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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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ABSTRACT

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].
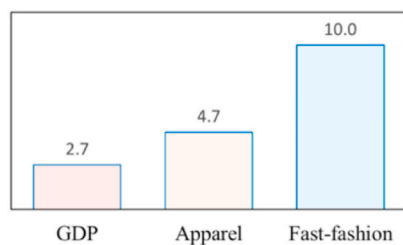
A series of ADFs have been developed since 2017 on a priority basis, as shown in Table 1. Based on this approach, in contrast to the limited number of products, a significant contribution to sales has been initiated by first-party sellers dependent on online sales, as shown in Fig. 2. Thus, Amazon has 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 A*DFs* 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.
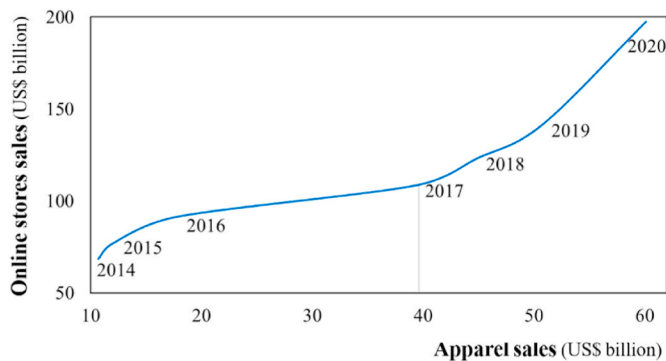Source: Watanabe et al. [21].

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
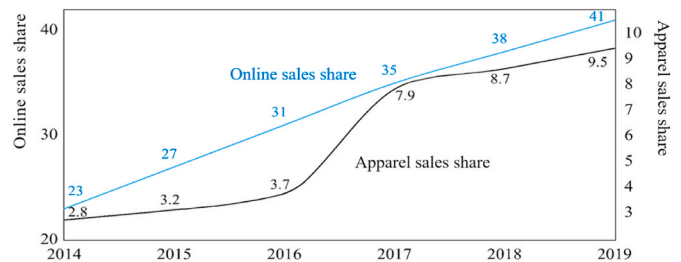

Fig. 3. Trends in Amazon's apparel sales share in the U.S. Market (2014–2019), **percentage**.
Sources: Lieber [32]; Statista [33]; Keyes [34]; Richter [35]; Wichser et al. [36]; PYMNTS [37]. Sabanoglu [38]; eMarketer [39].

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:

$$\eta = (\text{Apparel sales share}) \Big/ (\text{Online sales share}) = \frac{\frac{A_{Am}}{A_U}}{\frac{O_{Am}}{O_U}} = \frac{\frac{A_{Am}}{O_{Am}}}{\frac{A_U}{O_U}} = \frac{\frac{A_{Am}}{O_{Am}}}{\frac{A_U}{W_U}} \times \frac{O_U}{W_U} = (\text{Apparel intensity ratio}) \times (\text{U.S. online sales share}) \tag{1}$$

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
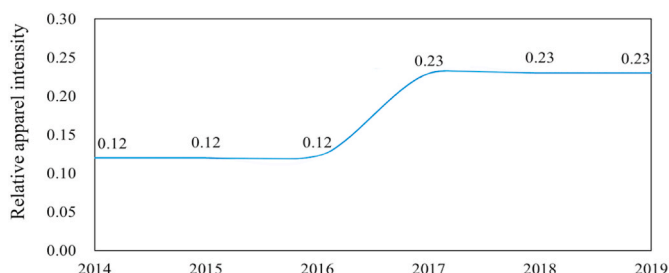
thus survivable life states but are more likely to fail than fully automated mechanisms [42].

(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

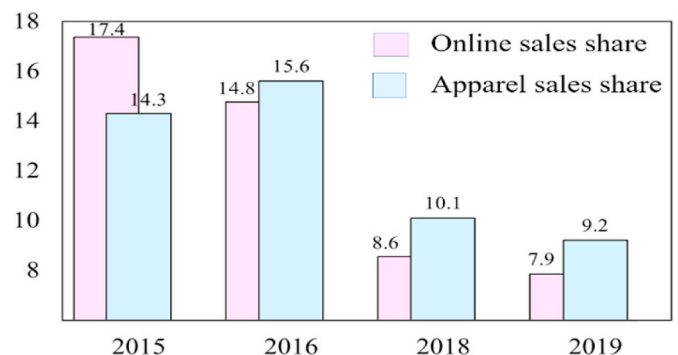Amazon, as an R&D-driven customer-centric firm [5,6], has fully

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*).
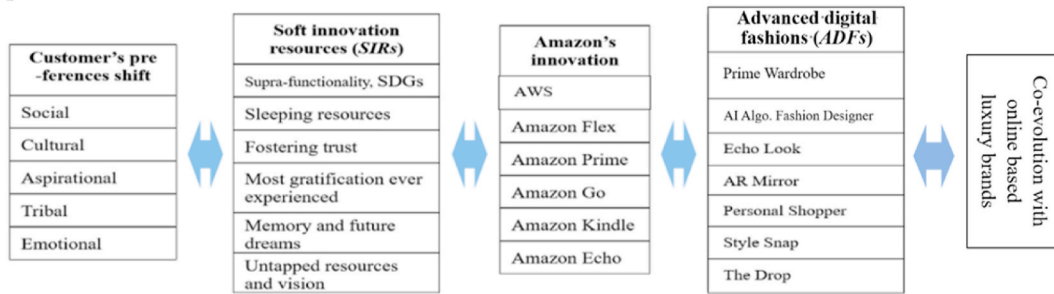
Fig. 6. Co-evolution between Amazon's SIRs-induced innovation and advanced digital fashion development.
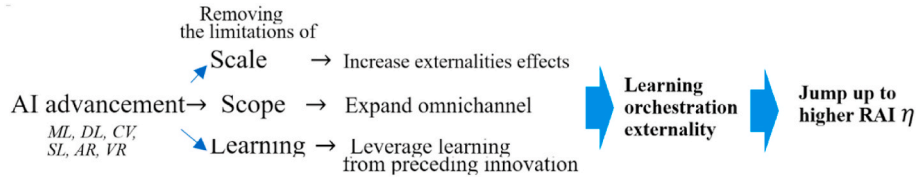

Fig. 7. Scheme of emerging learning orchestration externalities in Amazon's AI-driven advanced digital fashion development.

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.
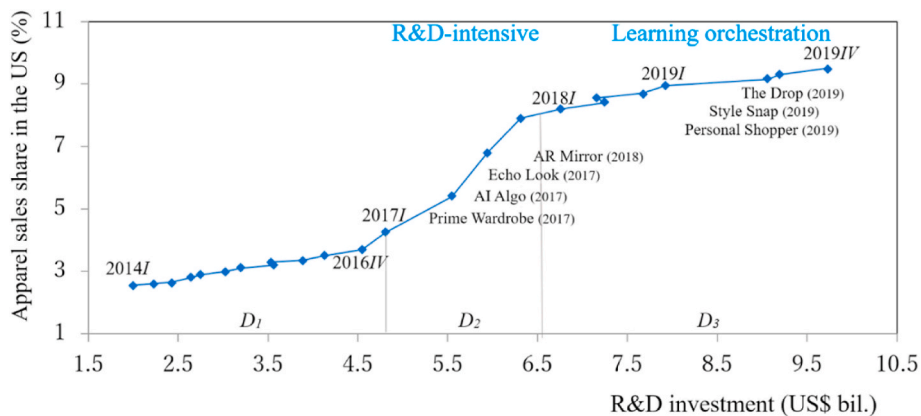

Fig. 8. Correlation between Amazon's R&D Investment and Apparel Share in the U.S. Market (2014–2019 quarterly).

Table 3

R&D contribution to shift to omnichannel approach in amazon (2014–2019).

$S(t) = Ae^{\lambda t}R(t)^{\alpha}$ $\quad$ $\ln S(t) = \ln A + \lambda t + \alpha \ln R(t)$							
$\ln S(t) = 1.75 + 0.03D_1 t + 0.13D_2 t + 0.02D_3 t + 0.85D_2 \ln R(t) - 0.85D_1 - 3.38D_2$							
	(49.38)	(35.98)	(5.81)	(12.30)	(3.31)		(−23.70) (−24.16)
$adj.R^2$ 0.999 $\quad$ *DW*2.46							

$S(t)$: 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.
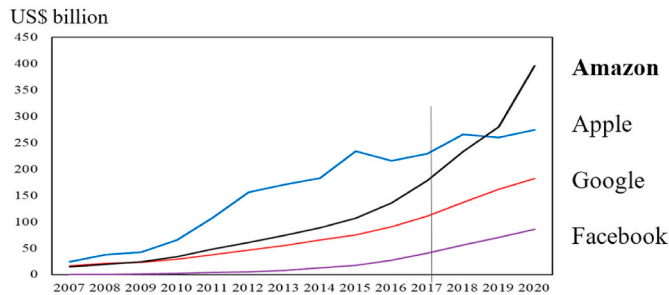

Fig. 9. Trend in sales in GAFA (2007–2020).
Source: US SEC [46].

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:
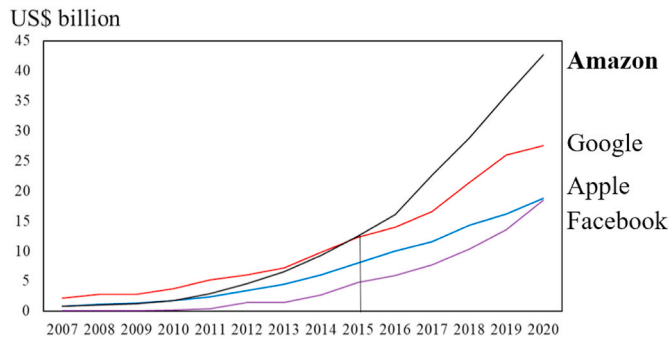
Fig. 14. Trend in R&D investment in GAFA (2007–2020).
Source: US SEC [46].
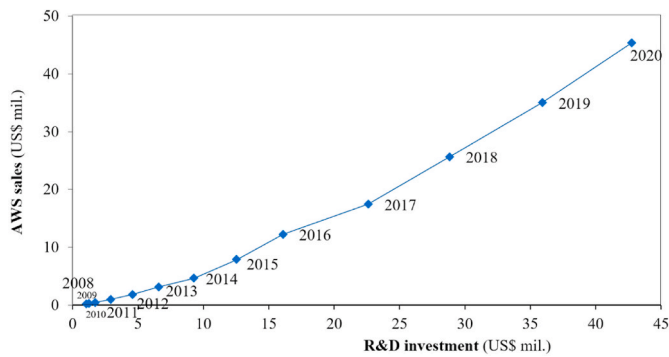
Fig. 15. Correlation between R&D and AWS (2008–2020).
Source: US SEC [46].

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.
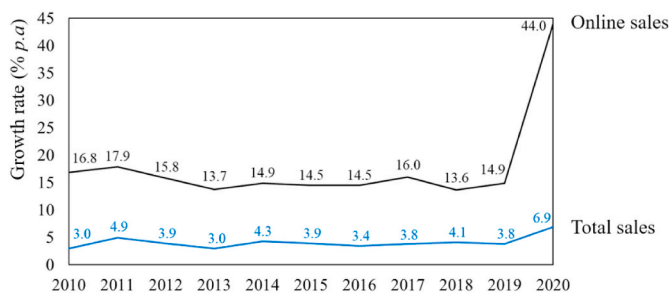
Fig. 16. Trend in growth rate of online sales and total sales in the US (2010–2020).
Source: Digital Commerce 360 [48].
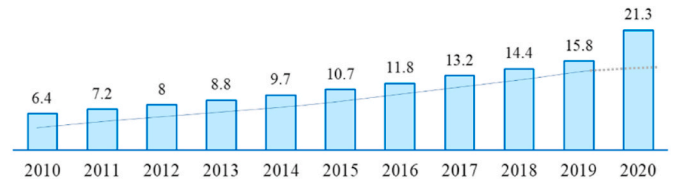
Fig. 17. Trend in Online Sales Penetration in the US (2010–2020), % of online sales out of total sales.
Source: Digital Commerce 360 [48].

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-
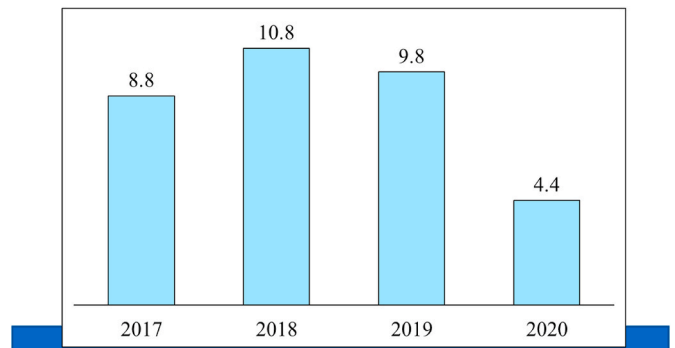
Fig. 18. Increase in Amazon's Retail e-Commerce Share in the US (2017–2020), % p.a.
Sources: Statista [22]; eMarketer [39].

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:

Amazon's apparel intensity $=$ Relative apparel intensity $\times$ Apparel share/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)

$$\frac{A_{Am}}{O_{Am}} = \eta \times \frac{A_U}{W_U} \Big/ \frac{O_U}{W_U} \quad \eta = 0.12 \text{ (before 2016)}, 0.23 \text{ (after 2017)} \quad (2)$$

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:

Relative apparel intensity $=$ (Amazon's apparel intensity $/$ Apparel intensity in the US$) \times ($Online sales share in the US)
$= ($Amazon's luxury brands intensity $\times$ Apparel and luxury brands ratio$) / ($Apparel intensity$)$
$\times ($Online sales share$)$.

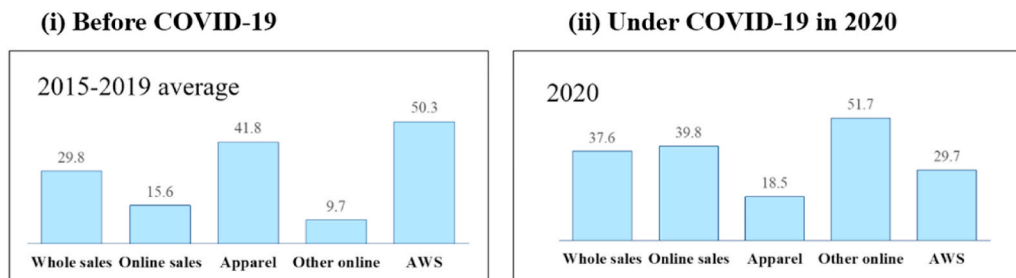

Fig. 19. Growth Rate in Amazon's Sales by Period (% *p.a*). All apparel is included in online sales.
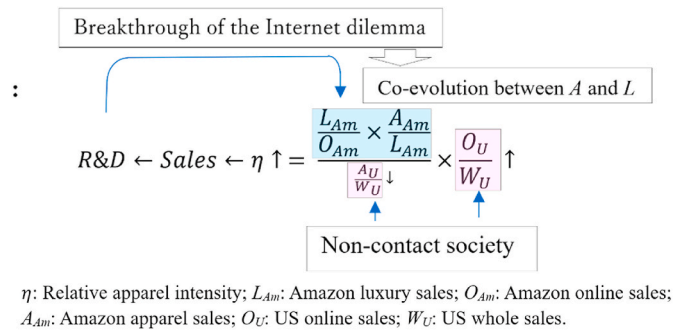Source: Statista [22].

:

$$R\&D \leftarrow Sales \leftarrow \eta \uparrow = \frac{\frac{L_{Am}}{O_{Am}} \times \frac{A_{Am}}{L_{Am}}}{\frac{A_U}{W_U} \downarrow} \times \frac{O_U}{W_U} \uparrow$$

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.

Fig. 20. Dynamism leveraging Co-evolution between ADFs and luxury brands development.

$$\eta = \frac{\frac{A_{Am}}{O_{Am}}}{\frac{A_U}{W_U}} \times \frac{O_U}{W_U} = \frac{\frac{L_{Am}}{O_{Am}} \times \frac{A_{Am}}{L_{Am}}}{\frac{A_U}{W_U}} \times \frac{O_U}{W_U} \quad (3)$$

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. 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].
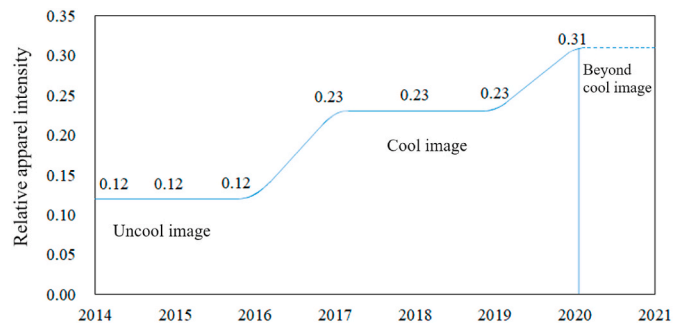

Fig. 21. Amazon's relative apparel intensity beyond its cool image.* $\frac{A_{Am}}{A_U}$ (2020) = 0.12 [55], $\frac{O_{Am}}{O_U}$ (2020) = 0.39 [39], $\frac{A_{Am}}{A_U} / \frac{O_{Am}}{O_U}$ = 0.31.
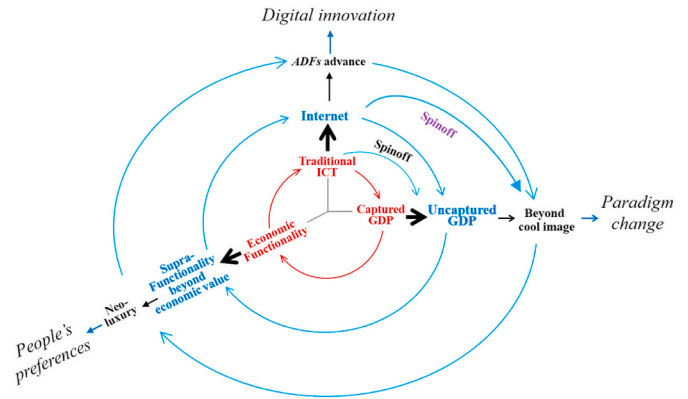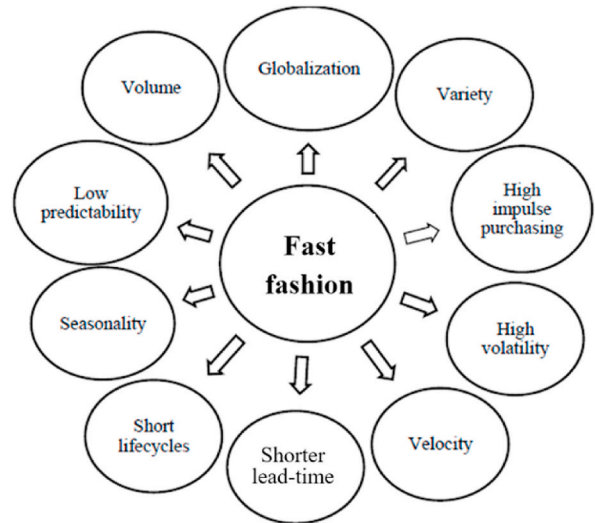

Fig. 23. Key features of the fashion industry in the digital economy. Source: Authors' elaboration based on Ciarniene et al. [58].

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.

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. 24. Key cultural shifts redefining the face of global luxury.
Source: Authors' elaboration based on Olbert [64].
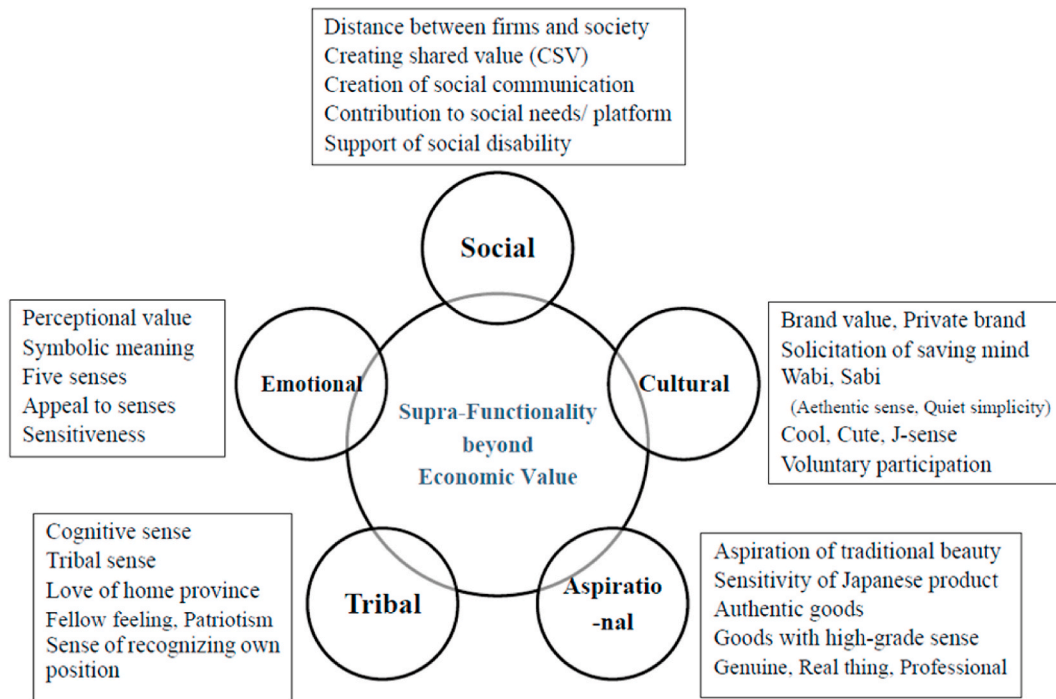
Fig. 25. Basic concept of supra-functionality beyond economic value.
Source: Watanabe et al. [56].
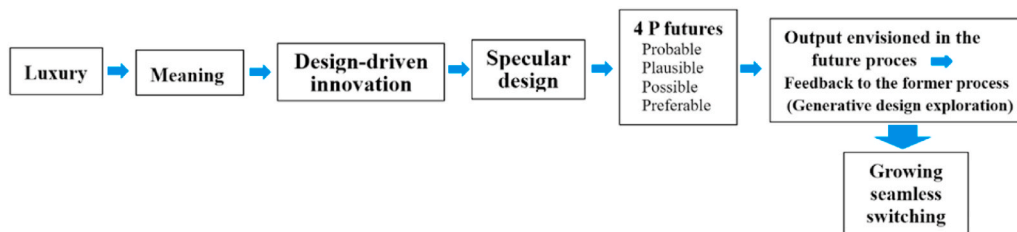
Fig. 26. The scheme in exploring new perspective of innovation.
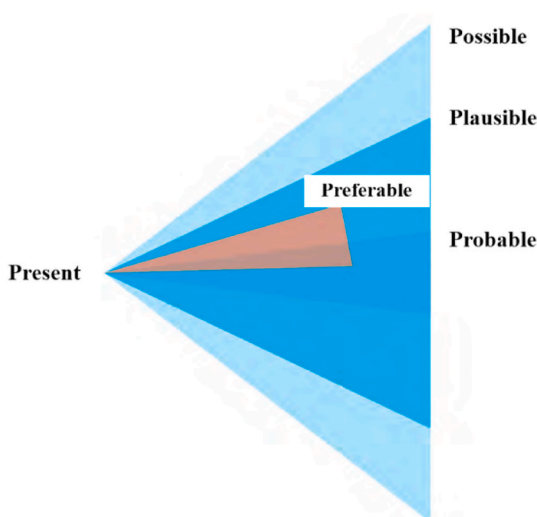
Fig. 27. PPPP for predicting the future.
Source: Dunne et al. [15].

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.
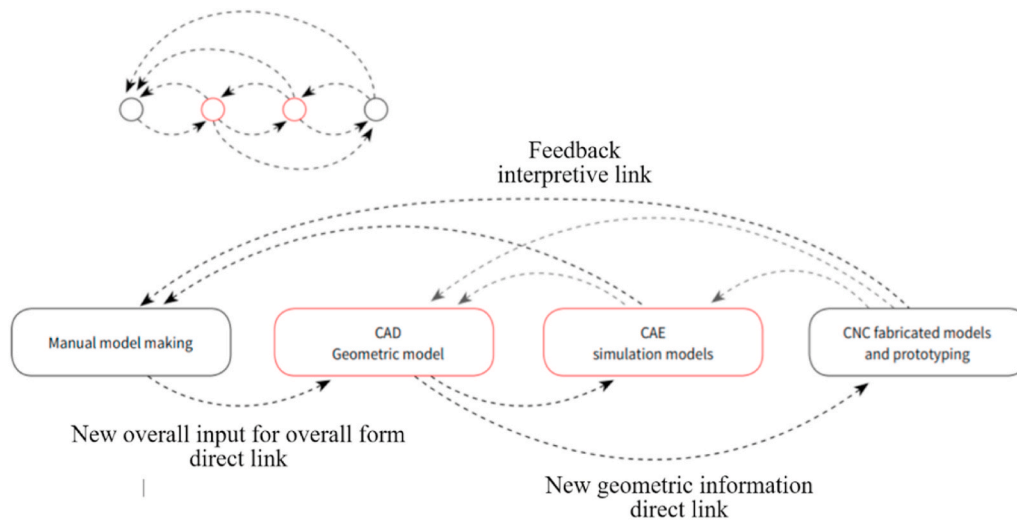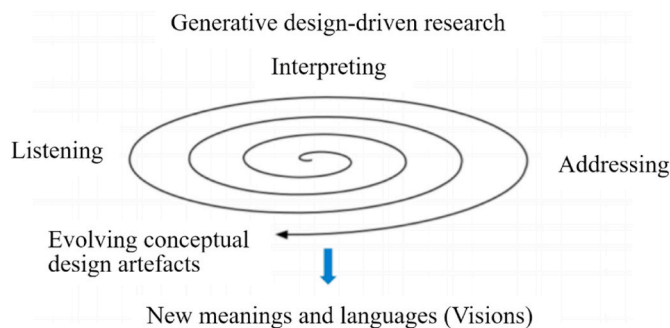
5.2.4. Generative design-driven innovation

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
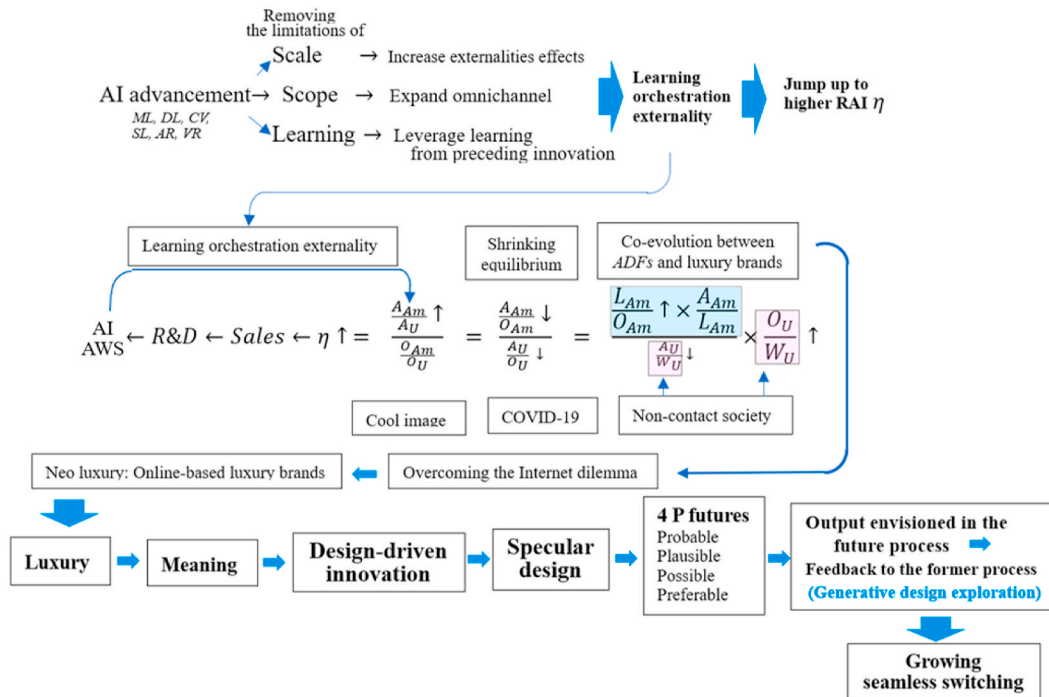
η: Relative apparel intensity, L: luxury, O: Online sales, A: Apparel sales, W: Whole sales, A_m: Amazon, U: US market.

Fig. 30. Dynamism leading to a supra-omnichannel with growing seamless switching.

Collab.: collaboration; Manf.: manufacturing

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 (7.01)	0.05 (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%.
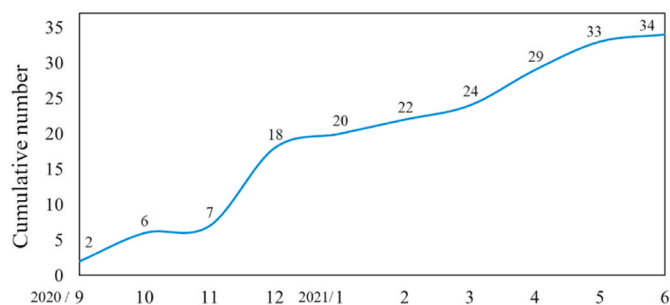
Fig. 32. Trend in cumulative number of luxury brands that joined luxury stores (september 2020–June 2021).

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.

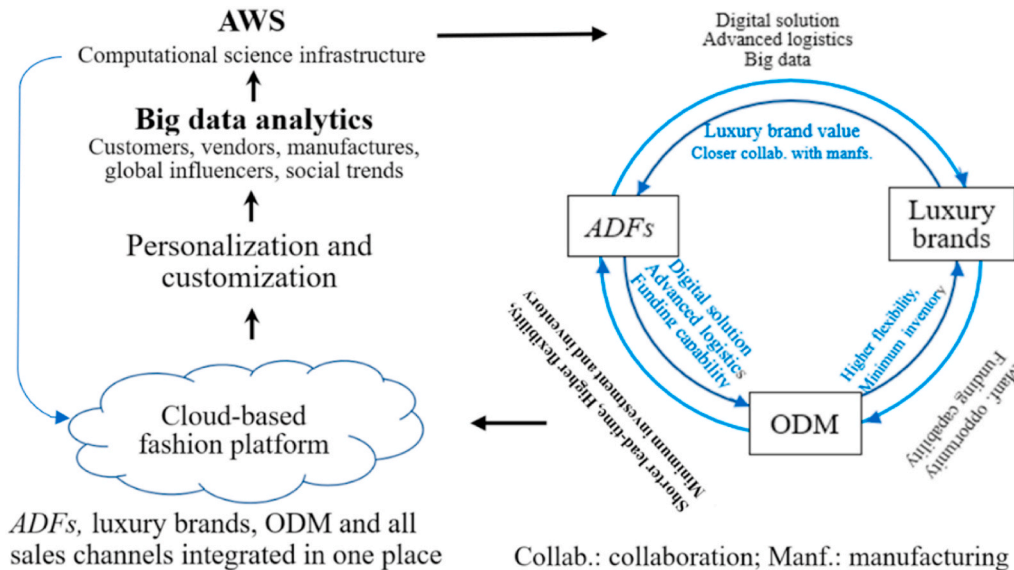Thus, dual co-evolution among ADFs, luxury brands, ODM co-evolution, and cloud-based fashion platform advancement emerges, as illustrated in Fig. 31.

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 socio-political 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).

$\eta = ($Apparel sales share: ASS$)/($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, $\frac{\Delta A_3}{A_3} \leq \frac{\Delta A_1}{A_1}$

$$\therefore \cdot \frac{\Delta A_3}{A_3} = \frac{\Delta \varphi(t)}{\varphi(t)} + \frac{\Delta A_1}{A_1} \leq \frac{\Delta A_1}{A_1} \therefore \frac{\Delta \varphi(t)}{\varphi(t)} = \frac{\Delta \varphi + \Delta \varphi'(t)}{\varphi(t)} = \frac{\Delta \varphi'(t)}{\varphi(t)} \leq 0$$

  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 $(A_1/OSS = \pi(t))$ 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.
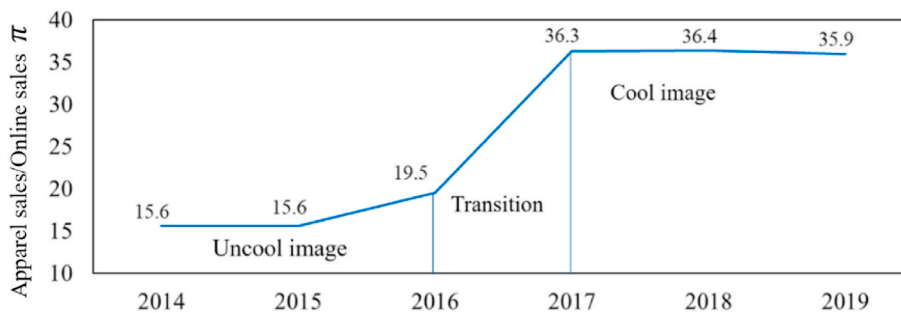

Fig. A1. Trend in Apparel Sales Share out of Online Sales in Amazon (2014–2019) - %.

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.
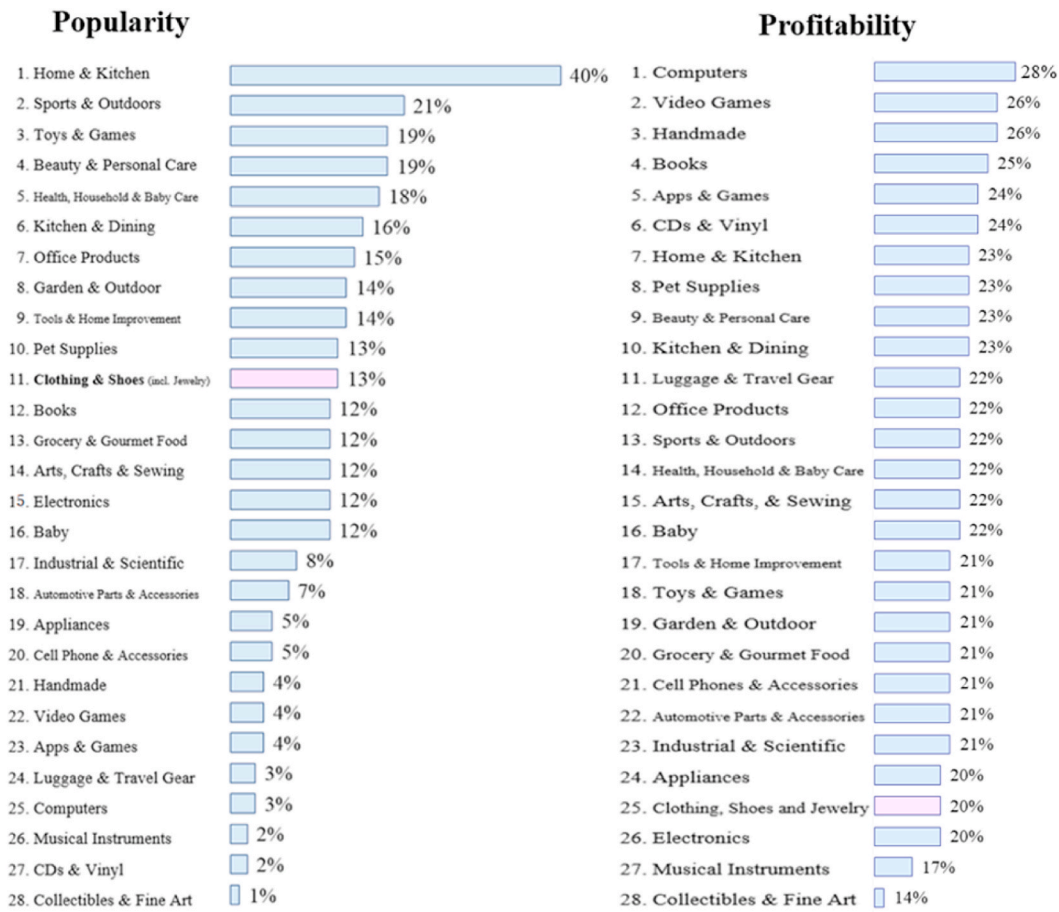
Popularity

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.
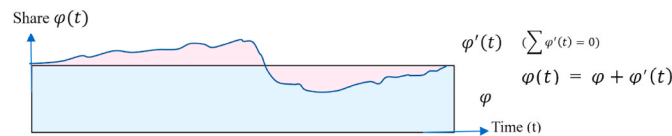

$$\varphi'(t) \quad (\sum \varphi'(t) = 0)$$
$$\varphi(t) = \varphi + \varphi'(t)$$

Fig. A3. Image of Third-party Sellers Sales Share in Amazon.

[93].

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