PUBLIC INTEREST IN CIRCULAR FASHION IN POST-PANDEMIC SCENARIO: ANALYSIS AND EVOLUTION PATHS FROM GOOGLE TRENDS DATA

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ABSTRACT

The COVID-19 pandemic has triggered transformative shifts in global economies and societal norms, catalyzing profound changes across industries, notably within the fashion sector—the world's third largest polluter. This period has realigned consumer preferences towards circular fashion, setting a precedent for the post-pandemic 'new normal' in this sector. It highlights the importance of leveraging this moment to explore the growth potential of circular fashion interest post-pandemic, demonstrating our collective resilience to significant threats and paving the way for sustainable resurgence. Using Google Trends, this study investigates the global shift in public interest towards circular fashion amid the COVID-19 pandemic, hypothesizing a surge in interest due to the pandemic's impact. Employing a time-series analytical framework, this study combines Google Trends data from 2017 to 2022 with quantitative methods like the grey forecast model and cusp catastrophe theory to map post-pandemic trends and evolutions. Our approach encompasses bibliometric keyword selection, time-series data aggregation, grey forecasting, and cusp catastrophe theory application for evolutionary modeling. Our analysis reveals a huge increase in public engagement with circular fashion post-pandemic, suggesting the pandemic is a potential catalyst for sustainable consumer behavior. The application of catastrophe theory reveals the polymorphic, mutating, gradual, lagging, and reversible nature of circular fashion's evolution. The study identifies a marked shift in Google search trends, indicating a robust post-pandemic increase in interest in a circular fashion. These insights provide a strategic basis for post-pandemic planning, aiming to enhance our understanding of consumer perspectives and inform industrial practices in a pandemic-resilient world.

1. INTRODUCTION

The global COVID-19 pandemic, declared by the World Health Organization on March 11, 2020, has caused major shifts in societal structures and public health paradigms, further catalyzing transformation(1). This adoption of measures such as social distancing, border restrictions, and contact tracing has led to profound alterations in life quality, including psychological disturbances and changes in physical activities(2, 3). Simultaneously, these shifts have spurred an intricate interplay of challenges and opportunities, leading to huge changes in consumer behavior, societal customs, and, notably, the sphere of circular fashion.

Before the COVID-19 pandemic, the fashion industry's pursuit of a distinctive style significantly impacted environmental sustainability, contributing to approximately 8-10% of worldwide emissions and excessive water consumption(4, 5). Circular fashion systems thus emerge as a sustainable strategy by reinfusing value into the market through recycling, signifying a significant paradigm shift in consumer acceptance of secondhand clothing. The pandemic's impact on less frequent wardrobe changes accelerates this shift, eroding the stigma surrounding preowned clothing. However, the growth of circular fashion during the COVID-19 pandemic faces considerable hurdles, prompting discussions on strategies for its post-pandemic expansion and evolution. As we proceed into the fourth year of the pandemic, considering its enduring implications becomes imperative, requiring an exploration of changes in consumer preference patterns, the heightened appeal of circular fashion due to its potential to curb environmental pollution, and altered consumer attitudes toward the environmental impact of the fashion industry.

Preliminary evidence suggests that the disruption of established behaviors caused by the pandemic could foster enduring sustainable behavior changes(6). The gradual eradication of the stigma associated with secondhand purchases coincides with increased demand for organic products and the popularity of sustainable brands, indicating a growing consumer interest in recycling and sustainable lifestyles. Concurrently, the fashion industry seeks to establish competitive differentiation through eco-fashion offerings while dealing with an economic downturn prompted by decreases in global economic, household consumption, energy prices, and stock market instability(7, 8). Thus, achieving an equilibrium between personal hygiene and community preferences for circular fashion becomes critical in the post-pandemic era. Given the potential for future outbreaks, this balance is not temporary but poses enduring challenges. However, the possibility of pandemic-induced changes in habitual behaviors fostering long-term sustainable modifications circularly remains uncertain. Identifying and addressing current needs is vital for the industry, bearing direct implications for the long-term influence of circular fashion in the post-pandemic world.

The explosion of 'big data' reflects the intricacy of contemporary scientific endeavors, offering a distinctive prospect for interdisciplinary exploration of intricate global issues, notably in a circular fashion. Google Trends, a freely accessible digital tool, enables the measurement of relative search volume fluctuations over specific periods and locales, offering an unmatched index of public interest. Its utility, established in myriad studies, is exploited for predicting social and economic factors across multiple empirical fields(9, 10). With Google catering to two-thirds of global search engine users, its data are utilized in our analysis. The current data procurement predominantly hinges on online sources, making Google Trends a potent instrument for capturing search term volumes and observing their temporal changes(10). This resource facilitates the creation of graphical, spatial, and temporal depictions of keyword-based search interest. The potential of network search data in shaping a circular fashion demand prediction model has yielded favorable outcomes, highlighting its superiority over conventional econometric and machine learning models based on historical data. Although Google Trends efficiently discerns demand shifts for specific topics, its usage in circular fashion remains underutilized. Hence, our research endeavors to fill this gap, delving into the potential of Google Trends' data to predict, uncover, and offer fresh perspectives on the significance and trends of circular fashion. This scrutiny extends to assessing circular fashion's role in promoting international scientific dialog and furthering global sustainability.

This study evaluated interest in the search term "circular fashion" in the post-pandemic era utilizing the freely accessible tool Google Trends. The objective was to discern whether the COVID-19 pandemic influenced the trend for the search term "circular fashion" and to contrast it with pre-pandemic data, delving into the potential reasons for these observations. Our contributions to the literature can be encapsulated as follows. First, we devise a new Google Trends index to capture attention to circular fashion. Numerous scientific studies have examined circular fashion, but few have examined its importance, role, or emerging trends in the post-pandemic era. Second, we use Google Trends data to introduce a novel data-driven forecasting methodology (i.e., discrete Grey forecasting model) for post-pandemic circular fashion. Finally, this research examines the potential evolution paths of circular fashion and consumer behavior in the post-pandemic era, proposing appropriate containment measures to promote circular fashion and providing theoretical support for optimization.

Following from the above, this study examines the following research questions (RQ):

RQ1: Has public interest in circular fashion issues evolved over time with the progression of the pandemic? Is there a discernible trend attributable to the pandemic?

RQ2: What role has the post-pandemic era played in promoting the development of circular fashion, and what new insights about its importance, role, and trends can be analyzed and developed?

RQ3: What potential causative factors and evolution paths mechanism is the post-pandemic era present for the sustainability of circular fashion at the consumer behavior level?

To answer these research questions, we first identified key topics related to circular fashion through comprehensive keyword selection for Google Trends analysis. We gathered annual time series data on circular fashion pre- and post-pandemic using bibliometrically validated keywords. We then applied a discrete Grey forecasting model to this unique dataset to predict public interest in circular fashion post-pandemic, offering a sturdy basis for policymaking. To address the unpredictable evolution of circular fashion, we employed cusp catastrophe theory to model future developments and devise strategies to tackle pandemic-induced challenges. Through data analysis, we can elucidate trends circularly, evaluate the long-term effects of the COVID-19 pandemic, and equip decision-makers with new insights to confront the challenges posed by the pandemic.

2. METHODS

In our methodically designed four-step study, bibliometrics is utilized to identify keywords associated with circular fashion for subsequent analysis via Google Trends. This validated keyword selection provides valuable annual time series data spanning pre- and post-pandemic eras. A discrete Grey forecasting model is implemented, projecting the potential public interest in circular fashion post-pandemic and informing strategic policy development. Given the unpredictable evolution of circular fashion, we incorporate cusp catastrophe theory, enabling comprehension of its future trajectory and shaping post-pandemic strategies. For a detailed illustration of our investigative methodology, refer to Figure 1.

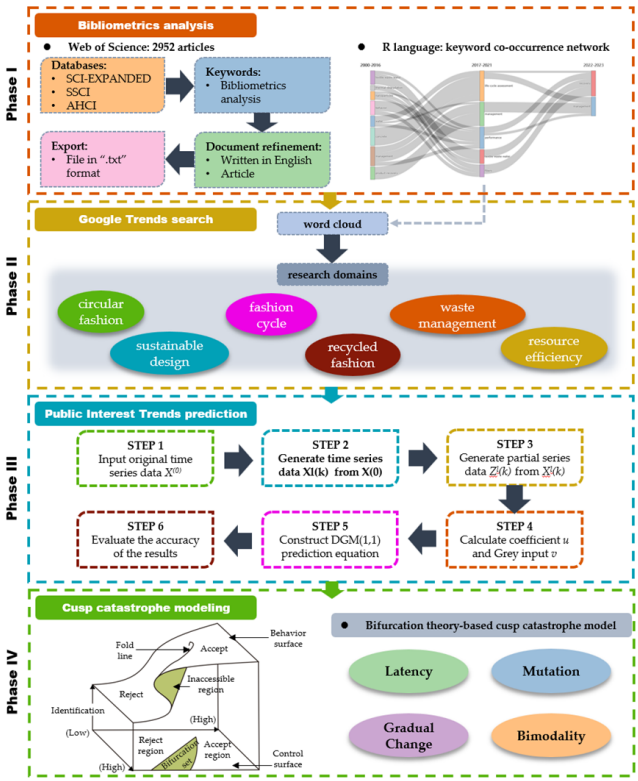

Fig. 1 Roadmap of the research framework for exploring circular fashion.

2.1. Keyword Selection for Google Trends Analysis

In this investigation, we judiciously designate Google Trends search terms, exploiting the bountiful prospects presented by the age of big data for circular predictive modeling. Leveraging the dependency on search engines, we foresee the evolution of circular fashion while acknowledging its intrinsic uncertainties. Despite sporadic anomalies in search volumes, we have formulated a standard for keyword amalgamation by utilizing bibliometrics, capitalizing on its instantaneous data update and interpretative capabilities, thus generating indices pertinent to circular fashion. This research constructs an academic theoretical framework of circular fashion via bibliometric scrutiny(11).

We adopted R language software (version 4.2.0, 64-bit), and a keyword co-occurrence network was developed to extract key terms after grouping, reveal dominant sectors within the current circular fashion dialog, and establish fundamental terms for the Google Trend investigation. A comprehensive exploration was conducted within the SCI-EXPANDED, SSCI, and AHCI databases on the Web of Science, applying a strategic keyword search finalized on June 12, 2023, and targeting research post-2000. The employed search strategy included the following: (topic="Circular Fashion" OR "Sustainable Fashion" OR "Sustainab*" OR "Closed-loop Fashion" OR "Slow Fashion" OR "Eco-fashion" OR "Zero Waste Fashion" OR "Upcycling" OR "Recycl*" OR "Second-hand Fashion" OR "Green Fashion") AND (topic="-Textile Waste" OR "Textile Recycl*" OR "Material Lifespan" OR "Material Recovery" OR "Product Lifespan" OR "Product Recovery" OR "Resource Efficiency" OR "Waste Minimization"). Only articles written in English were considered, narrowing the document type to "article" for a concentrated analysis. This thorough inquiry provides an encompassing domain panorama, fortifying future circular fashion investigations.

The representation of pivotal terminologies in the word cloud generated from bibliometric analysis, as illustrated in Figure 2, underscores redundancy and convergence in interpreting these terms. The dependability of the outcomes was fortified by refining the keyword assemblage to those most relevant to circular fashion, thereby mandating a methodical classification of these terminologies to enhance comprehension. The word cloud and literature review insights facilitated the identification of six fundamental research realms pertinent to circular fashion: Circular Design, Production Recovery, Lifecycle Analysis, Waste Reduction, Performance Assessment, and Emission Reduction. These principles informed the collation of Google Trends data from 2017 to 2022, providing a foundation for robust modeling following the computation of annual averages.

Fig. 2 Wordcloud visualization in circular fashion scholarship.

In the multifaceted realm of Circular Fashion, the pivotal concepts of Circular Design, Production Recovery, Lifecycle Analysis, Waste Reduction, Performance Assessment, and Emission Reduction function as the compass points guiding navigation. Circular design forms the basis for aesthetic allure, utility, and recyclability, delineating a roadmap for Product Recovery. The interaction between design and recovery revitalizes discarded products, engendering a reuse system. Lifecycle Analysis subsequently dissects this complex interaction, providing a panoramic perspective on the product's trajectory from creation and utilization to disposal and recovery. Concurrently, Waste Reduction, a byproduct and objective of effective design and recovery strategies, further catalyzes Emission Reduction, aligning with overarching environmental goals. Performance Assessment, functioning as an exhaustive audit mechanism,

gauges the comprehensive effectiveness of the circular network. It assesses the design's success, the efficacy of recovery, and the degree of waste and emission reduction, offering valuable feedback to refine the system. The culmination of these interconnected processes materializes as Emission Reduction, which serves as the unified aspiration of all aspects of the network. Collectively, these six terms epitomize the interconnected network central to the ethos of Circular Fashion — an industry striving for sustainability and regeneration, minimizing waste, and mitigating environmental impact.

2.2. Data Extraction

Worldwide search data from 2017 to 2022 were gleaned via Google Trends, utilizing search terms including "Circular Design," "Production Recovery," "Lifecycle Analysis," "Waste Reduction," "Performance Assessment," and "Emission Reduction." These data underwent a normalization process by Google Trends for an equitable comparison, portraying relative popularity on a spectrum from 0 (minimally popular) to 100 (maximally popular). The tool's proprietary normalization procedures make the precise search volumes inaccessible to the general public and academic investigators. Bibliometric analysis facilitated the extraction of six fundamental keywords, which were subsequently deployed as search criteria within Google Trends. A comprehensive global search spanning 2004 to the present was executed. Monthly data from 2017 to 2022 were collated and calculated into annual averages, presenting annual relative popularity statistics.

The advent of the COVID-19 pandemic toward the end of 2019 earmarked 2020 as a partition point, framing the periods 2017-2019 as pre-pandemic and 2020 onward as post-pandemic. Figure 3a visually elucidates the procured data, unmasking an increasing trend interspersed with intermittent variances associated with the six identified themes of circular fashion. These patterns intriguingly parallel the global course of the COVID-19 pandemic. A subsequent application of ANOVA established the variance in relative popularity pre- and post-pandemic (as illustrated in Figure 3b), accentuating the profound influence of COVID-19 on public interest in a circular fashion. This analysis intimates that the identified trends in circular fashion during the post-pandemic era could provide stakeholders with a reference for strategic planning. In Figure 3c, we present the popularity of the six keywords in different regions, where a darker color indicates higher popularity. From the figure, it can be seen that there are regional differences in the attention given to circular fashion in different countries.

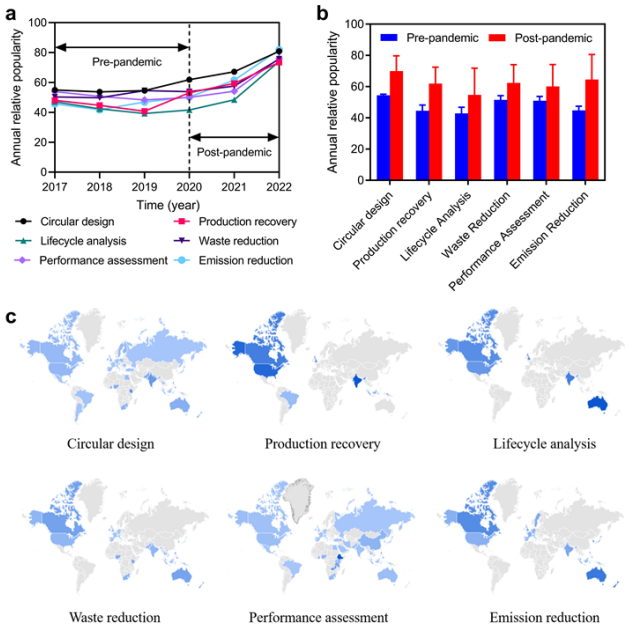

Figure 3. (a) Annual relative prevalence of circular fashion and (b) comparative analysis of pre- and post-pandemic periods, spanning 2017-2022; (c) Explore results by region (darker colors indicate more popularity).

2.3. Data Analysis

Data were extracted from Google Trends using search terms such as “Circular Design,” “Production Recovery,” “Lifecycle Analysis,” “Waste Reduction,” “Performance Assessment,” and “Emission Reduction.” These were collected monthly and transformed into yearly data. Aggregate relative popularity data from 2017 to 2022 were collated, mean values were calculated, and the means for the corresponding COVID-19 period in 2020 were determined. A comparative analysis of the relative search volume means for these timeframes was undertaken using an independent samples t-test under the assumption of unequal variances; a two-sided p-value <0.05 was considered indicative of statistical significance. Tasks associated with bibliometric analysis and data visualization were accomplished by applying R language software (version 4.2.0, 64-bit). This allowed for a thorough literature examination and enhanced understanding of the dataset. Grey system theory was incorporated using Grey Modeling software (V7.0, Nanjing University of Aeronautics and Astronautics, Nanjing, China).

3. RESULTS

3.1. Evolving Public Interest Trends in Circular Fashion in the Post-pandemic Scenario

Leveraging amassed data, we applied a Grey predictive model, which underwent rigorous accuracy examinations. This model, adept at tracking three-year trend trajectories, elucidates field dynamics through temporal shift examinations. Our Discrete Grey Model (DGM (1,1)) is a critical compass for circular fashion stakeholders, predicting thematic prominences for 2023-2025. The DGM(1,1), uniquely skilled at navigating incomplete information and small samples, is an indispensable asset in Grey system analytics(12). Although the GM(1,1) model shows promise when the original data sequence adopts an exponential nature, sizeable errors may surface with larger numerical values. Long-term forecast precision typically diminishes, whereas short-term predictions consistently assure enhanced reliability. To improve the accuracy of the GM(1,1) model, Xie et al.(12) proposed a discrete DGM(1,1) variant. While the DGM(1,1) and GM(1,1) models share a common predictive scaffold, the DGM(1,1) notably amplifies the accuracy of Grey forecasting. Considering the steady nature of short-term trends in a circular fashion, our study aims to predict annual popularity over the next three years by applying a DGM(1,1) model to a range of circular fashion topics. For illustrative purposes, the relative annual popularity of circular fashion is used as an example for constructing the DGM(1,1) model.

(1) The relative annual popularity of circular design from 2017 to 2022 (55.00, 53.67, 54.58, 61.83, 67.17, 80.83) serves as the original sequence;

(2) The 1-AGO generation sequence is then computed: (55.00, 108.67, 163.25, 225.08, 292.25, 373.08);

(3) The determined model parameters are $\beta 1=1.11$ and $\beta 2=44.27$;

(4) The projected values from 2017 to 2025 become 55.00, 50.57, 56.37, 62.82, 70.02, 78.04, 86.98, 96.95, and 108.06, respectively.

Annual popularity predictions can be made using this method for other circular fashion themes, such as “Production Recovery,” “Lifecycle Analysis,” “Waste Reduction,” “Performance Assessment,” and “Emission Reduction.”. Figure 4 depicts the relative prevalence and forecast status for each research field.

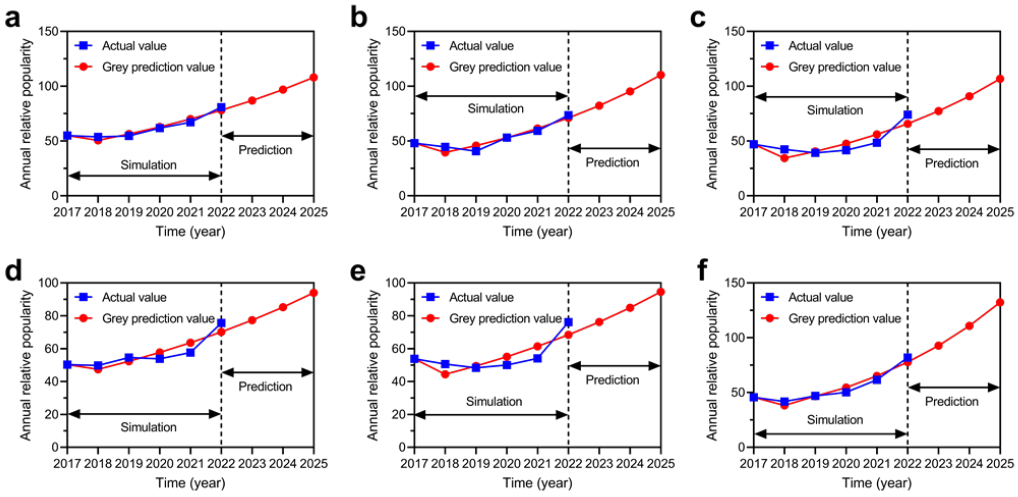

Figure 4. Relative prevalence and forecast status of each research field. (a) circular design; (b) production recovery; (c) lifecycle analysis; (d) waste reduction; (e) performance assessment; (f) emission reduction.

Following this, the validation phase computes the residual sequence, which arises from the variance between the predicted and original sequences. This investigation's mean precision across the six forecasted fields reaches 90%. The mean absolute percentage error (MAPE) criterion(13) was employed for evaluation, indicating excellent forecasting power with a MAPE under 10%; good between 10% and 20%; reasonable from 20% to 50%; and inaccurate when exceeding 50%. The respective MAPE values during 2017-2022 for circular design, production recovery, lifecycle analysis, waste reduction, performance assessment, and emission reduction were 3.06%, 5.12%, 10.50%, 5.62%, 8.11%, and 4.73%, respectively. Even with potential errors in sequences demonstrating huge fluctuations, the overall precision of the forecast remains remarkably high. The six sequences predicted by this model generally concur with actual data, thereby offering invaluable insights into the evolutionary trends of circular fashion. Our predictions indicate a rise in public interest in a circular fashion over the next three years.

3.2. The Evolution Paths of Circular Fashion

The COVID-19 pandemic triggered profound disturbances in the circular fashion sector, magnifying existing complexities through sweeping reforms and policy recalibrations. Despite challenges in internal transformation and external competition, the sector demonstrated notable resilience, generating unprecedented opportunities within an evolving landscape. The pandemic-induced prioritization of essential needs incited a contraction in fashion demand, compelling an exhaustive reassessment of the course of circular fashion. Established environmentally friendly fashion paradigms also pressure the emerging circular fashion field substantially. Existing research, predominantly qualitative and descriptive, leaves a void in quantitative evaluations of post-pandemic circular fashion trends.

This study harnesses the cusp catastrophe model(14, 15) to decode the evolution of circular fashion. The industry's sustainability is interpreted as the blended impact of these elements, represented through a bifurcation theory-based cusp catastrophe model. This model characterizes the circular fashion industry, distinguishing three stages: high, unstable, and low sustainability. Understanding this cyclical pattern requires an examination of symbolic transformational trajectories, as depicted in Figure 5. The evolutionary trajectory of circular fashion unveils distinct characteristics across varying evolution processes(15).

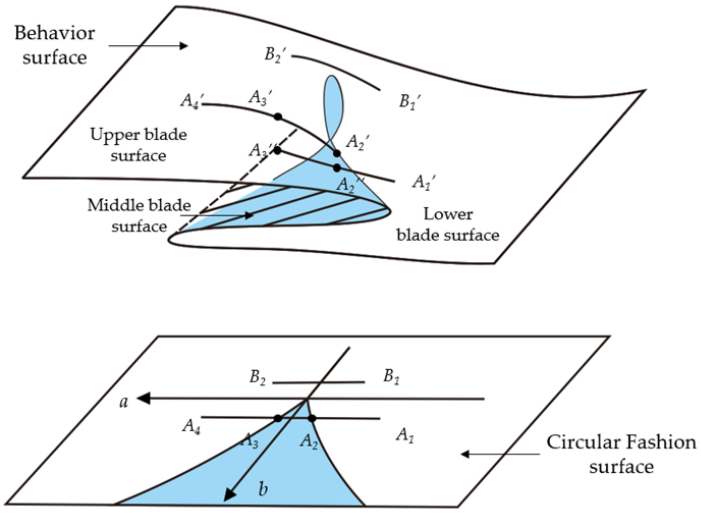

Figure 5. Circular fashion evolution system in the post-pandemic era.

(1) Latency: The transformational trajectory from to reveals a discernable latency, with maturation following an incremental progression until culmination at . This is mirrored in the evolutionary pathway of post-pandemic circular fashion, where even after stimuli cessation, a latency persists, indicative of a phase of adaptation. This latency is exemplified by the phased assimilation of eco-conscious fashion trends, underscoring consumers' preparedness for new concepts.

(2) Mutation: Within the evolutionary journey from , a mutation at prompts an immediate leap to , catalyzing a paradigm shift in circular fashion preferences. Such abrupt transitions, often sparked by unexpected events or technological advancements, can drastically transform attitudes. The pandemic's instigation of health-conscious fashion preference stands as a quintessential example.

(3) Gradual Change: The trajectory from to bypasses the apex, avoiding the mutation zones, reflecting a pattern of gradual, consistent evolution in the realm of circular fashion. For instance, the incremental transformation of consumer habits in response to a burgeoning ecological consciousness exemplifies the gradual ascent of eco-friendly products.

(4) Bimodality: In instances where (a, b) reside in the upper half-region of the apex curve, the uniqueness of the X value is lost, indicating a bimodal trend in circular fashion consumer choices. Consumers may concurrently engage with multiple fashion trends, such as environmental consciousness and high-tech products, reflecting the diverse contexts and requirements influencing trend adoption.

4. DISCUSSION

The COVID-19 pandemic has served as an unexpected catalyst in the evolution of sustainable fashion, prompting major changes in fashion consumption patterns, communication styles, and societal perceptions of fashion. The post-pandemic era is characterized by many challenges and opportunities for sustainable fashion, including a decrease in overall fashion consumption and an increasing preference for mindful purchasing behaviors. These shifts in societal norms and behaviors necessitate a detailed analysis of the societal implications of the pandemic, shaped largely by varied governmental strategies and consumer preferences.

The fashion industry, a stalwart example of consumption-driven growth, is at a critical juncture in this conversation. The findings from our research underscore the growing importance of a circular economy fueled by mounting concerns around sustainability among consumers and businesses. Importantly, our research highlights consumers'

roles as key drivers of the rising interest in sustainable fashion, spurred significantly by their penchant for second-hand purchases(16). This evolution is evidenced by the increase in participants supporting organic clothing, embodying a “buy less, buy better” mentality that has begun to permeate the industry(17).

Major fashion brands are capitalizing on the benefits of sustainable business models, such as enhanced reputation and market differentiation, and are championing policies that encourage sustainability. The COVID-19 pandemic has amplified the necessity for sustainable and circular approaches to transform production and consumption patterns. While the pandemic-driven reduction in consumer spending poses challenges, it has also highlighted the importance of incorporating waste reduction strategies and eco-friendly materials at the beginning of production processes, reducing waste, and promoting strategic planning centered around product disassembly and recycling(18, 19). The surge in demand for sustainable fashion has disrupted the historically fast-paced, unsustainable fashion culture, epitomized by the United Nations launch of the Alliance for Sustainable Fashion in 2019. Utilizing Google Trends data, we analyzed search behaviors on “circular fashion” before and during the pandemic. These data reveal fascinating insights that warrant further investigation to comprehend their implications for circular fashion in a post-pandemic world.

The scope of our study, however, is limited to a certain range of information, focusing primarily on specific websites and scholarly articles and potentially overlooking key conversations on social media platforms (e.g., Facebook, Youtube, Twitter)(20). This limitation is further exacerbated by an inherent bias in Google Trends data, suggesting that our results primarily reflect a subpopulation proficient in digital literacy and Google usage rather than a comprehensive demographic representation. Moreover, the interpretation of data is complex due to the array of motivations driving Google searches, introducing ambiguity in discerning the intent behind data points. Google Trends data represent relative, not absolute, search trends, dependent on the frequency of a term relative to all regional searches at a specific time, adjusted to the highest recorded search volume. Major events like national lockdowns can drastically shift online behavior and inflate total searches, distorting the relative search index. Other limitations include the scarcity of data from alternative search engines, government control over search engines, language barriers, and varying internet usage patterns, all of which pose substantial challenges to a holistic understanding of search trends. Our choice of search terms in this study may reflect inherent bias, and the absence of quantitative data on search terms within Google Trends data hinders definitive interpretations of search volumes. Furthermore, disparities in internet use across different regions and demographic groups may skew the results. Despite these limitations, this study emphasizes key trends emerging post-COVID-19 and reaffirms the value of Google Trends data for preliminary trend analysis.

5. CONCLUSION

This study conducts an in-depth analysis of circular fashion in the aftermath of the COVID-19 pandemic, forecasting its potential ascension as the new normal and outlining prospective post-pandemic scenarios. The far-reaching impacts of the pandemic are clear: it has precipitated a health crisis, inducing public interest circularly. By leveraging the potential of big data analysis and implementing Google Trends data, we scrutinize the path and the emerging trends of circular fashion with precision. Our research offers several key insights:

(1) The pandemic’s evolution has markedly shifted public sentiment and focus toward circular fashion. The post-pandemic landscape presents a convoluted mix of challenges and opportunities: a dip in circular fashion consumption, a repercussion of the pandemic, is offset by the surge in rational consumption habits and successful pandemic mitigation measures, thus delineating a fresh trajectory for circular fashion.

(2) Post-pandemic epochs have played a crucial role in promoting circular fashion, with public interest demonstrating an increasing trend and expected to persist. We utilized DGM(1,1) to predict circular fashion trends, demonstrating its aptness, reliability, and high efficiency in processing raw data and uncovering inherent patterns. Nevertheless, careful interpretation is essential, given the innate limitations of Google Trends data.

(3) The evolution of circular fashion in the post-pandemic phase displays a concurrent dynamic of gradual and sudden changes. Under the guidance of mutation theory and using the punctuated equilibrium model, we observe that the progression of circular fashion embodies diversity, mutation, gradualism, latency, and reversibility. Amidst this distinctive context, our concentration should center on the principles, trajectory, and portrayal of the circular fashion industry. The pandemic has instigated transformation, disruption, persistence, and uncertainty.

Conflicts of Interest: The authors declare no conflict of interest.

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