxury shoe manufacturer Louis Vuitton that symbolizes the **marriage of good taste and French and Italian knowhow**.Vuitton's shoe factory in Fiesso d'Artico that, resembles a modern art museum [92].

pandemic into a springboard for new innovation leading to the platform's notable growth.

An empirical analysis using a techno-economic approach focusing on Amazon's development of a series of ADFs and neo-luxury before and during the COVID-19 pandemic was conducted. The following notable findings were obtained.

Amazon abruptly became the global apparel leader with respect to sales share based on learning orchestration externality through the development of a series of ADFs.

Careful attention was paid to balancing economic benefits and sociopolitical dimensions, including a rich assortment for customer satisfaction, by managing the optimal balance between shares of apparel sales and online sales.

With this business strategy, the COVID-19 pandemic induced co-evolution between ADFs and neo-luxury that corresponds to the cultural shift to a new age of meaning.

As meaning is the focal driver of design-driven innovation that incorporates a generative function by transforming a future vision into new innovation, meaning-seeking innovation emerged as a self-propagating generative function.

Amazon has been advancing AWS as an innovative, advanced composite cloud infrastructure. This incorporates a generative function and develops a cloud-based fashion platform by integrating all stakeholders in one place.

Given the common key function, self-propagating generative function, AWS, and neo-luxury resonated and induced co-evolution between them. Activated co-evolution further advanced cloud-based fashion

platforms, leading to a virtuous cycle between them. Thus, dual co-evolution between ADFs and luxury brands' co-evolution and cloud-based fashion platform advancement emerged.

This dual co-evolution appeared (growing seamless switching), and a new perspective of innovation toward a non-contact society can be pioneered.

In addition, this paper paved the way to a new challenge to reveal the inside of the black box of Amazon's unique business model, about which the majority of information has been kept private. An interdisciplinary approach applying concepts of homeostasis and resonance to techno-economic analysis was demonstrated. All lead to the expectation of linking broken logic, constructing plausible logic, and demonstrating hypothetical postulates.

These findings provide the following insights for pioneering a new frontier beyond current business models toward a non-contact society after the COVID-19 pandemic:

(i) The dual co-evolution between ADFs and luxury brand co-evolution and cloud-based fashion platform advancement should be accelerated.
(ii) Dynamism in emerging self-propagating generative function in neo-luxury should be further elucidated.
(iii) A specular design concept that develops thinking for innovation from the perspective of the future should be further developed.
(iv) Application of homeostasis and resonance concepts to innovation management strategy should be developed.

(v) Growing seamless switching should be further developed in broad fields and generalized for transforming traditional R&D management.

Limitations of this research include the focus on Amazon and the development of its apparel and luxury brands. In addition, limited-time experiences for reviewing luxury brands' performance as less than one year (since September 2020) should be noted.

Future research should focus on similar analyses in broader sectors and use a sufficient time range for these luxury brands' performance. The effects of co-evolution with ODM could also be investigated.

Appendix 1. Data Construction

Table A1
Sales in GAFA.

Sales (US$ billion)					**Growth rate** (% p.a)				
	Google	Apple	Facebook	Amazon		Google	Apple	Facebook	Amazon
2014	18.9	7.0	58.2	**19.5**	2014	66.0	182.8	12.5	**89.0**
2015	13.6	27.8	43.2	**20.2**	2015	75.0	233.7	17.9	**107.0**
2016	20.4	−7.7	54.2	**27.1**	2016	90.3	215.6	27.6	**136.0**
2017	22.8	23.2	47.5	**30.8**	2017	110.9	229.2	40.7	**177.9**
2018	23.4	15.9	37.1	**30.9**	2018	136.8	265.6	55.8	**232.9**
2019	18.3	−2.0	26.7	**20.4**	2019	161.9	260.2	70.7	**280.5**
2020	12.2	5.5	21.6	**37.6**	2020	181.7	274.5	86.0	**386.1**

Sources: US SEC [46].

Table A2
Amazon's Sales by Product Group (US$ billion)

	Online stores	Physical stores	Third-party seller services	Subscription services	AWS	Other	Net sales
2014	68.5 (77.0)	–	11.8 (13.3)	2.8 (3.1)	4.6 (5.2)	1.3 (1.5)	**89.0**
2015	76.9 (71.9)	–	16.1 (15.0)	4.5 (4.2)	7.9 (7.4)	1.7 (1.6)	**107.0**
2016	91.4 (67.2)	–	23.0 (16.9)	6.4 (4.7)	12.2 (9.0)	3.0 (2.2)	**136.0**
2017	108.4 (60.9)	5.8 (3.3)	31.9 (17.9)	9.7 (5.5)	17.5 (9.8)	4.7 (2.6)	**177.9**
2018	123.0 (52.8)	17.2 (7.4)	42.7 (18.3)	14.2 (6.1)	25.7 (11.0)	10.1 (4.3)	**232.9**
2019	141.2 (50.3)	17.2 (6.1)	53.8 (19.2)	19.2 (6.8)	35.0 (12.5)	14.1 (5.0)	**280.5**
2020	197.4 (51.1)	16.2 (4.2)	80.5 (20.8)	25.2 (6.5)	45.4 (11.8)	21.5 (5.6)	**386.1**

The figures in parentheses indicate the share (%).
Sources: Statista [22].

Table A3
Amazon's Sales by Global Market (US$ billion)

	USA	Germany	UK	Japan	Others	Total
2014	54.7 (61.5)	11.9	8.3	7.9	6.2	**89.0**
2015	70.5 (65.9)	11.8	9.0	8.3	7.4	**107.0**
2016	90.3 (66.4)	14.1	9.5	10.8	11.3	**136.0**
2017	120.5 (67.7)	17.0	11.3	11.9	17.2	**177.9**
2018	160.1 (68.7)	19.9	14.5	13.8	24.6	**232.9**
2019	193.6 (69.0)	22.2	17.5	16.0	31.2	**280.5**
2020	263.5 (68.2)	29.6 (7.7)	26.5 (6.9)	20.5 (5.3)	46.0 (11.9)	**386.1**

The figures in parentheses indicate the share (%).
Sources: Statista [22].

Table A4
Amazon's Apparel Sales in the US and Global Market (US$ billion)

	1. Amazon total sales in the US	2. Apparel in the US	3. Amazon apparel share in the US (%)	4. Amazon apparel in the US (2 × 3)	5. Amazon apparel in the global market (4/US market share)	Sources for 2 (1: Table A3; 3: Fig. 3)
2014	**54.7**	235	2.8	**6.6**	**10.7**	Statista [22]
2015	**70.5**	247	3.2	**7.9**	**12.0**	Statista [22]
2016	**90.3**	318	3.7	**11.8**	**17.8**	Statista [22]

Table A4 (*continued*)

	1. Amazon total sales in the US	2. Apparel in the US	3. Amazon apparel share in the US (%)	4. Amazon apparel in the US (2 × 3)	5. Amazon apparel in the global market (4/US market share)	Sources for 2 (1: Table A3; 3: Fig. 3)
2017	**120.5**	337	7.9	**26.6**	39.3	Statista [22]
2018	**160.1**	354	8.7	**30.8**	44.8	Statista [22]
2019	**193.6**	368	9.5	**35.0**	50.7	Statista [22] cf 35.6 (W–F, 2021)
2020	**263.5**			**41.0***	60.1	*Wells Fargo [89]

Assumed that apparel in the global market is proportional to the whole sales ratio (global/US in Table A3).
Sources: Statista [22]; Wells Fargo [89].

Table A5
Amazon's Sales and Growth Rate by Product Group in the Global Market (US$ billion, % *p.a*)

	Online stores	Physical stores	Third-party seller services	Subscription services	AWS	Other	Net sales	Apparel
2014	68.5	–	11.8	2.8	4.6	1.3	**89.0** (19.5)	10.7
2015	76.9 (12.3)	–	16.1 (36.4)	4.5 (60.7)	7.9 (71.7)	1.7 (30.8)	**107.0** (20.2)	12.0 (12.1)
2016	91.4 (18.9)	–	23.0 (42.9)	6.4 (42.2)	12.2 (54.4)	3.0 (76.5)	**136.0** (27.1)	17.8 (48.3)
2017	108.4 (18.6)	5.8	31.9 (38.7)	9.7 (51.6)	17.5 (43.4)	4.7 (56.7)	**177.9** (30.8)	39.3 (120.8)
2018	123.0 (13.5)	17.2 (196.6)	42.7 (33.9)	14.2 (46.4)	25.7 (46.9)	10.1 (114.9)	**232.9** (30.9)	44.8 (14.0)
2019	141.2 (14.8)	17.2 (0)	53.8 (26.0)	19.2 (35.2)	35.0 (35.2)	14.1 (39.6)	**280.5** (20.4)	50.7 (13.7)
2020	197.4 (39.8)	16.2 (−5.8)	80.5 (49.6)	25.2 (31.3)	45.4 (29.7)	21.5 (52.5)	**386.1** (37.6)	60.1 (18.5)

Table A6
R&D in GAFA.

	R&D investment (US$ billion)					**Growth rate** (% p.a)			
	Google	Apple	Facebook	Amazon		Google	Apple	Facebook	Amazon
2014	37.8	35.0	88.4	**41.3**	2014	9.83	6.04	2.67	**9.28**
2015	24.9	33.6	80.5	**35.1**	2015	12.28	8.07	4.82	**12.54**
2016	13.6	24.5	22.8	**28.31**	2016	13.95	10.05	5.92	**16.09**
2017	19.2	15.2	30.9	**40.6**	2017	16.63	11.58	7.75	**22.62**
2018	28.8	23.0	32.5	**27.5**	2018	21.42	14.24	10.27	**28.84**
2019	21.5	13.9	32.4	**24.6**	2019	26.02	16.22	13.60	**35.93**
2020	6.0	15.6	35.7	**19.0**	2020	27.57	18.75	18.45	**42.74**

Sources: US SEC [46].
Sources: US SEC [46]. AWS sales in 2008–2012 were estimated by Amazon's annual reports.

Table A7
Trend in Amazon's Sales and R&D (1997–2020) – US$ mil.

Year	Sales	Growth rate (% p.a)	R&D	AWS sales
1997	148		13	
1998	609	311.5	46	
1999	1640	169.3	159	
2000	2762	68.4	269	
2001	3122	13.0	241	
2002	3933	26.0	216	
2003	5264	33.8	257	
2004	6921	31.5	283	
2005	8490	22.7	451	
2006	10,711	26.2	662	
2007	14,835	38.5	818	
2008	19,166	29.2	1033	210
2009	24,509	27.9	1240	280
2010	34,204	39.6	1734	450
2011	48,077	40.6	2909	950
2012	61,093	27.1	4564	1800
2013	74,452	21.9	6565	3108

Table A7 (*continued*)

Year	Sales	Growth rate (% p.a)	R&D	AWS sales
2014	88,988	19.5	9275	4644
2015	107,006	20.2	12,540	7880
2016	135,987	27.1	16,085	12,219
2017	177,866	30.8	22,620	17,459
2018	232,887	30.9	28,837	25,655
2019	280,522	20.5	35,931	35,026
2020	386,064	37.6	42,740	45,370

Appendix 2. Homeostasis for Customer-Centric Apparel Leader

1. Structure of Amazon's Apparel Sales Site

Table A8

Structure of Amazon's Apparel Sales Site

	Products number *1	Quantity Net sales share *2	Quality	Place of the game	Owner of the products	Retailer	Revenue for Amazon	Composition of net sales	Effects of online sales
First-party seller	13.7%	15.6%	Higher value Category	Amazon marketplace	Amazon	Amazon	Sales	Online stores	Significant relevance *4
Third-party seller	86.3%	2.5%	Lower value Items	Amazon marketplace	Third-party	Third-party Amazon as a manager of marketplace*3	Commissions, related fulfilment and shipping fees or	Third-party seller services	No significant relevance
Amazon fashion site	100%	18.1%							

* 1 Share of number of products offered for sale in the Amazon fashion site in 2018 [20].

* 2 Apparel sales share in 2019 was 18.1% (authors' estimate based on Statista). Third-party seller services sales share was 19.2% (Statista). The percentage of sellers in the clothing and shoes category (including jewelry) in third-party sellers services was 13% (Connolly, 2021). Therefore, third-party seller services sales share of apparel can be estimated as 19.2% × 0.13 = 2.5%.

* 3 As an owner and manager of its marketplace, Amazon claims third-party on certain conditions relevant to price, inventory and display, except for luxury brands.

* 4 Advancement of online sales → Induce R&D → Advancement of AWS/AI → Development of *ADFs* → Higher value category of products → Online stores sales increase

Amazon apparel sales consist of first-party sales (sold by Amazon itself) and third-party product sales. While the exact share between them is private, Coresight Research [20] revealed that, as far as number of products are concerned, Amazon depends heavily on the latter as it shared 86.3% of number of third-party products in 2018. Amazon appears to be focusing its first-party clothing inventory on higher value categories and most of the private labels tend to be clustered in specific clothing categories [20]. Shoppers feel greater reassurance on issues such as product authenticity, shipping returns charges, and returns policies when they buy direct from Amazon than when they buy from third-party sellers.

Therefore, greater first-party inventory would increase customer satisfaction and strengthen the relationships between Amazon and brands.

With this strategic policy, Amazon depends on a highly segmented approach to its first-party sales, which tend to be concentrated within specific high-value categories and focused on each of its own brands on a particular consumer type or product category. At the same time, in order to correspond to customer's demand on the variety of products, abundant lower value items for rich assortment are expected to be provided by third-party sellers.

This policy demonstrates the long tail phenomenon in a huge amount of its apparel products both by first and third-party sales. However, sales of high-value products are initiated by segmented category of business within first-party sellers. The development of *ADFs* from 2017 is a typical case. Therefore, contrasting the limited number of products, significant contribution to revenues (sales) has been initiated by first-party sellers depending on online sales.[4]

2. Homeostasis Management

Relative apparel intensity, RAI (η) can be depicted as follows:

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[4] Amazon shares an extremely high level of online sales than its competitors, representing 50% of net sales in 2019. Its apparel sales share in 2019 was estimated at as 18% of net sales, the majority of which depended on online sales. Strong first-seller sales initiatives in developing *ADFs* from 2017 contributed to a significant increase in online store sales. While certain apparel sales (including those in Luxury Stores starting from 2020) were conducted in third-party seller services (Maters, 2021), these shares seemed to remain limited (around 2% of net sales) as the third-party seller services share was 19.2% of net sales in 2019 and the percentage of sellers in the clothing and shoes category (including jewelry) in third-party sellers services was 13% (11th out of 28 categories) (Fig. A2). Profitability of this category was 25th out of 28 categories (Jungle Scout, 2021).

$\eta = (\text{Apparel sales share: ASS})/(\text{Online sales share: OSS})$

$$= \frac{\frac{A_{Am}}{A_U}}{\frac{O_{Am}}{O_U}} \equiv \frac{ASS}{OSS} \tag{A1}$$

A_{Am}: Amazon apparel sales; A_U: US apparel sales; O_{Am}: Amazon online sales; O_U: US online sales.

$$ASS = A_1 + A_3 \tag{A2}$$

A_1: First-party sellers sales share; A_3: Third-party sellers sales share.
 Third-party sellers sales share

$$\varphi(t) = \varphi + \varphi'(t) = A_3/A_1 \ll 1 \tag{A3}$$

φ: Constant rate over the period; $\varphi'(t)$: Fluctuating rate depending on time.
 $A_3 = \varphi(t) A_1$ Whilst small ratio, certain level of A_3 maintains by fluctuating within a certain range.
 Since revenues (sales) growth depends on rapid increase in A_1, $\frac{\Delta A_3}{A_3} \leq \frac{\Delta A_1}{A_1}$

$$\therefore \frac{\Delta A_3}{A_3} = \frac{\Delta \varphi(t)}{\varphi(t)} + \frac{\Delta A_1}{A_1} \leq \frac{\Delta A_1}{A_1} \therefore \frac{\Delta \varphi(t)}{\varphi(t)} = \frac{\Delta \varphi + \Delta \varphi'(t)}{\varphi(t)} = \frac{\Delta \varphi'(t)}{\varphi(t)} \leq 0$$

In order to maintain A_3, $\frac{\Delta \varphi(t)}{\varphi(t)} = \frac{\Delta \varphi'(t)}{\varphi(t)} \geq 0$.
 Therefore, $\Delta \varphi'(t) \approx 0$ This can be satisfied by $\sum \varphi'(t) = 0$ (fluctuation converge) (A4).
 Provided that A_1 depends on OSS with the ratio $\pi(t)$

$$A_1 = \pi(t) \ OSS \tag{A5}$$

$$ASS = (1 + \varphi(t)) \ A_1 = (1 + \varphi(t)) \ \pi(t) \ OSS \tag{A6}$$

$$\eta = ASS / OSS = (1 + \varphi(t)) \ \pi(t)$$

Since $\varphi(t) \ll 1$,
 $\ln \eta = \ln(1 + \varphi(t)) + \ln \pi(t) \approx \varphi(t) + \ln \pi(t)$

$$\frac{\Delta \eta}{\eta} \approx \Delta \varphi(t) + \frac{\Delta \pi(t)}{\pi(t)} = \Delta \varphi'(t) + \frac{\Delta \pi(t)}{\pi(t)} \tag{A7}$$

Given the homeostasis management as.

(i) minimize fluctuation rate of third-party sellers sales share $(\sum \varphi'(t) = 0)$, and
(ii) maintain dependence of first-party sellers sales on online sales $(A_1/\text{OSS} = \pi(t))$ stable $(\frac{\Delta \pi}{\pi} \approx 0)$,

homeostasis management can be expected as. $\frac{\Delta \eta}{\eta} \approx 0$.
 Since $\frac{\Delta \pi}{\pi} \approx 0$ (Fig. A1), under the condition $\sum \varphi'(t) = 0$, $\frac{\Delta \eta}{\eta} \approx 0$ (Homeostasis).
 Fig.A1 demonstrates $\pi(t)$ maintains the same level in each respective stage.
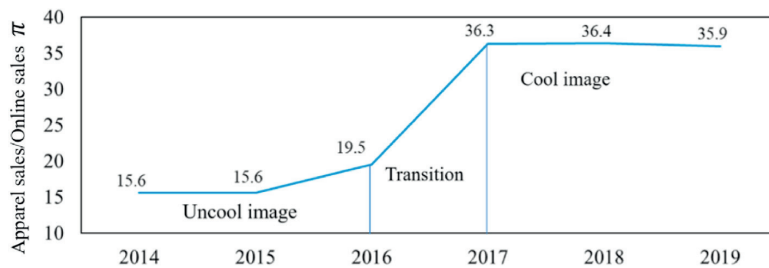

Fig. A1. Trend in Apparel Sales Share out of Online Sales in Amazon (2014–2019) - %.

3. Image of third-party sellers sales in Amazon

As a customer centric e-commerce leader, careful attention to maintain the richness of product lineup has been paid by including low profit margin products as demonstrated in Fig. A2.
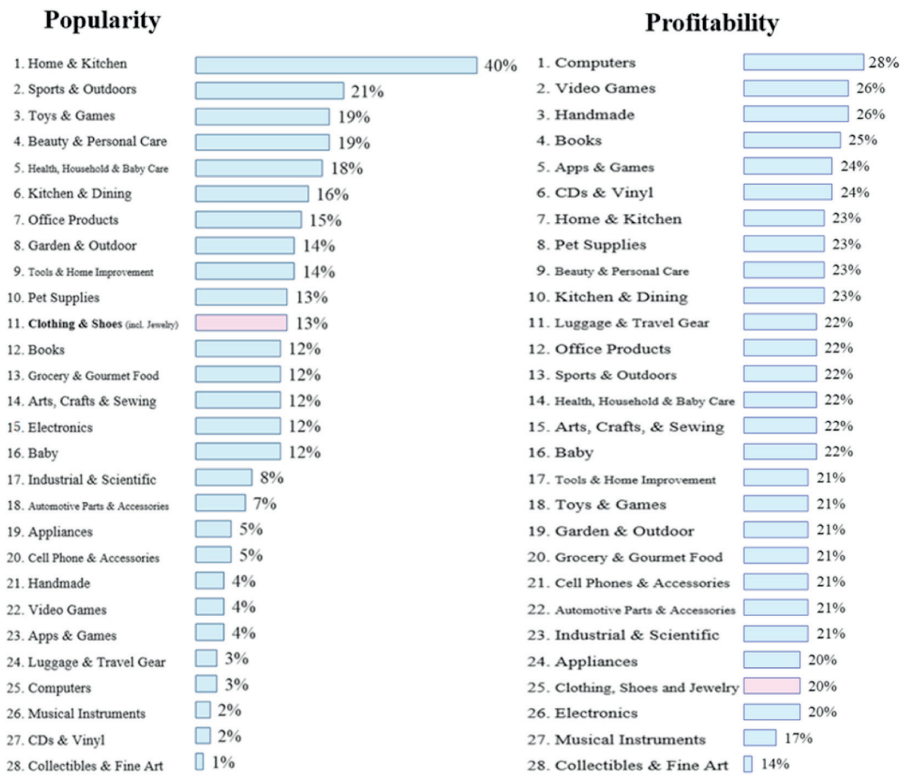
Popularity

1. Home & Kitchen	40%
2. Sports & Outdoors	21%
3. Toys & Games	19%
4. Beauty & Personal Care	19%
5. Health, Household & Baby Care	18%
6. Kitchen & Dining	16%
7. Office Products	15%
8. Garden & Outdoor	14%
9. Tools & Home Improvement	14%
10. Pet Supplies	13%
11. Clothing & Shoes (incl. Jewelry)	13%
12. Books	12%
13. Grocery & Gourmet Food	12%
14. Arts, Crafts & Sewing	12%
15. Electronics	12%
16. Baby	12%
17. Industrial & Scientific	8%
18. Automotive Parts & Accessories	7%
19. Appliances	5%
20. Cell Phone & Accessories	5%
21. Handmade	4%
22. Video Games	4%
23. Apps & Games	4%
24. Luggage & Travel Gear	3%
25. Computers	3%
26. Musical Instruments	2%
27. CDs & Vinyl	2%
28. Collectibles & Fine Art	1%

Profitability

1. Computers	28%
2. Video Games	26%
3. Handmade	26%
4. Books	25%
5. Apps & Games	24%
6. CDs & Vinyl	24%
7. Home & Kitchen	23%
8. Pet Supplies	23%
9. Beauty & Personal Care	23%
10. Kitchen & Dining	23%
11. Luggage & Travel Gear	22%
12. Office Products	22%
13. Sports & Outdoors	22%
14. Health, Household & Baby Care	22%
15. Arts, Crafts, & Sewing	22%
16. Baby	22%
17. Tools & Home Improvement	21%
18. Toys & Games	21%
19. Garden & Outdoor	21%
20. Grocery & Gourmet Food	21%
21. Cell Phones & Accessories	21%
22. Automotive Parts & Accessories	21%
23. Industrial & Scientific	21%
24. Appliances	20%
25. Clothing, Shoes and Jewelry	20%
26. Electronics	20%
27. Musical Instruments	17%
28. Collectibles & Fine Art	14%

Fig. A2. Popularity and Profitability of Product Categories in Amazon's Third-party Seller Services (2020). Popularity: % of sellers listed in the third-party seller services. Profitability: Average profit margin..
Source: Connolly (2021).

Third-party sellers sales share consists of φ (constant rate over the period) and $\varphi'(t)$ (fluctuating rate depending on time). Fluctuation is managed to minimize through the period as $\sum \varphi'(t) = 0$ as illustrated in Fig. A3.
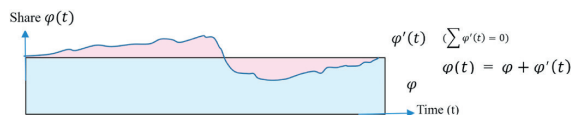

$$\varphi'(t) \quad (\sum \varphi'(t) = 0)$$
$$\varphi(t) = \varphi + \varphi'(t)$$

Fig. A3. Image of Third-party Sellers Sales Share in Amazon.

[93].

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V

A NEW PERSPECTIVE ON THE TEXTILE AND APPAREL INDUSTRY IN THE DIGITAL TRANSFORMATION ERA

by

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

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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

1. Introduction

The textile and apparel (fashion) industry has social, cultural, and economic signifi-cance 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 struc-ture, 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.
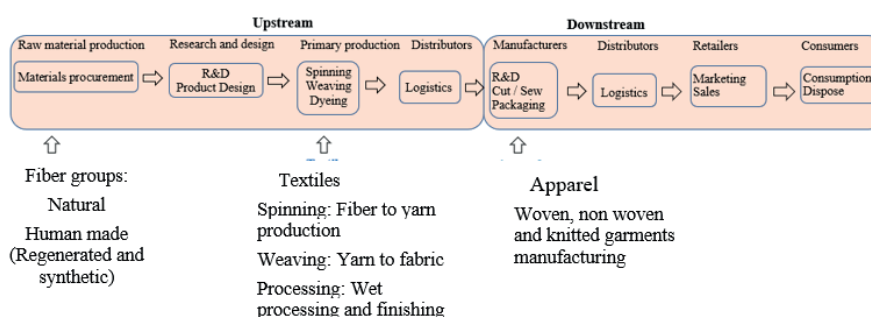

Figure 1. Value chain structure of the fashion industry.

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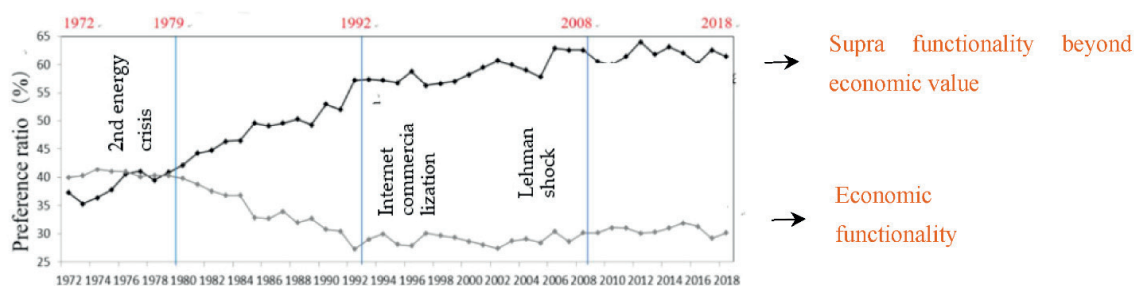
Figure 2. The trend in the shift of people's preferences in Japan (1972–2018). Source: National Survey of Lifestyle Preferences [50].

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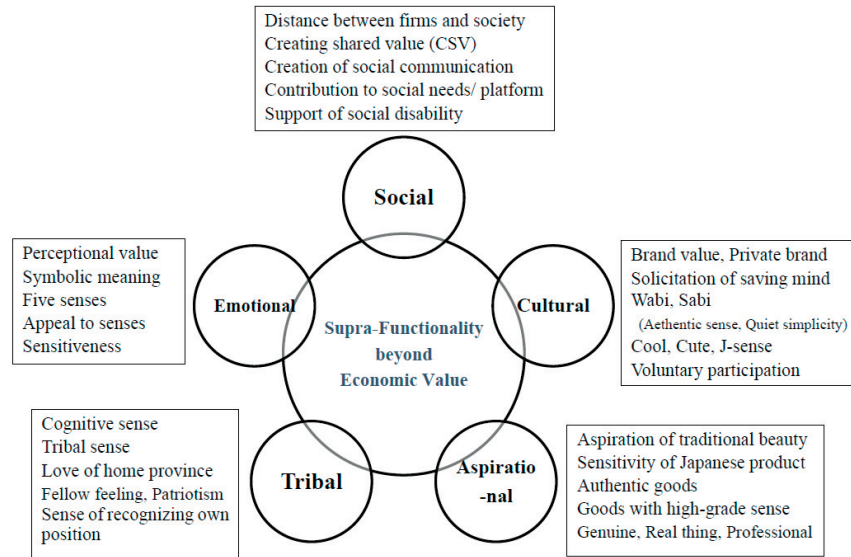
Figure 3. Concept of supra-functionality beyond economic value. Sources: [7–9].

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.

Elasticity of GDP to textile and apparel
$$\varepsilon_{AG} = \frac{5}{3} = 1.66$$

Elasticity of GDP to fast fashion
$$\varepsilon_{FG} = \frac{10}{3} = 3.33$$

Elasticity of textile and apparel to fastfashion
$$\varepsilon_{FA} = \frac{10}{5} = 2$$
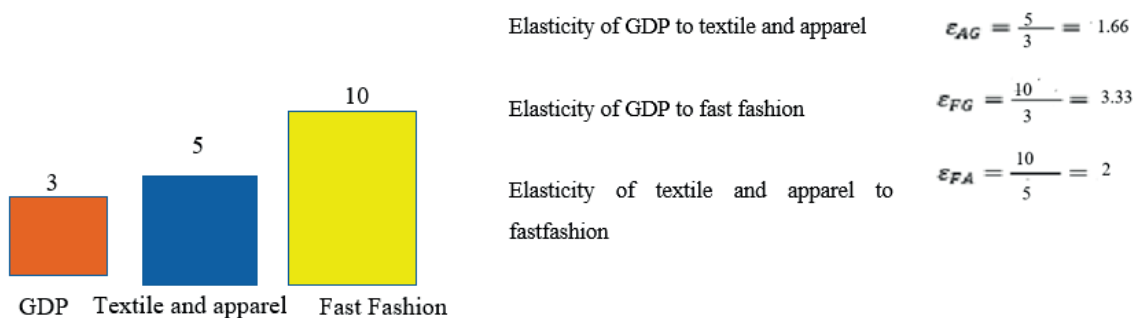
Figure 4. Comparison of the average growth rate of global GDP, total textile and apparel, and fast fashion (2011–2015).—%*p.a.* Source: Authors' elaboration based on [53,54].

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.
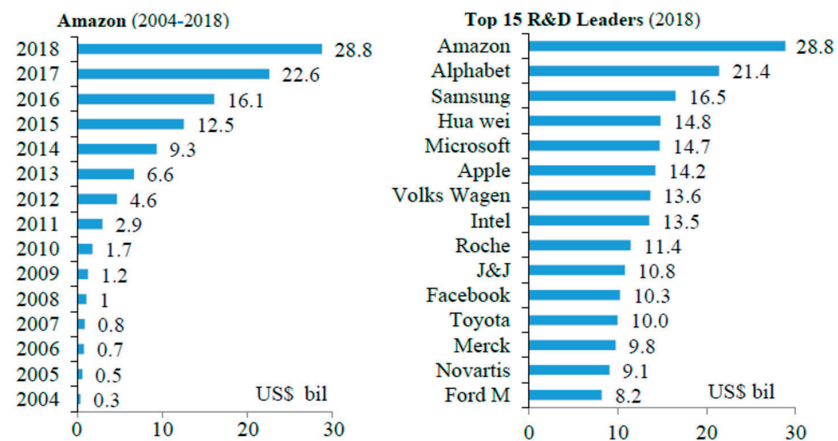
Figure 5. Amazon's conspicuous jump to become the world's top R&D leader—R&D investment. Sources: [64,65].
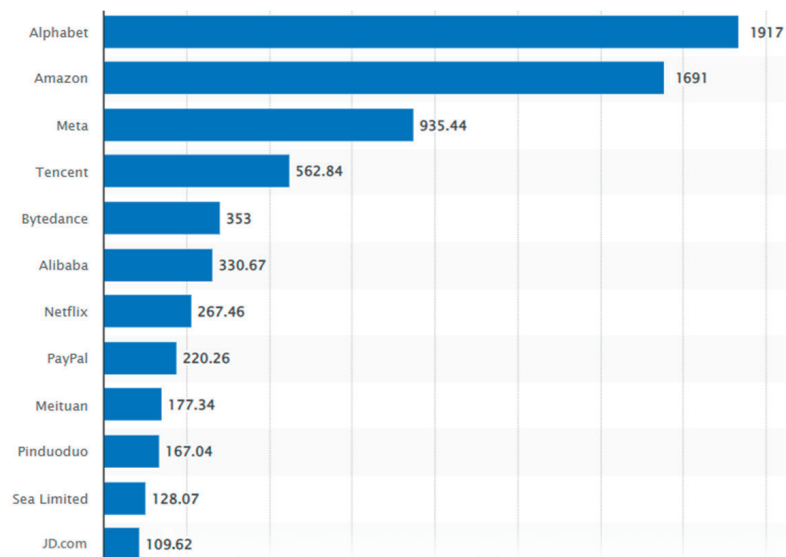
Figure 6. The market capitalization of the largest internet companies worldwide (June 2022). Source: [66].

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.
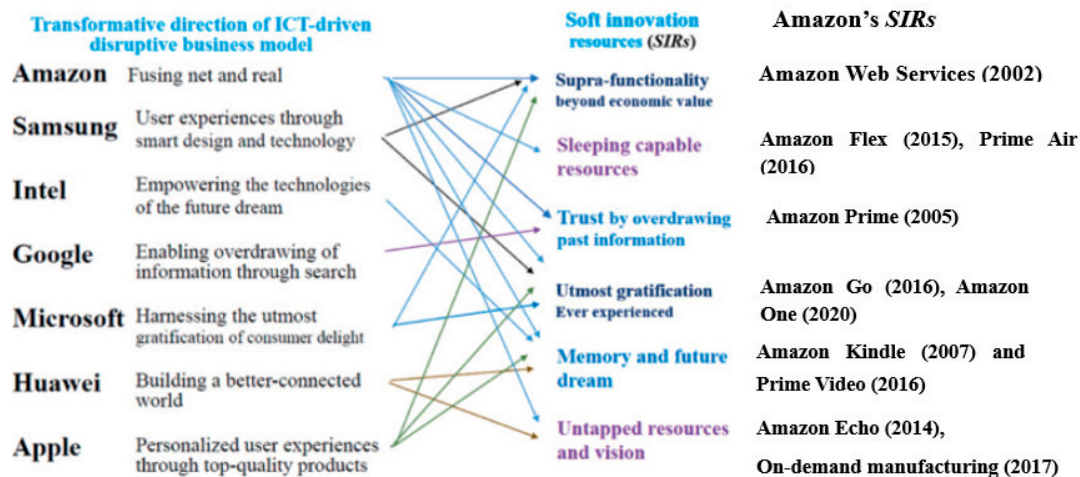

Figure 7. Soft innovation resources developed by top ICT leaders and corresponding examples in Amazon.

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

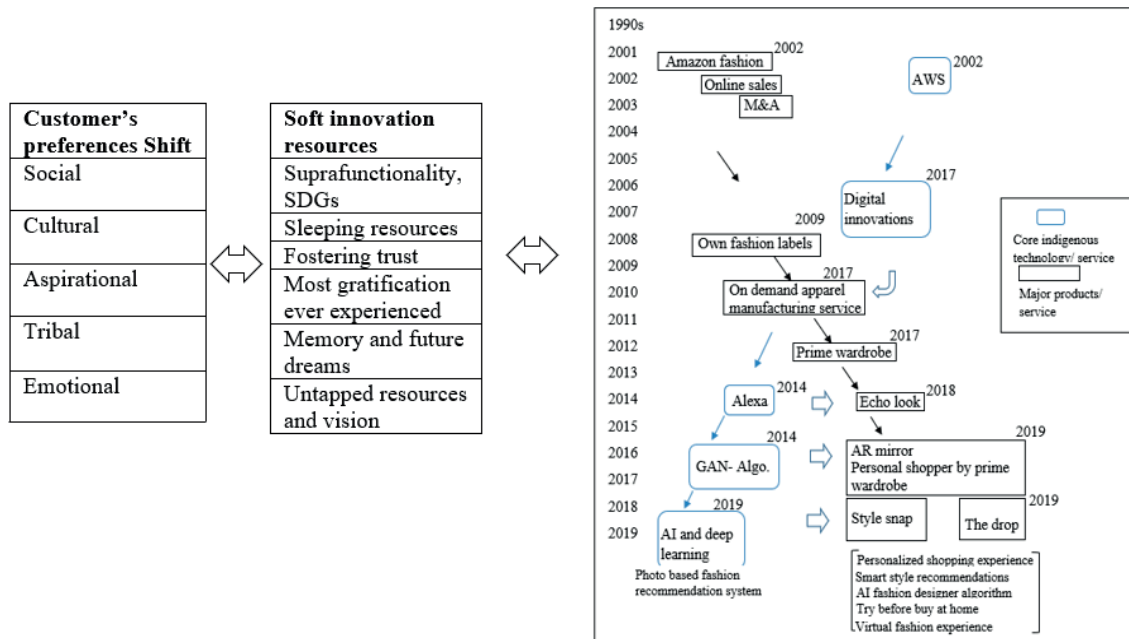to move from selling basic apparel as traditional value to more fashionable higher-value categories.

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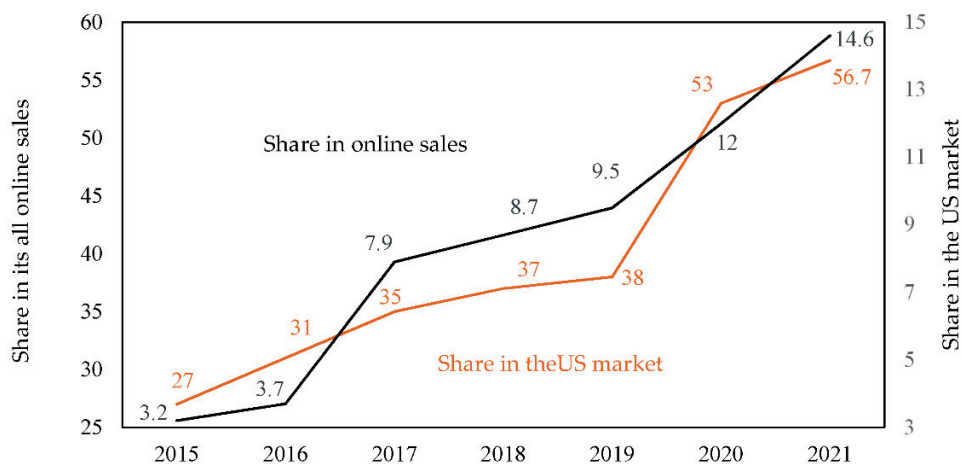
Figure 9. Trends in Amazon's apparel sales share (2015 to 2021): percentage. Sources: [70–76].

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.
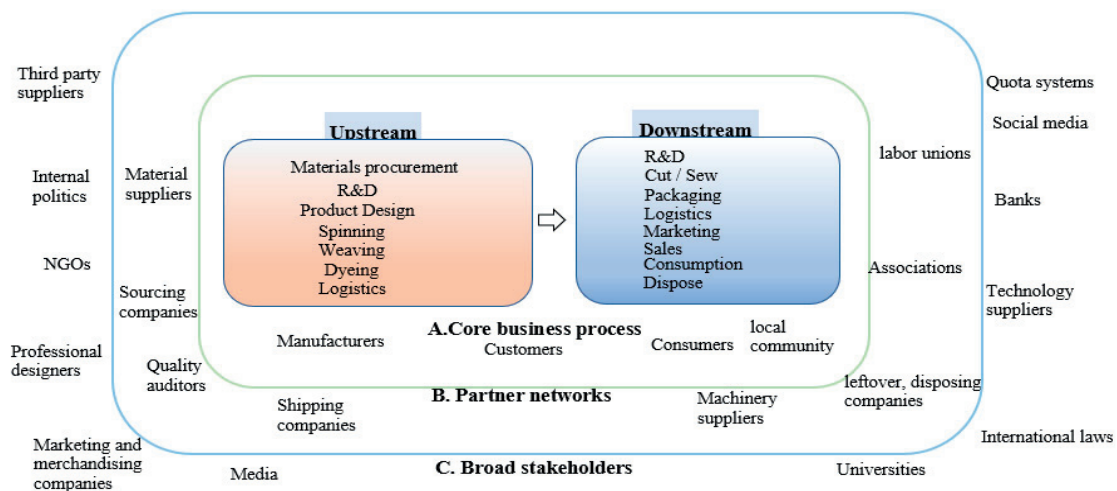

Figure 10. Relative importance of stakeholders in the Amazon fashion business. Source; Authors.

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.
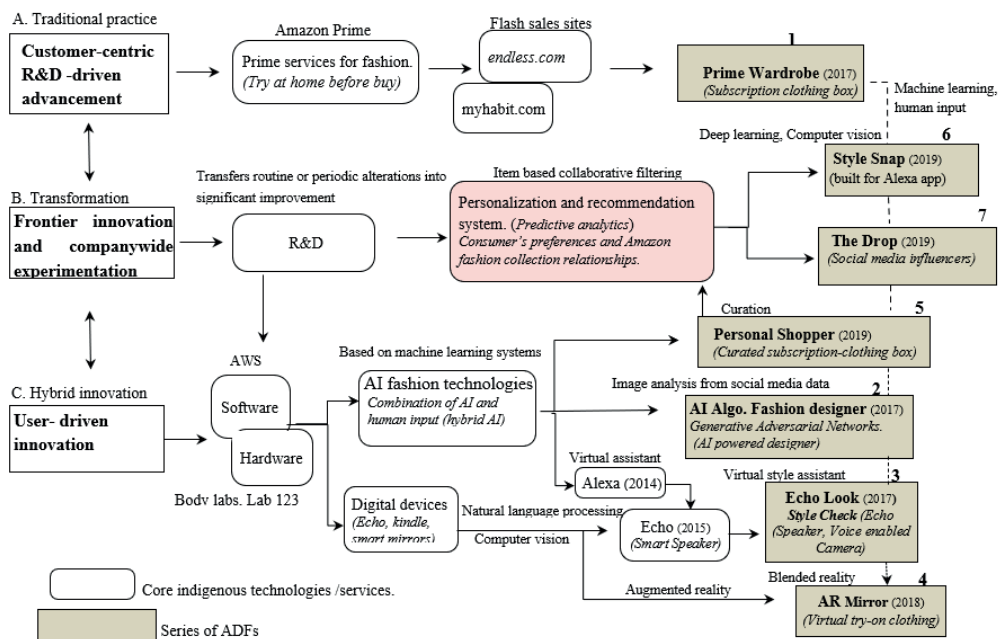

Figure 11. Amazon's ADFs development by learning from preceding innovations. Source: Authors' elaboration based on [10].

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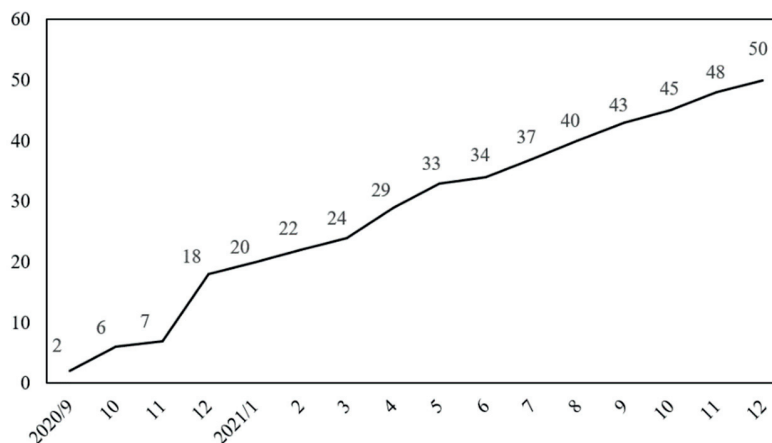
Figure 12. The trend in the cumulative number of luxury brands joining Amazon.

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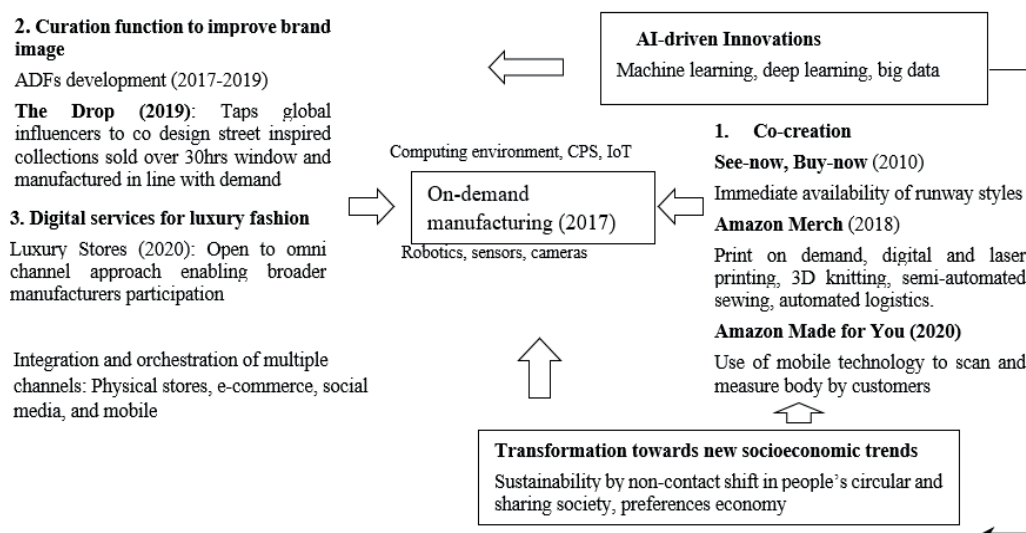
Figure 13. Amazon's initiatives toward on-demand manufacturing in the luxury fashion business.

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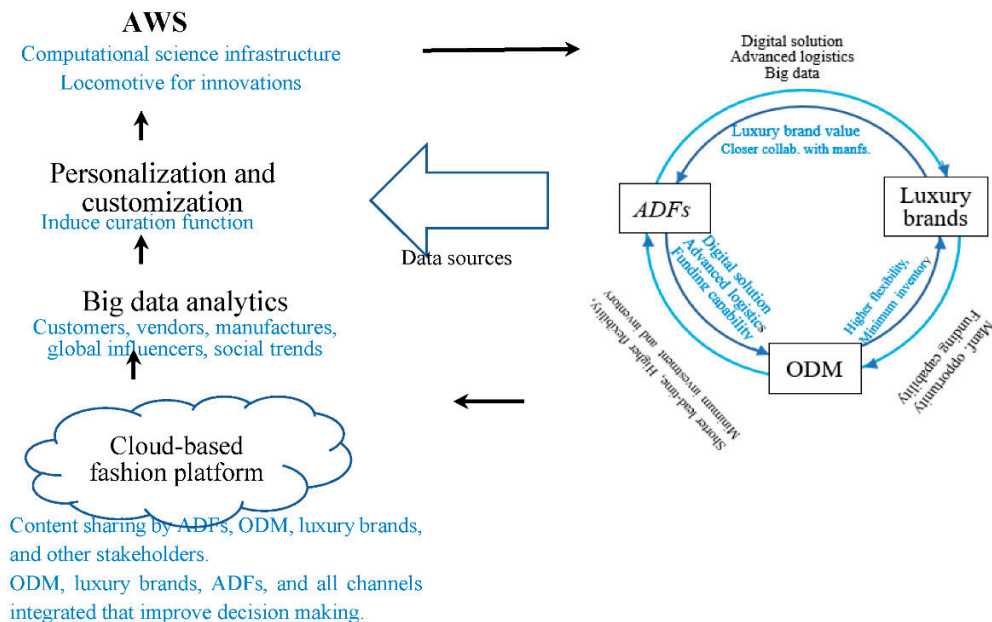
Figure 14. Dual co-evolution Among ADFs, luxury brands, ODM co-evolution, and cloud-based fashion platform advancement.

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.
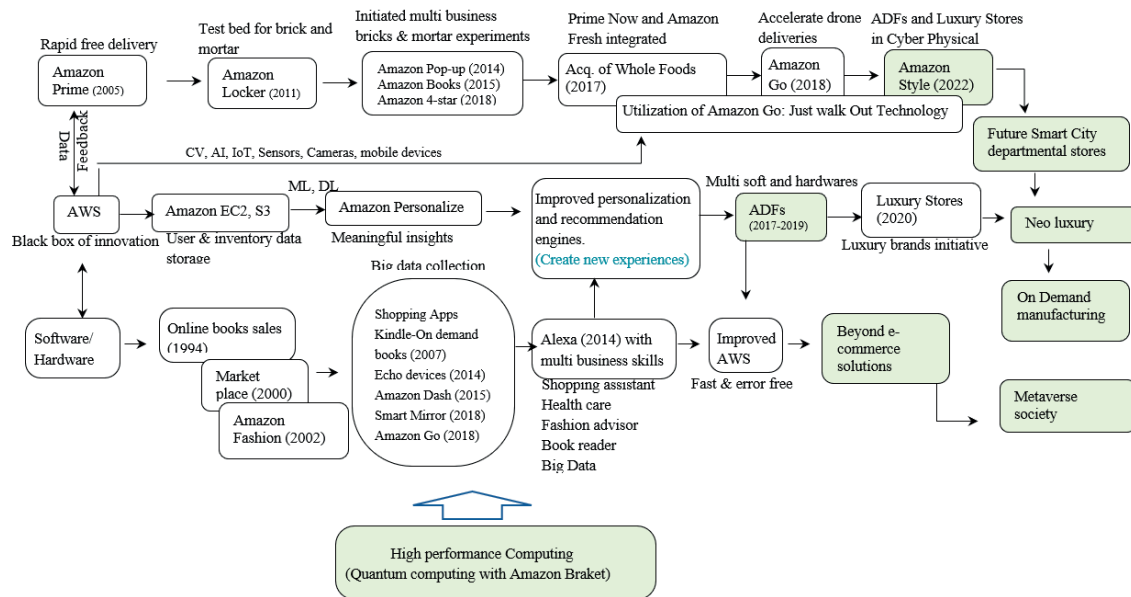

Figure 15. Learning orchestration beyond e-commerce.

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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