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Retail Data Measurement Tools, Cognitive Artificial Intelligence Algorithms, and Metaverse Live Shopping Analytics in Immersive Hyper-Connected Virtual Spaces

Katarina Zvarikova[1], Katarina Frajtova Michalikova[1], and Mary Rowland[2]

ABSTRACT. Based on an in-depth survey of the literature, the purpose of the paper is to explore retail data measurement tools, cognitive artificial intelligence algorithms, and metaverse live shopping analytics in immersive hyper-connected virtual spaces. In this research, previous findings were cumulated showing that artificial intelligence chatbot customer service can boost customer engagement and hyper-realistic personalized interactive experiences by use of visual analytics, shopper behavioral data, and location data, and we contribute to the literature by indicating that digital interactive performance in relation to virtual products and possessions shapes customer habits by harnessing location data. Throughout February 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including "metaverse" + "live shopping analytics," "retail data measurement tools," "cognitive artificial intelligence algorithms," and "immersive hyper-connected virtual spaces." As research published in 2022 was inspected, only 87 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, we selected 18 mainly empirical sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Dedoose, Distiller SR, and SRDR.

Keywords: retail; metaverse; shopping; cognition; virtual; space

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1. Introduction

Text analytics, data visualizations, and simulation modeling (Andrei et al., 2016; Friedman et al., 2022; Lăzăroiu et al., 2022; Popescu et al., 2017a, b) can assist immersive technologies in configuring customer interaction experiences. The purpose of our systematic review is to examine the recently published literature on retail data measurement tools, cognitive artificial intelligence algorithms, and metaverse live shopping analytics and integrate the insights it configures on immersive hyper-connected virtual spaces. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that smart customer targeting, customer profiling and behavior analysis, artificial intelligence-enabled self-services (Andronie et al., 2021a, b; Hackman and Reindl, 2022; Nemțeanu et al., 2022; Popescu, 2018) can determine affective, cognitive, and behavioral intentions and optimize virtual experiences that drive customer loyalty. The actuality and novelty of this study are articulated by addressing digital capabilities and metaverse assets, that is an emerging topic involving much interest. Our research problem is whether by deploying artificial neural networks, retail analytics can create relentless streams of meaningful, appealing, and engaging experiences (Balica et al., 2022; Kliestik et al., 2020; Obadă and Dabija, 2022; Popescu, 2017) by integrating consumer retail data, shopping patterns, and purchasing behaviors.

In this review, prior findings have been cumulated indicating that artificial intelligence chatbot customer service can boost customer engagement and hyper-realistic personalized interactive experiences by use of visual analytics, shopper behavioral data, and location data (Clayton and Kral, 2021; Lăzăroiu et al., 2017; Peters, 2022; Vinerean et al., 2022) across a unified interconnected digital realm. The identified gaps advance engaging brand awareness and building seamless shopping experiences. Our main objective is to indicate that machine learning-based product recognition can identify purchase trends in extended reality environments by mining customer data during live e-commerce shopping and user journeys. This systematic review contributes to the literature on frictionless metaverse purchase experiences by clarifying that digital interactive performance in relation to virtual products and possessions shapes customer habits (Crowell et al., 2022; Lăzăroiu et al., 2020; Poliak et al., 2021; Watson, 2022) by harnessing location data.

2. Theoretical Overview of the Main Concepts

Data visualizations and visual analytics define differentiated consumer preferences, tailored and frictionless virtual shopping experiences, and responsiveness to customer demands, building and scaling interconnected networks of seamless transactions across virtual and augmented reality-powered immersive spaces. Consumer customized shopping experiences in engaging immersive hyper-connected virtual spaces can be optimized by augmented reality tools, cognitive artificial intelligence algorithms, and picture-making neural networks. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), configuring robust immersive experiences throughout metaverse live shopping (section 4), digital capabilities and metaverse assets (section 5), the economic infrastructure of the metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout February 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including "metaverse" + "live shopping analytics," "retail data measurement tools," "cognitive artificial intelligence algorithms," and "immersive hyper-connected virtual spaces." The search terms were determined as being the most employed words or phrases across the analyzed literature. As research published in 2022 was inspected, only 87 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, we selected 18 mainly empirical sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Dedoose, Distiller SR, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + live shopping analytics	23	5
metaverse + retail data measurement tools	22	5
metaverse + cognitive artificial intelligence algorithms	22	4
metaverse + immersive hyper-connected virtual spaces	20	4
Type of paper		
Original research	67	17
Review	3	1
Conference proceedings	9	0
Book	3	0
Editorial	5	0

Source: Processed by the authors. Some topics overlap.

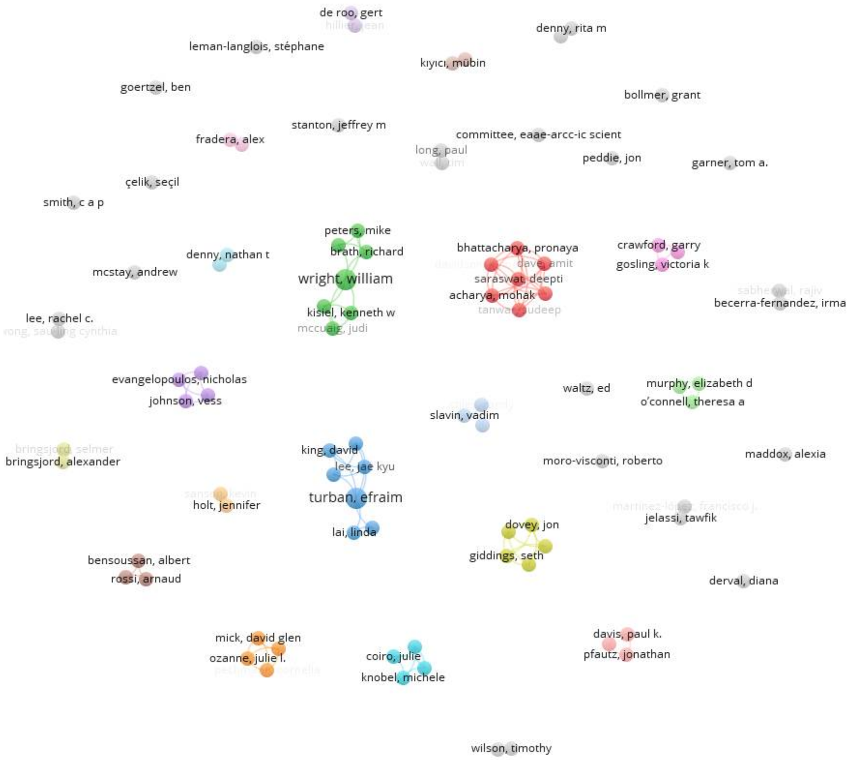
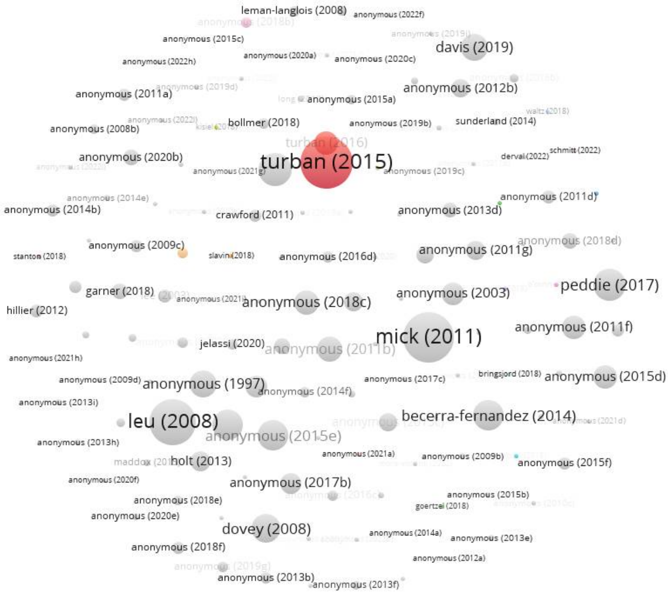


Figure 1 Co-authorship



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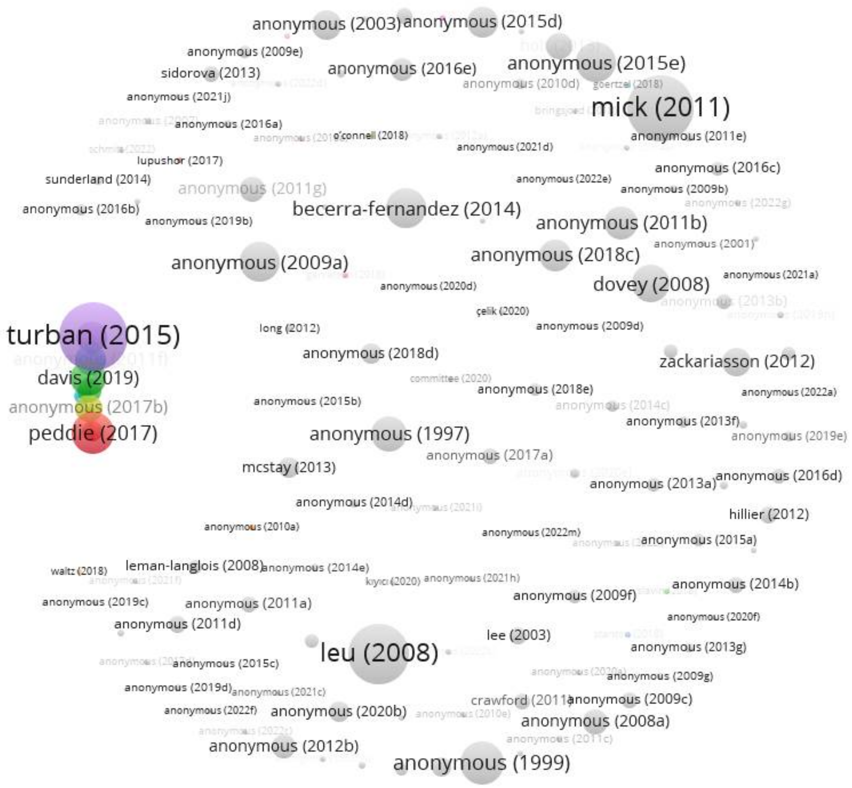

Figure 3 Bibliographic coupling

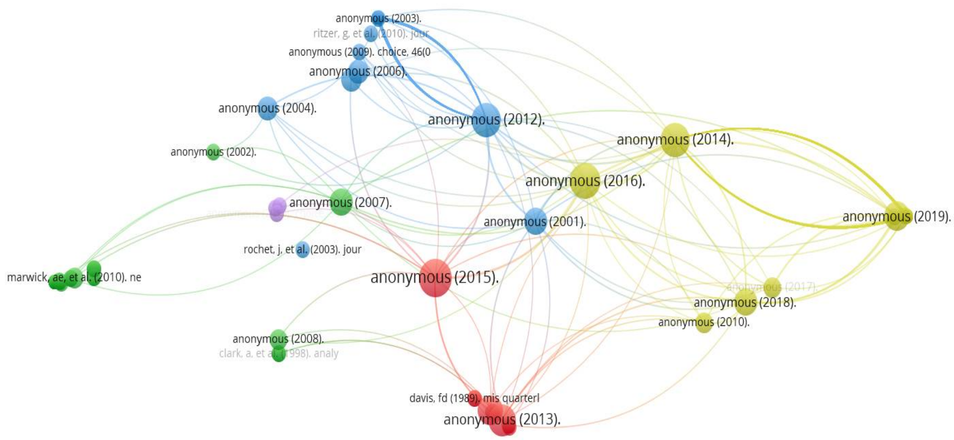

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Personalized recommendations drive customer metaverse platform engagement and conversion, creating engaging brand awareness and building seamless shopping experiences.	Beniiche et al., 2022; Gursoy et al., 2022; Zhang et al., 2022a
Customer predictive analytics and computer vision tools can assist business intelligence operations and consolidate lifetime customer value by integrating granular decisions to configure robust immersive experiences throughout metaverse live shopping.	Lv et al., 2022; Park and Kim, 2022; Zhang et al., 2022b
Accurate real-time data visualization can drive brand awareness and engagement, predicting customer response sentiment by use of intuitive personal shopping assistant bots during metaverse experiences.	Almarzouqi et al. 2022; Solakis et al., 2022; Turner, 2022
Burgeoning shopper and retail data measurement tools can configure robust customer profiles, enhance user satisfaction, and increase consumer engagement, resulting in frictionless metaverse purchase experiences.	Beniiche et al., 2022; Elawady et al., 2022; Hwang and Chien, 2022
Digital capabilities and metaverse assets can further customer journey through data aggregation and management, sensor data-driven Internet of Things, metadata analysis and sharing, and artificial intelligence training data processing, leading to intuitive and immersive shopping experiences.	Gills and Hosseini, 2022; Gursoy et al., 2022; Park et al., 2022
Entertaining and immersive e-commerce can trigger impulse purchases by identifying and capturing contextual data in user-generated digital virtual environments, while relying on deep analytics for operational planning, decisions, and costs in terms of metaverse platform engagement.	Guo and Gao, 2022; Lv et al., 2022; Zhang et al., 2022a
Data tracking apps can identify shifting consumer behaviors during live shopping events in virtual marketplaces across an immersive and decentralized 3D digital world that supports metaverse payments.	Park and Kim, 2022; Turner, 2022; Zhang et al., 2022b
Retail analytics leverages data mining, capturing and processing, in addition to predictive modeling, improving purchasing journey and customer satisfaction across real-time immersive 3D worlds, and articulating the economic infrastructure of the metaverse.	Almarzouqi et al. 2022; Reis and Ashmore, 2022; Xi et al., 2022
Data sharing and governance across interoperable networks of virtual realms can lead to capturing and retaining customer base through networking applications, devices, and tools.	Liu et al., 2022; Solakis et al., 2022; Zhao et al., 2022

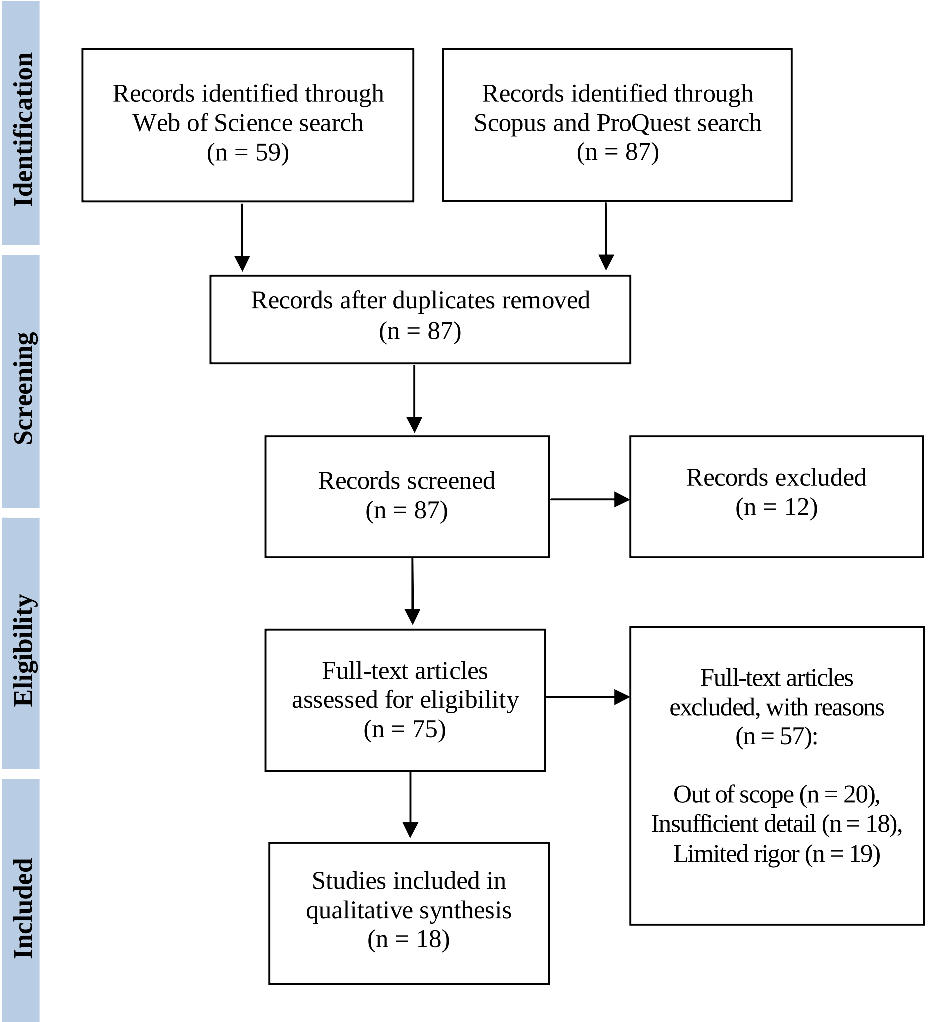

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

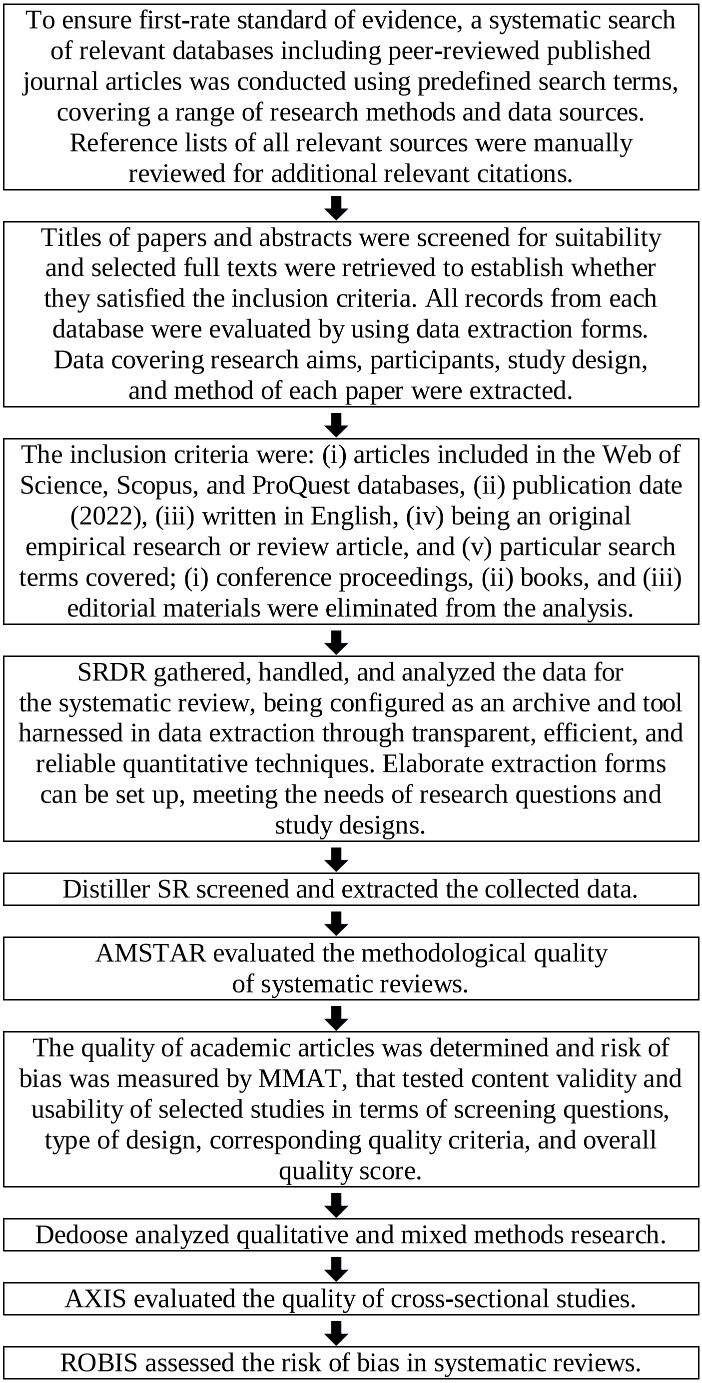

Figure 6 Screening and quality assessment tools

4. Configuring Robust Immersive Experiences throughout Metaverse Live Shopping

Personalized recommendations drive customer metaverse platform engagement and conversion (Beniiche et al., 2022; Gursoy et al., 2022; Zhang et al., 2022a), creating engaging brand awareness and building seamless shopping experiences. Consumer customized shopping experiences in engaging immersive hyper-connected virtual spaces can be optimized by augmented reality tools, cognitive artificial intelligence algorithms, and picture-making neural networks. Virtual consumer engagement in immersive 3D worlds during retail livestreaming can be assessed by leveraging biometric data.

Customer predictive analytics and computer vision tools can assist business intelligence operations and consolidate lifetime customer value (Lv et al., 2022; Park and Kim, 2022; Zhang et al., 2022b) by integrating granular decisions to configure robust immersive experiences throughout metaverse live shopping. Artificial intelligence chatbot customer service can boost customer engagement and hyper-realistic personalized interactive experiences by use of visual analytics, shopper behavioral data, and location data across a unified interconnected digital realm.

Accurate real-time data visualization can drive brand awareness and engagement (Almarzouqi et al. 2022; Solakis et al., 2022; Turner, 2022), predicting customer response sentiment by use of intuitive personal shopping assistant bots during metaverse experiences. Seamless connected shopping experiences can be achieved by artificial intelligence-enabled logistics optimization, Internet of Things-connected sensors, data and analytics technology, and computing power improvements across virtual retail stores and during shoppable live-video events, influencing consumer patterns through augmented reality lifestyles and virtualized habits. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Personalized recommendations drive customer metaverse platform engagement and conversion, creating engaging brand awareness and building seamless shopping experiences.	Beniiche et al., 2022; Gursoy et al., 2022; Zhang et al., 2022a
Customer predictive analytics and computer vision tools can assist business intelligence operations and consolidate lifetime customer value by integrating granular decisions to configure robust immersive experiences throughout metaverse live shopping.	Lv et al., 2022; Park and Kim, 2022; Zhang et al., 2022b
Accurate real-time data visualization can drive brand awareness and engagement, predicting customer response sentiment by use of intuitive personal shopping assistant bots during metaverse experiences.	Almarzouqi et al. 2022; Solakis et al., 2022; Turner, 2022

5. Digital Capabilities and Metaverse Assets

Burgeoning shopper and retail data measurement tools can configure robust customer profiles, enhance user satisfaction, and increase consumer engagement (Beniiche et al., 2022; Elawady et al., 2022; Hwang and Chien, 2022), resulting in frictionless metaverse purchase experiences. Data visualizations and visual analytics define differentiated consumer preferences, tailored and frictionless virtual shopping experiences, and responsiveness to customer demands, building and scaling interconnected networks of seamless transactions across virtual and augmented reality-powered immersive spaces.

Digital capabilities and metaverse assets can further customer journey through data aggregation and management, sensor data-driven Internet of Things, metadata analysis and sharing, and artificial intelligence training data processing (Gills and Hosseini, 2022; Gursoy et al., 2022; Park et al., 2022), leading to intuitive and immersive shopping experiences. Digital interactive performance in relation to virtual products and possessions shapes customer habits by harnessing location data.

Entertaining and immersive e-commerce can trigger impulse purchases by identifying and capturing contextual data in user-generated digital virtual environments (Guo and Gao, 2022; Lv et al., 2022; Zhang et al., 2022a), while relying on deep analytics for operational planning, decisions, and costs in terms of metaverse platform engagement. Text analytics, data visualizations, and simulation modeling can assist immersive technologies in configuring customer interaction experiences. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Burgeoning shopper and retail data measurement tools can configure robust customer profiles, enhance user satisfaction, and increase consumer engagement, resulting in frictionless metaverse purchase experiences.	Beniiche et al., 2022; Elawady et al., 2022; Hwang and Chien, 2022
Digital capabilities and metaverse assets can further customer journey through data aggregation and management, sensor data-driven Internet of Things, metadata analysis and sharing, and artificial intelligence training data processing, leading to intuitive and immersive shopping experiences.	Gills and Hosseini, 2022; Gursoy et al., 2022; Park et al., 2022
Entertaining and immersive e-commerce can trigger impulse purchases by identifying and capturing contextual data in user-generated digital virtual environments, while relying on deep analytics for operational planning, decisions, and costs in terms of metaverse platform engagement.	Guo and Gao, 2022; Lv et al., 2022; Zhang et al., 2022a

6. The Economic Infrastructure of the Metaverse

Data tracking apps can identify shifting consumer behaviors during live shopping events in virtual marketplaces (Park and Kim, 2022; Turner, 2022; Zhang et al., 2022b) across an immersive and decentralized 3D digital world that supports metaverse payments. By deploying artificial neural networks, retail analytics can create relentless streams of meaningful, appealing, and engaging experiences by integrating consumer retail data, shopping patterns, and purchasing behaviors. Business-driven data analytics can maximize frictionless customer engagement processes in digital try-on options, leading to user base growing, real-time networking with engaged communities, and value co-creation while predicting shopper traffic patterns.

Retail analytics leverages data mining, capturing and processing, in addition to predictive modeling, improving purchasing journey and customer satisfaction across real-time immersive 3D worlds (Almarzouqi et al. 2022; Reis and Ashmore, 2022; Xi et al., 2022), and articulating the economic infrastructure of the metaverse. Smart customer targeting, customer profiling and behavior analysis, artificial intelligence-enabled self-services can determine affective, cognitive, and behavioral intentions and optimize virtual experiences that drive customer loyalty.

Data sharing and governance across interoperable networks of virtual realms can lead to capturing and retaining customer base through networking applications, devices, and tools (Liu et al., 2022; Solakis et al., 2022; Zhao et al., 2022), optimizing data-driven decision making and business outcomes. Machine learning-based product recognition can identify purchase trends in extended reality environments by mining customer data during live e-commerce shopping and user journeys. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Data tracking apps can identify shifting consumer behaviors during live shopping events in virtual marketplaces across an immersive and decentralized 3D digital world that supports metaverse payments.	Park and Kim, 2022; Turner, 2022; Zhang et al., 2022b
Retail analytics leverages data mining, capturing and processing, in addition to predictive modeling, improving purchasing journey and customer satisfaction across real-time immersive 3D worlds, and articulating the economic infrastructure of the metaverse.	Almarzouqi et al. 2022; Reis and Ashmore, 2022; Xi et al., 2022
Data sharing and governance across interoperable networks of virtual realms can lead to capturing and retaining customer base through networking applications, devices, and tools, optimizing data-driven decision making and business outcomes.	Liu et al., 2022; Solakis et al., 2022; Zhao et al., 2022

7. Discussion

We integrate our systematic review throughout research indicating how virtual consumer engagement in immersive 3D worlds during retail livestreaming can be assessed by leveraging biometric data. Our research complements recent analyses clarifying how seamless connected shopping experiences can be achieved by artificial intelligence-enabled logistics optimization, Internet of Things-connected sensors, data and analytics technology, and computing power improvements across virtual retail stores and during shoppable live-video events, influencing consumer patterns through augmented reality lifestyles and virtualized habits. We elucidate, by cumulative evidence, previous research demonstrating how business-driven data analytics can maximize frictionless customer engagement processes in digital try-on options, leading to user base growing, real-time networking with engaged communities, and value co-creation while predicting shopper traffic patterns.

8. Synopsis of the Main Research Outcomes

Machine learning-based product recognition can identify purchase trends in extended reality environments by mining customer data during live e-commerce shopping and user journeys. Smart customer targeting, customer profiling and behavior analysis, artificial intelligence-enabled self-services can determine affective, cognitive, and behavioral intentions and optimize virtual experiences that drive customer loyalty.

9. Conclusions

Relevant research has investigated whether digital interactive performance in relation to virtual products and possessions shapes customer habits by harnessing location data. This systematic literature review presents the published peer-reviewed sources covering how text analytics, data visualizations, and simulation modeling can assist immersive technologies in configuring customer interaction experiences. The research outcomes drawn from the above analyses indicate that by deploying artificial neural networks, retail analytics can create relentless streams of meaningful, appealing, and engaging experiences by integrating consumer retail data, shopping patterns, and purchasing behaviors.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on retail data measurement tools, cognitive artificial intelligence algorithms, and metaverse live shopping analytics in immersive hyper-connected virtual spaces may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of data sharing and governance across interoperable networks of virtual realms.

Subsequent analyses should develop on metaverse platform engagement. Future research should thus investigate intuitive and immersive shopping experiences. In the future, attention should be directed to real-time immersive 3D worlds.

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This article does not contain any studies with human participants or animals performed by the authors.

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Author contributions
All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement
The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record
The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement
The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Predictive Algorithms, Data Visualization Tools, and Artificial Neural Networks in the Retail Metaverse

Laura Rydell*

ABSTRACT. In this article, I cumulate previous research findings indicating that, by leveraging natural language processing, sentiment analytics, business intelligence tools, data-driven decision making, and real-time Internet of Things data, online and virtual marketplaces configure customer loyalty and demand, shopping habits, and changing customer order patterns, while customizing user experiences. I contribute to the literature on predictive algorithms, data visualization tools, and artificial neural networks in the retail metaverse by showing that natural language processing and data sharing technologies, together with data visualization capabilities and sentiment analysis, can enhance business performance in livestreaming e-commerce, configuring consumer purchasing habits and improving customer expectations, confidence, loyalty, and engagement. Throughout March 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "retail metaverse" + "predictive algorithms," "data visualization tools," and "artificial neural networks." As I inspected research published in 2022, only 84 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 17, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, ROBIS, and SRDR.

Keywords: retail; metaverse; visualization; algorithm; neural network; artificial

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1. Introduction

By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that by leveraging natural language processing, sentiment analytics, business intelligence tools, data-driven decision making, and real-time Internet of Things data (Andrei et al., 2020; Kral et al., 2020; Nica et al., 2018; Pop et al., 2022; Rowland and Porter, 2021), online and virtual marketplaces configure customer loyalty and demand, shopping habits, and changing customer order patterns, while customizing user experiences. The purpose of my systematic review is to examine the recently published literature on predictive algorithms, data visualization tools, and artificial neural networks and integrate the insights it configures on in the retail metaverse. The actuality and novelty of this study are articulated by addressing metaverse platform and application interoperability, that is an emerging topic involving much interest. My research problem is whether customer monitoring systems, machine vision, and immersive technologies (Glogovețan et al., 2022; Hudson, 2022; Peters, 2022; Popescu, 2018; Valle, 2021) can influence consumer engagement, behavior, and preferences, in addition to buying habits (Andronie et al., 2021a, b, c; Nica, 2018; Popescu et al., 2017), during virtual shopping sessions across interconnected digital spaces..

In this review, prior findings have been cumulated indicating that natural language processing and data sharing technologies, together with data visualization capabilities and sentiment analysis, can enhance business performance in livestreaming e-commerce, configuring consumer purchasing habits and improving customer expectations, confidence, loyalty, and engagement. The identified gaps advance immersive technologies, enhanced forecasting capabilities, and autonomous trade systems in the retail metaverse. My main objective is to indicate that artificial intelligence-enabled self-service experiences integrate data storage and processing, socio-economic interoperability (Ionescu, 2021; Nica, 2017; Pocol et al., 2022; Popescu et al., 2020), tailored shopping recommendations, and customized production in the virtual economy. This systematic review contributes to the literature on the retail metaverse by clarifying that immersive digital environments can shape consumer behavior patterns, purchase habits, and brand loyalty (Balica, 2022; Krizanova et al., 2019; Nica et al., 2022; Popescu, 2017) through visual screening and image recognition technologies, advanced analytics, and real-time 3D content creation tools.

2. Theoretical Overview of the Main Concepts

Customer decision journeys can be impacted by data visualization, computational linguistics, extended reality technologies, and social commerce tools by use of real-time datasets in virtual environments. Personalized product recommendations can attract and retain customers by use of augmented and virtual reality technologies, articulating immersive retail experiences in interconnected virtual worlds. Natural language processing tools and speech analytics can reduce customer churn and acquisition cost by leveraging personalized and convenient user services, voice biometric verification, and algorithmically-driven emotionally-engaging content in virtual stores. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), virtual assets and digital ownership in the metaverse economy (section 4), immersive technologies, enhanced forecasting capabilities, and autonomous trade systems in the retail metaverse (section 5), immersive experiences across customer journeys in the retail metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout March 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "retail metaverse" + "predictive algorithms," "data visualization tools," and "artificial neural networks." The search terms were determined as being the most employed words or phrases across the analyzed literature. As I inspected research published in 2022, only 84 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 17, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
retail metaverse + predictive algorithms	26	5
retail metaverse + data visualization tools	29	6
retail metaverse + artificial neural networks	29	6
Type of paper		
Original research	61	17
Review	3	0
Conference proceedings	12	0
Book	4	0
Editorial	4	0

Source: Processed by the author. Some topics overlap.

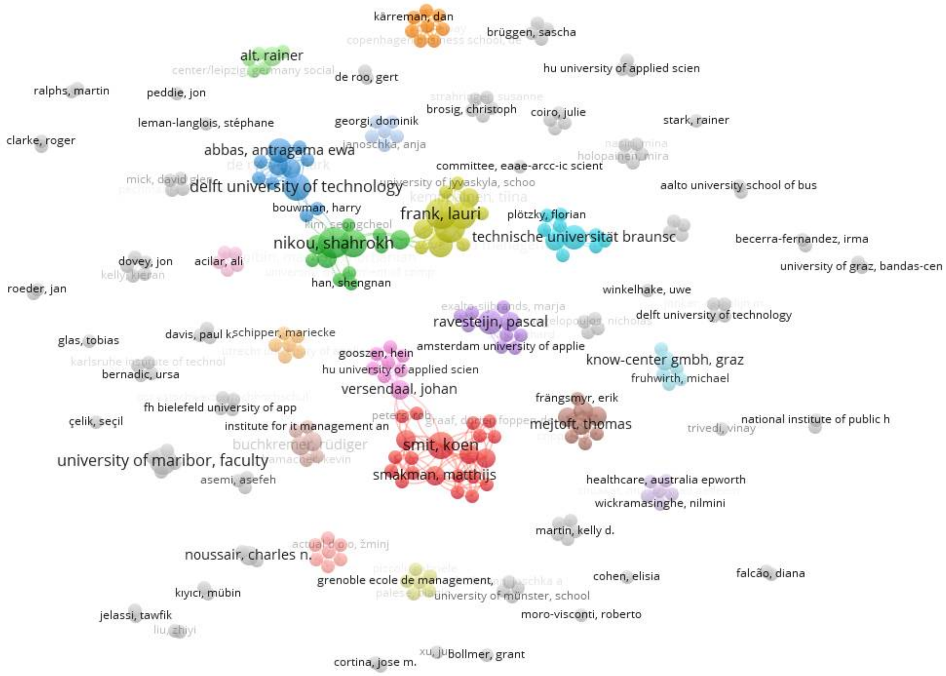

Figure 1 Co-authorship

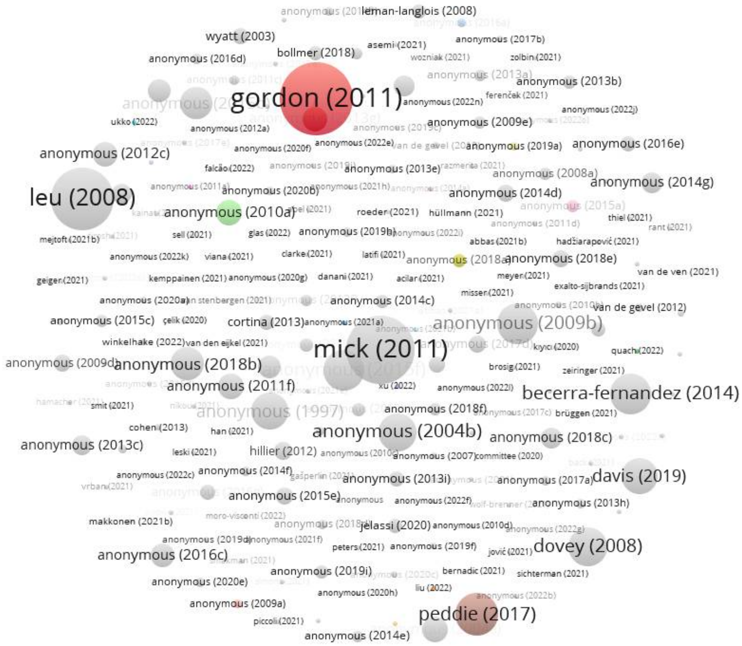

Figure 2 Citation

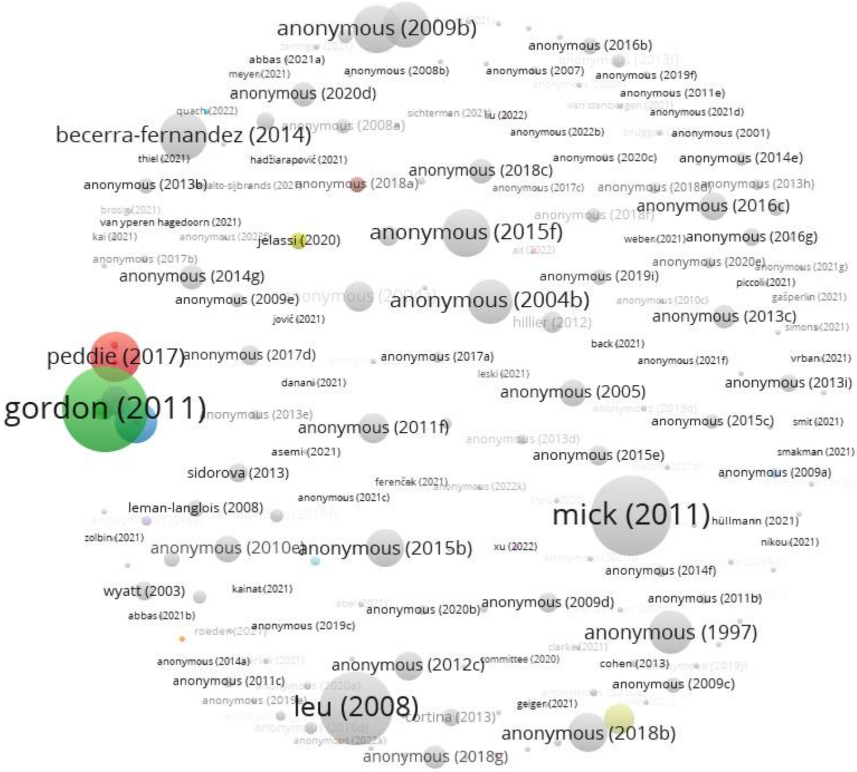

Figure 3 Bibliographic coupling

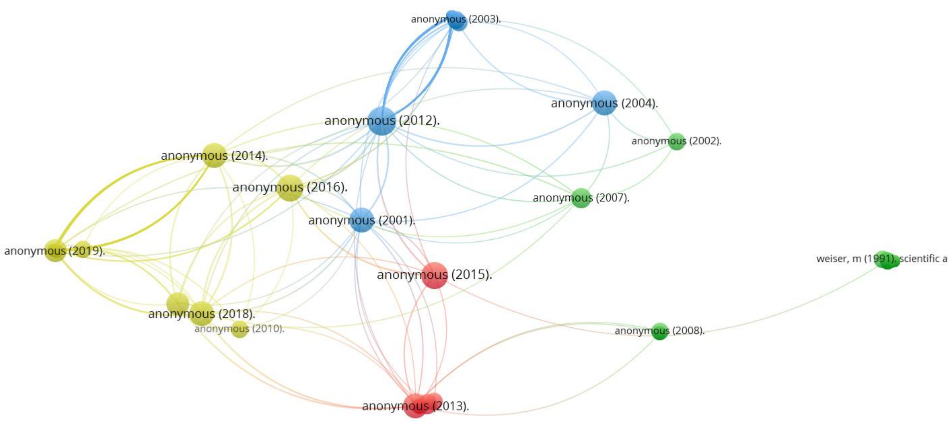

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Biometric payment methods, through face and palm recognition software, configure an online frictionless swift consumer journey in the retail metaverse.	Akyildiz et al., 2022; Gibbert et al., 2022; Laviola et al., 2022
The embedded deployment of big data analytics in business operations configures digital commerce in online marketplaces through real-time data management during livestream shopping events in the metaverse economy.	Hollensen et al., 2022; Skalidis et al., 2022; Wang, 2022
Predictive customer analytics and geospatial mapping can improve immersive 3D experiences and lead to consumer digital engagement and pattern changes as regards virtual assets and digital ownership in the metaverse economy.	Dozio et al., 2022; Jang et al., 2022; Yeh et al., 2022
E-commerce businesses deploy customer data and articulate convenient shopping experiences in terms of metaverse platform and application interoperability.	Gössling and Schweiggart, 2022; Kshetri, 2022; Zhang et al., 2022a
Contextual consumer data can assist virtually enhanced personalized shopping and purchase journeys by use of immersive technologies, enhanced forecasting capabilities, and autonomous trade systems in the retail metaverse.	Lin et al., 2022; Skalidis et al., 2022; Zyda, 2022a
Immersive virtual experiences can integrate customer data through ambient sound recognition and processing, resulting in personalized customer shopping experience, growing consumer engagement, and frictionless and experiential e-commerce in the metaverse economy.	Akyildiz et al., 2022; Dozio et al., 2022; Jang et al., 2022
5G cellular networks can create operational efficiency and competitive advantage in augmented reality-based livestream shopping by integrating customer mobility data and shaping metaverse engagement and experiences.	Gibbert et al., 2022; Wang, 2022; Zhang et al., 2022a
Assessing digital customer engagement across interconnected virtual worlds requires location data, visual analytics, movement and behavior tracking, biometric payment tools, and ambient sound recognition software, articulating immersive experiences across customer journeys in the retail metaverse.	Hollensen et al., 2022; Yeh et al., 2022; Zhang et al., 2022b
Data management processes and visualization tools require deep neural networks and advanced data analytics to shape customer journeys across interconnected digital worlds and virtual shopping malls, and thus enhance metaverse engagement.	Kraus et al., 2022; Laviola et al., 2022; Zyda, 2022b

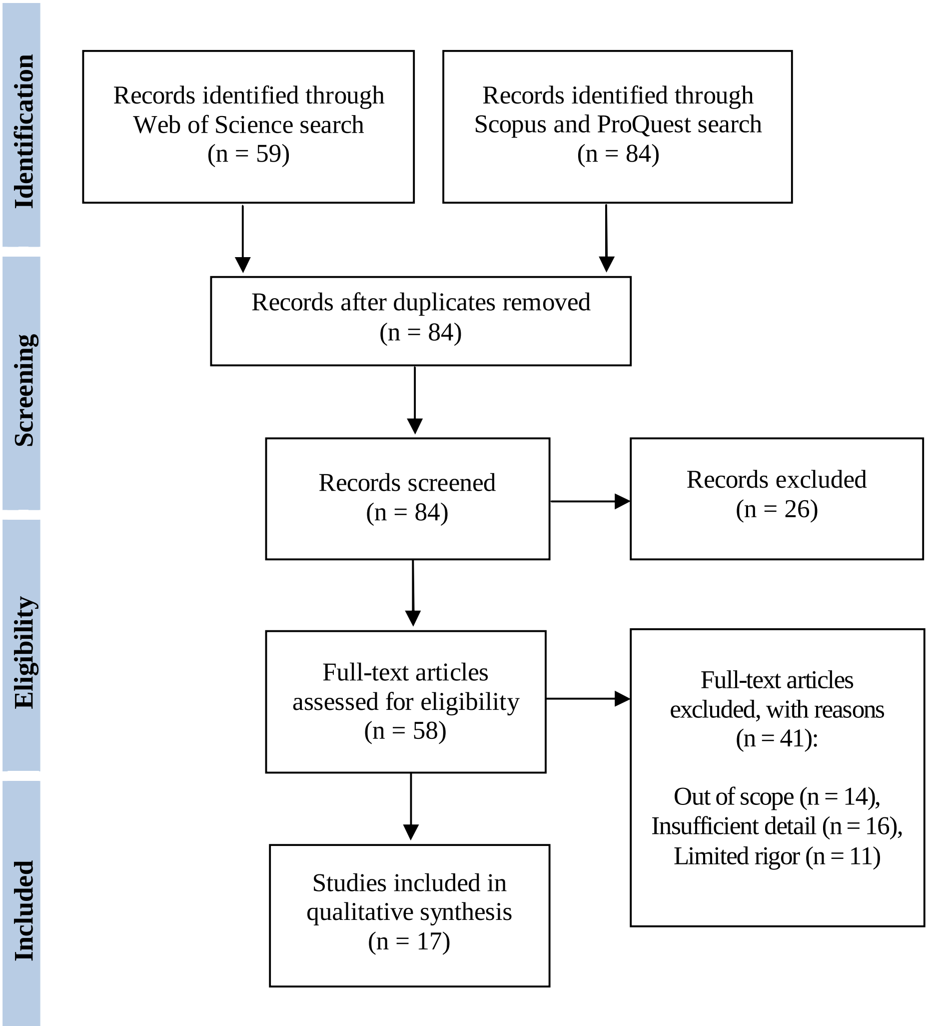

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

Distiller SR screened and extracted the collected data.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

Dedoose analyzed qualitative and mixed methods research.

↓

ROBIS assessed the risk of bias in systematic reviews.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

Figure 6 Screening and quality assessment tools

4. Virtual Assets and Digital Ownership in the Metaverse Economy

Biometric payment methods, through face and palm recognition software, configure an online frictionless swift consumer journey (Akyildiz et al., 2022; Gibbert et al., 2022; Laviola et al., 2022) in the retail metaverse. Customer monitoring systems, machine vision, and immersive technologies can influence consumer engagement, behavior, and preferences, in addition to buying habits, during virtual shopping sessions across interconnected digital spaces. Realistic virtual shopping experiences can optimize consumer confidence and expectations in retail business.

The embedded deployment of big data analytics in business operations configures digital commerce in online marketplaces through real-time data management (Hollensen et al., 2022; Skalidis et al., 2022; Wang, 2022) during livestream shopping events in the metaverse economy. Customer decision journeys can be impacted by data visualization, computational linguistics, extended reality technologies, and social commerce tools by use of real-time datasets in virtual environments. Artificial intelligence-enabled self-service experiences integrate data storage and processing, socio-economic interoperability, tailored shopping recommendations, and customized production in the virtual economy.

Predictive customer analytics and geospatial mapping can improve immersive 3D experiences and lead to consumer digital engagement and pattern changes (Dozio et al., 2022; Jang et al., 2022; Yeh et al., 2022) as regards virtual assets and digital ownership in the metaverse economy. Natural language processing and data sharing technologies, together with data visualization capabilities and sentiment analysis, can enhance business performance in livestreaming e-commerce, configuring consumer purchasing habits and improving customer expectations, confidence, loyalty, and engagement. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Biometric payment methods, through face and palm recognition software, configure an online frictionless swift consumer journey in the retail metaverse.	Akyildiz et al., 2022; Gibbert et al., 2022; Laviola et al., 2022
The embedded deployment of big data analytics in business operations configures digital commerce in online marketplaces through real-time data management during livestream shopping events in the metaverse economy.	Hollensen et al., 2022; Skalidis et al., 2022; Wang, 2022
Predictive customer analytics and geospatial mapping can improve immersive 3D experiences and lead to consumer digital engagement and pattern changes as regards virtual assets and digital ownership in the metaverse economy.	Dozio et al., 2022; Jang et al., 2022; Yeh et al., 2022

5. Immersive Technologies, Enhanced Forecasting Capabilities, and Autonomous Trade Systems in the Retail Metaverse

E-commerce businesses deploy customer data and articulate convenient shopping experiences (Gössling and Schweiggart, 2022; Kshetri, 2022; Zhang et al., 2022a) in terms of metaverse platform and application interoperability. Social commerce tools can configure personalized product recommendations during livestream shopping events through blockchain-based technologies in immersive digital environments and virtual spaces, optimizing metaverse experience and consumer confidence, and resulting in seamless omnichannel engagement.

Contextual consumer data can assist virtually enhanced personalized shopping and purchase journeys (Lin et al., 2022; Skalidis et al., 2022; Zyda, 2022a) by use of immersive technologies, enhanced forecasting capabilities, and autonomous trade systems in the retail metaverse. By leveraging natural language processing, sentiment analytics, business intelligence tools, data-driven decision making, and real-time Internet of Things data, online and virtual marketplaces configure customer loyalty and demand, shopping habits, and changing customer order patterns, while customizing user experiences.

Immersive virtual experiences can integrate customer data through ambient sound recognition and processing (Akyildiz et al., 2022; Dozio et al., 2022; Jang et al., 2022), resulting in personalized customer shopping experience, growing consumer engagement, and frictionless and experiential e-commerce in the metaverse economy. Personalized product recommendations can attract and retain customers by use of augmented and virtual reality technologies, articulating immersive retail experiences in interconnected virtual worlds. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

E-commerce businesses deploy customer data and articulate convenient shopping experiences in terms of metaverse platform and application interoperability.	Gössling and Schweiggart, 2022; Kshetri, 2022; Zhang et al., 2022a
Contextual consumer data can assist virtually enhanced personalized shopping and purchase journeys by use of immersive technologies, enhanced forecasting capabilities, and autonomous trade systems in the retail metaverse.	Lin et al., 2022; Skalidis et al., 2022; Zyda, 2022a
Immersive virtual experiences can integrate customer data through ambient sound recognition and processing, resulting in personalized customer shopping experience, growing consumer engagement, and frictionless and experiential e-commerce in the metaverse economy.	Akyildiz et al., 2022; Dozio et al., 2022; Jang et al., 2022

6. Immersive Experiences across Customer Journeys in the Retail Metaverse

5G cellular networks can create operational efficiency and competitive advantage in augmented reality-based livestream shopping (Gibbert et al., 2022; Wang, 2022; Zhang et al., 2022a) by integrating customer mobility data and shaping metaverse engagement and experiences. Computer vision algorithms can improve digital shopping in virtual retail environments by leveraging transaction analytics in consumer journeys.

Assessing digital customer engagement across interconnected virtual worlds requires location data, visual analytics, movement and behavior tracking, biometric payment tools, and ambient sound recognition software (Hollensen et al., 2022; Yeh et al., 2022; Zhang et al., 2022b), articulating immersive experiences across customer journeys in the retail metaverse. Immersive digital environments can shape consumer behavior patterns, purchase habits, and brand loyalty through visual screening and image recognition technologies, advanced analytics, and real-time 3D content creation tools.

Data management processes and visualization tools require deep neural networks and advanced data analytics to shape customer journeys across interconnected digital worlds and virtual shopping malls (Kraus et al., 2022; Laviola et al., 2022; Zyda, 2022b), and thus enhance metaverse engagement and experiences. Natural language processing tools and speech analytics can reduce customer churn and acquisition cost by leveraging personalized and convenient user services, voice biometric verification, and algorithmically-driven emotionally-engaging content in virtual stores. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

5G cellular networks can create operational efficiency and competitive advantage in augmented reality-based livestream shopping by integrating customer mobility data and shaping metaverse engagement and experiences.	Gibbert et al., 2022; Wang, 2022; Zhang et al., 2022a
Assessing digital customer engagement across interconnected virtual worlds requires location data, visual analytics, movement and behavior tracking, biometric payment tools, and ambient sound recognition software, articulating immersive experiences across customer journeys in the retail metaverse.	Hollensen et al., 2022; Yeh et al., 2022; Zhang et al., 2022b
Data management processes and visualization tools require deep neural networks and advanced data analytics to shape customer journeys across interconnected digital worlds and virtual shopping malls, and thus enhance metaverse engagement and experiences.	Kraus et al., 2022; Laviola et al., 2022; Zyda, 2022b

7. Discussion

I integrate my systematic review throughout research indicating how realistic virtual shopping experiences can optimize consumer confidence and expectations in retail business. My research complements recent analyses clarifying how social commerce tools can configure personalized product recommendations during livestream shopping events through blockchain-based technologies in immersive digital environments and virtual spaces, optimizing metaverse experience and consumer confidence, and resulting in seamless omnichannel engagement. I elucidate, by cumulative evidence, previous research demonstrating how computer vision algorithms can improve digital shopping in virtual retail environments by leveraging transaction analytics in consumer journeys.

8. Synopsis of the Main Research Outcomes

Customer monitoring systems, machine vision, and immersive technologies can influence consumer engagement, behavior, and preferences, in addition to buying habits, during virtual shopping sessions across interconnected digital spaces. Customer decision journeys can be impacted by data visualization, computational linguistics, extended reality technologies, and social commerce tools by use of real-time datasets in virtual environments.

9. Conclusions

Relevant research has investigated whether natural language processing and data sharing technologies, together with data visualization capabilities and sentiment analysis, can enhance business performance in livestreaming e-commerce. This systematic literature review presents the published peer-reviewed sources covering how natural language processing tools and speech analytics can reduce customer churn and acquisition cost by leveraging personalized and convenient user services, voice biometric verification, and algorithmically-driven emotionally-engaging content in virtual stores. The research outcomes drawn from the above analyses indicate that online and virtual marketplaces configure customer loyalty and demand, shopping habits, and changing customer order patterns, while customizing user experiences.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on predictive algorithms, data visualization tools, and artificial neural networks in the retail metaverse may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of virtual assets and digital ownership in the metaverse economy.

Subsequent analyses should develop on livestream shopping events in the metaverse economy. Future research should thus investigate frictionless and experiential e-commerce in the metaverse economy. In the future, attention should be directed to immersive experiences across customer journeys in the retail metaverse.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the author.

Data availability statement

All data generated or analyzed are included in the published article.

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Author contributions

The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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The Virtual Economy of the Metaverse: Computer Vision and Deep Learning Algorithms, Customer Engagement Tools, and Behavioral Predictive Analytics

Robert Watson*

ABSTRACT. The purpose of this study is to examine the virtual economy of the metaverse in terms of computer vision and deep learning algorithms, customer engagement tools, and behavioral predictive analytics. In this article, I cumulate previous research findings indicating that tailored services in the virtual economy focus on customer retention, increased brand recognition, and optimized digital shopping experiences, by tracking consumer sentiment, behavior, and engagement, thus improving business competitiveness. I contribute to the literature on optimized purchase behavior as regards items traded in the metaverse by showing that customer engagement and product data management can optimize brand visibility and performance, increasing average order and customer lifetime value. Throughout February 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "virtual economy," "computer vision algorithms," "deep learning algorithms," "customer engagement tools," and "behavioral predictive analytics." As I inspected research published between 2021 and 2022, only 82 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 16, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, MMAT, and SRDR.

Keywords: virtual; economy; metaverse; algorithm; customer; analytics

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1. Introduction

Virtual retail algorithms can integrate consumer behavior and data across 3D immersive environments. The purpose of my systematic review is to examine the recently published literature on the virtual economy of the metaverse and integrate the insights it configures on computer vision and deep learning algorithms, customer engagement tools, and behavioral predictive analytics. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that on-demand product customization services can improve operational efficiency (Andrei et al., 2016; Ionescu, 2021; Lăzăroiu, 2018; Olssen, 2021) as regards experiential retail in virtual commerce through digital marketing tools, smart connected devices, and natural language processing algorithms, furthering rich customer experiences. The actuality and novelty of this study are articulated by addressing creative ideation in metaverse spaces, that is an emerging topic involving much interest. My research problem is whether customized data workflows, digital contact tracing technologies, and personalized content can improve customer brand loyalty (Barbu et al., 2021; Jenkins, 2022; Lăzăroiu et al., 2022; Popescu, 2017), leading to live shopping-based instant buying.

In this review, prior findings have been cumulated indicating that tailored services in the virtual economy focus on customer retention, increased brand recognition, and optimized digital shopping experiences (Blake, 2022; Johnson and Nica, 2021; Mihăilă et al., 2016; Popescu et al., 2018), by tracking consumer sentiment, behavior, and engagement, thus improving business competitiveness. The identified gaps advance optimized purchase behavior as regards items traded in the metaverse. My main objective is to indicate that virtual navigation tools, spatial analytics, and behavioral data can customize user experiences (Popescu et al., 2021; Rowland et al., 2021; Svabova et al., 2020; Vătămănescu et al., 2020) in shared virtual environments. This systematic review contributes to the literature on product and service enhancements (Crowell, 2022; Kliestik et al., 2020; Musova et al., 2021; Popescu, 2018) and offering and channel expansion in metaverse spaces by clarifying that customer engagement and product data management (Gasparin and Schinckus, 2022; Lăzăroiu et al., 2017; Nemțeanu et al., 2022) can optimize brand visibility and performance, increasing average order and customer lifetime value.

2. Theoretical Overview of the Main Concepts

Contextual streamlined interactions increase data-informed operational decision-making efficiency and build long-term customer loyalty, leading to multidimensional omnichannel connected experiences through customer location tracking and monitoring. Computer vision and natural language processing techniques, deep learning artificial intelligence tools and algorithms, and real-time and historical customer data analytics are pivotal in articulating frictionless personalized shopping experiences on immersive shopping and augmented reality commerce platforms. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), creative ideation in metaverse spaces (section 4), business intelligence tools in metaverse commerce (section 5), possessions and assets in the metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout February 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "virtual economy," "computer vision algorithms," "deep learning algorithms," "customer engagement tools," and "behavioral predictive analytics." The search terms were determined as being the most employed words or phrases across the analyzed literature. As I inspected research published between 2021 and 2022, only 82 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 16, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, MMAT, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + virtual economy	19	4
metaverse + computer vision algorithms	14	3
metaverse + deep learning algorithms	14	3
metaverse + customer engagement tools	13	3
metaverse + behavioral predictive analytics	12	3
Type of paper		
Original research	55	16
Review	6	0
Conference proceedings	13	0
Book	4	0
Editorial	4	0

Source: Processed by the author. Some topics overlap.

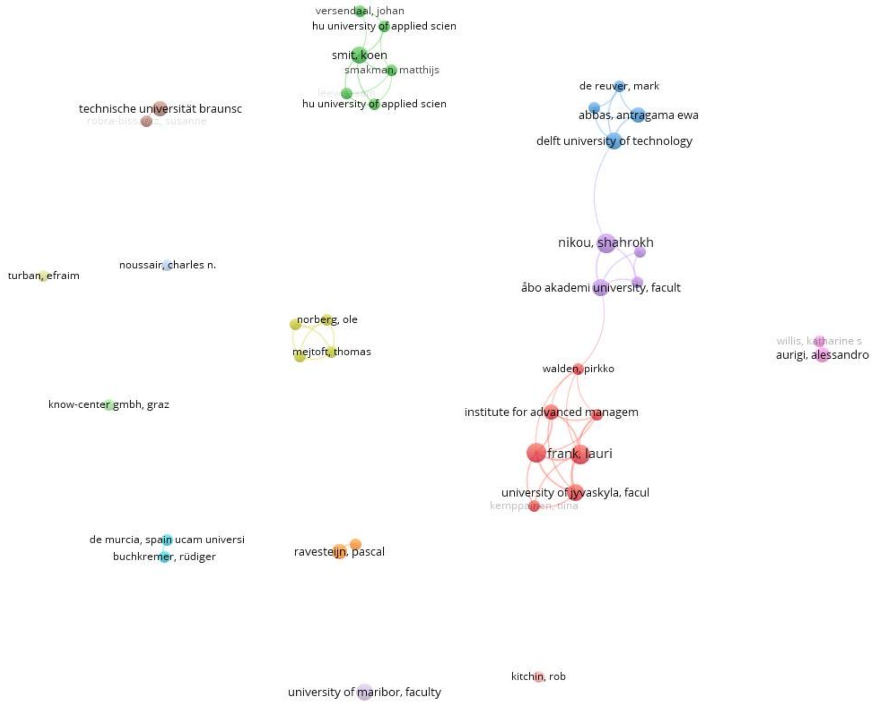

Figure 1 Co-authorship

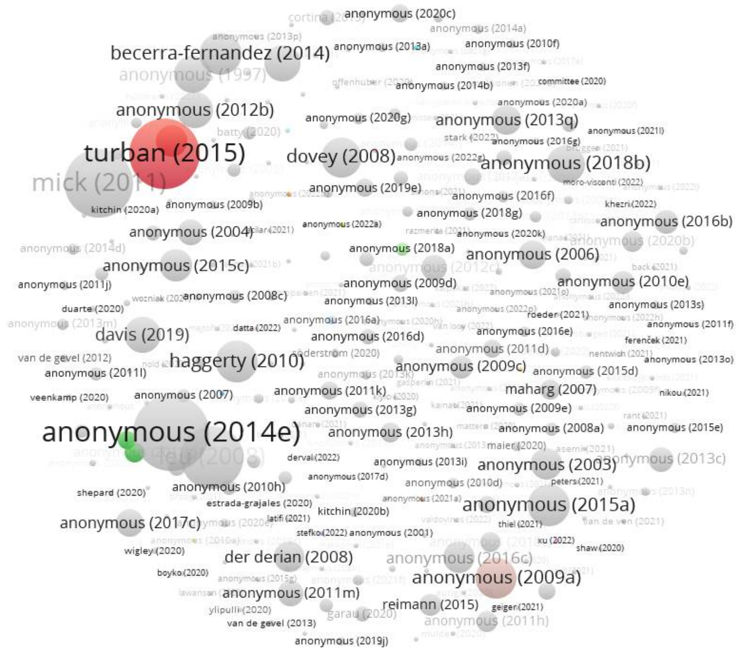

Figure 2 Citation

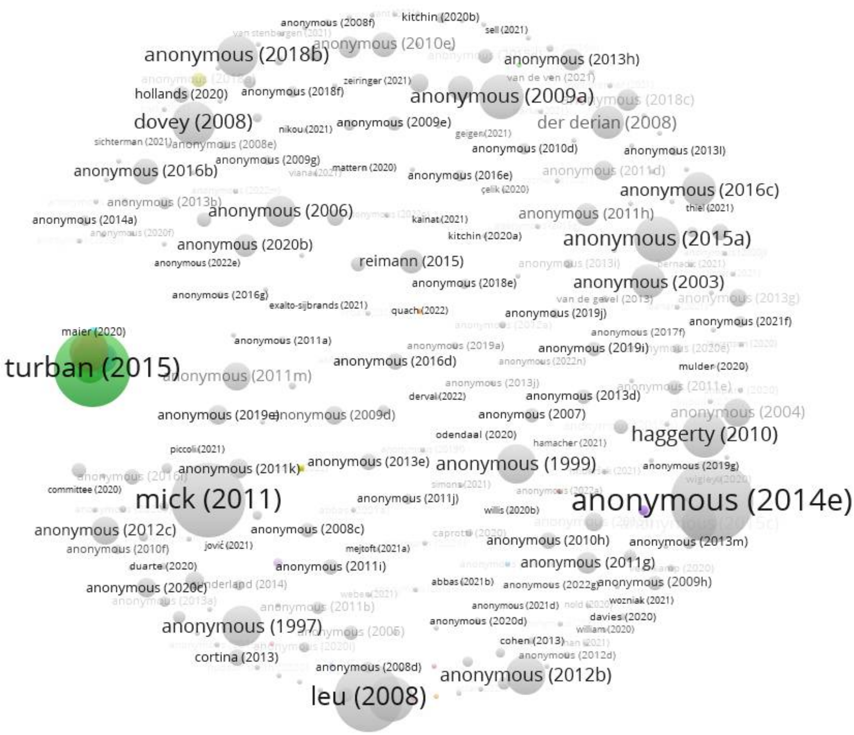

Figure 3 Bibliographic coupling

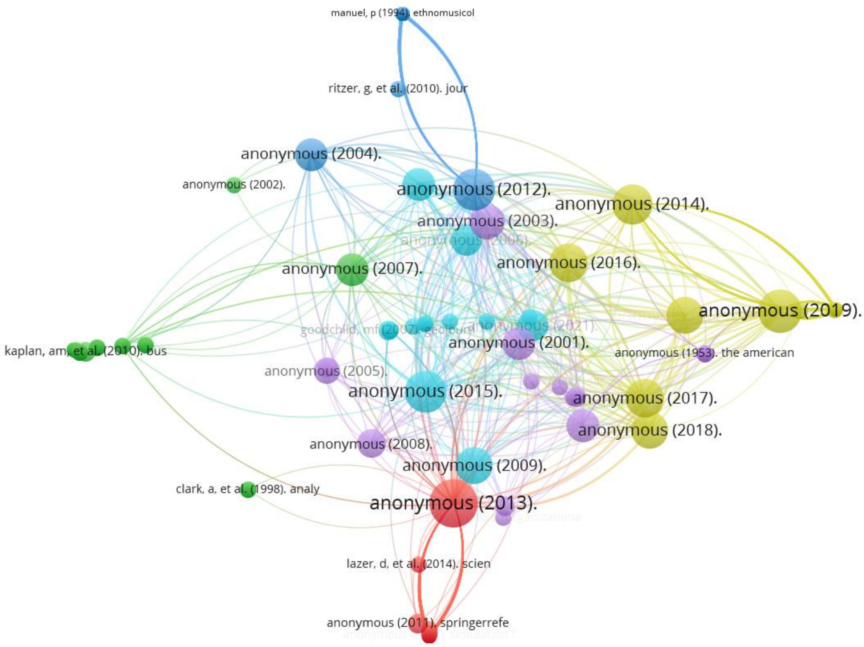

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Leveraging data derived from customer purchases, returns, and feedback can drive creative ideation in metaverse spaces. Virtual retail algorithms can integrate consumer behavior and data across 3D immersive environments.	Kozinets, 2022; Laviola et al., 2022; Park et al., 2022
Harnessing visual imagery, machine learning-based product recognition, and customer location data can drive operational improvements in metaverse spaces.	Lv et al., 2022; Siyaev and Jo, 2021; Zhang et al., 2022
Customer engagement tools improve resource and operational efficiency by determining digital product purchase intentions through collecting, processing, and transacting user location data in metaverse spaces.	Chandra, 2022; Han et al., 2022; Jang et al., 2022
Computer vision and deep learning algorithms can assist metaverse technologies in forecasting user preferences and behaviors, while optimizing customer support as regards virtual merchandise.	Hwang and Chien, 2022; Lin et al., 2022; Park and Kim, 2022
Natural language processing techniques and content creator monetization tools integrate customer purchasing history and configure seamless shopping experiences as regards items traded in the metaverse.	Kozinets, 2022; Turner, 2022; Xi et al., 2022)
Business intelligence tools in metaverse commerce can improve customer service performance and bring about personalized shopping experiences through proactive real-time engagement. Customized data workflows, digital contact tracing technologies, and personalized content can improve customer brand loyalty, leading to live shopping-based instant buying.	Akyildiz et al., 2022; Siyaev and Jo, 2021; Zhang et al., 2022
Harnessing customer-generated data can predict purchase intention, optimizing business performance by product and service enhancements and offering and channel expansion in metaverse spaces.	Hwang and Chien, 2022; Laviola et al., 2022; Wang, 2022
Shopper confidence and engagement across seamlessly interconnected virtual worlds can result in optimized purchase behavior as regards items traded in the metaverse.	Park et al., 2022; Lv et al., 2022; Xi et al., 2022
Retail performance has been increased by digital channel shifting and expanding in terms of speed and convenience as regards possessions and assets in the metaverse. Customer engagement and product data management can optimize brand visibility and performance, increasing average order and customer lifetime value.	Han et al., 2022; Lin et al., 2022; Zhang et al., 2022

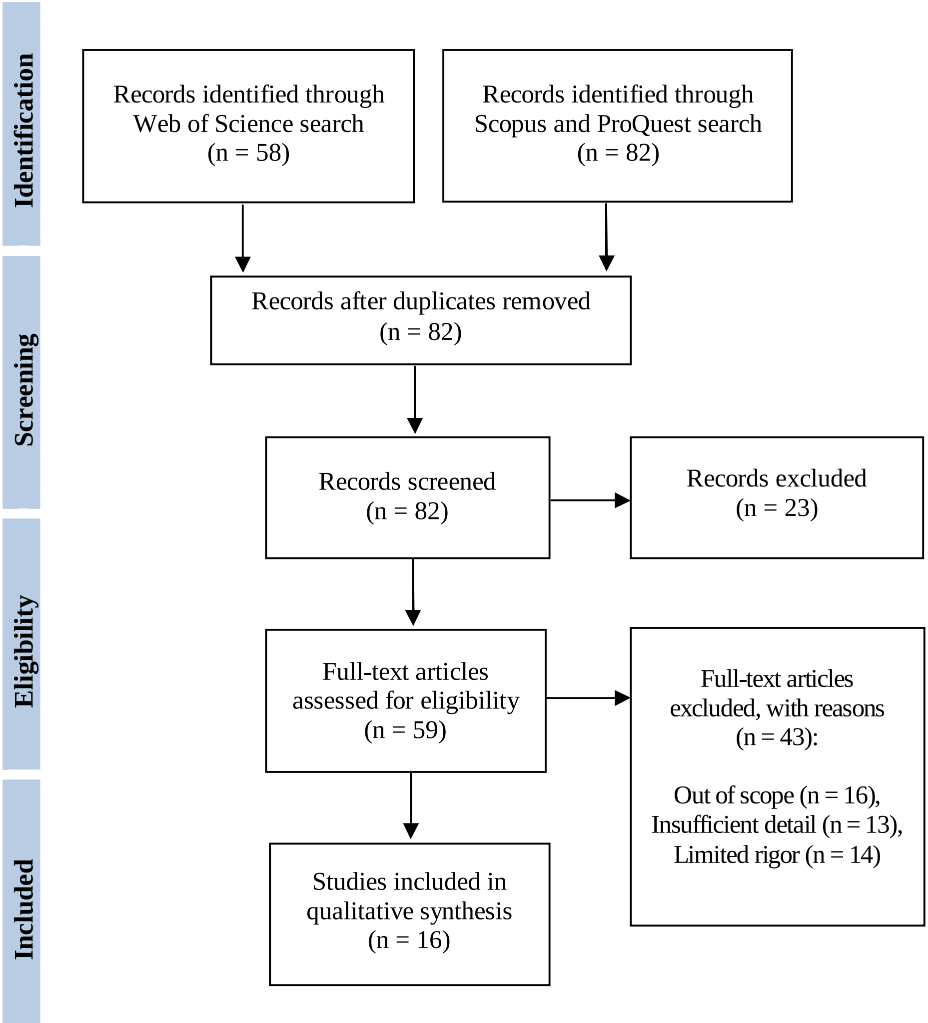

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.

To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

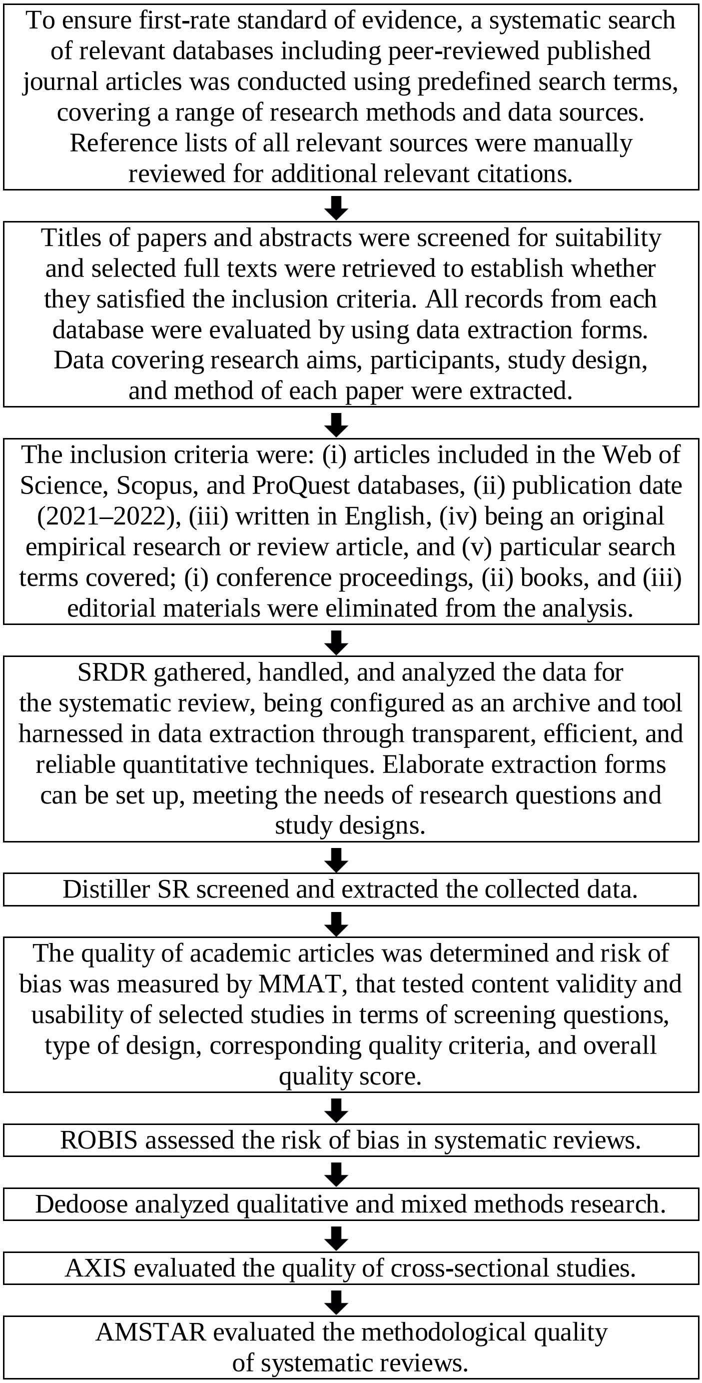

Figure 6 Screening and quality assessment tools

4. Creative Ideation in Metaverse Spaces

Leveraging data derived from customer purchases, returns, and feedback (Kozinets, 2022; Laviola et al., 2022; Park et al., 2022) can drive creative ideation in metaverse spaces. Personalized promotions and discounts, targeted campaigns, shopper engagement technologies, predefined offers, groundbreaking integrated value propositions, and product recommendations can improve user experience, diversified operational strategy, and process efficiency, thus leading to lasting competitive advantage. Virtual retail algorithms can integrate consumer behavior and data across 3D immersive environments.

Harnessing visual imagery, machine learning-based product recognition, and customer location data (Lv et al., 2022; Siyaev and Jo, 2021; Zhang et al., 2022) can drive operational improvements in metaverse spaces. Tailored services in the virtual economy focus on customer retention, increased brand recognition, and optimized digital shopping experiences, by tracking consumer sentiment, behavior, and engagement, thus improving business competitiveness. Interactive technologies and business intelligence analytics can harness artificial neural networks, semantic vector search technology, and simulation modeling in virtual commerce as regards e-commerce platform-based livestream shopping events, resulting in expanded customer base, optimized purchasing decisions and customer convenience, and user loyalty and trust.

Customer engagement tools improve resource and operational efficiency by determining digital product purchase intentions (Chandra, 2022; Han et al., 2022; Jang et al., 2022) through collecting, processing, and transacting user location data in metaverse spaces. Computer vision and natural language processing techniques, deep learning artificial intelligence tools and algorithms, and real-time and historical customer data analytics are pivotal in articulating frictionless personalized shopping experiences on immersive shopping and augmented reality commerce platforms. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Leveraging data derived from customer purchases, returns, and feedback can drive creative ideation in metaverse spaces.	Kozinets, 2022; Laviola et al., 2022; Park et al., 2022
Harnessing visual imagery, machine learning-based product recognition, and customer location data can drive operational improvements in metaverse spaces.	Lv et al., 2022; Siyaev and Jo, 2021; Zhang et al., 2022
Customer engagement tools improve resource and operational efficiency by determining digital product purchase intentions through collecting, processing, and transacting user location data in metaverse spaces.	Chandra, 2022; Han et al., 2022; Jang et al., 2022

5. Business Intelligence Tools in Metaverse Commerce

Computer vision and deep learning algorithms can assist metaverse technologies in forecasting user preferences and behaviors (Hwang and Chien, 2022; Lin et al., 2022; Park and Kim, 2022), while optimizing customer support as regards virtual merchandise. Engaging customizable immersive spaces are instrumental in digital shopping journey, taking into account changing consumer demands while focusing on personalized and meaningful customer experiences. On-demand product customization services can improve operational efficiency as regards experiential retail in virtual commerce through digital marketing tools, smart connected devices, and natural language processing algorithms, furthering rich customer experiences.

Natural language processing techniques and content creator monetization tools integrate customer purchasing history and configure seamless shopping experiences (Kozinets, 2022; Turner, 2022; Xi et al., 2022) as regards items traded in the metaverse. Contextual streamlined interactions increase data-informed operational decision-making efficiency and build long-term customer loyalty, leading to multidimensional omnichannel connected experiences through customer location tracking and monitoring.

Business intelligence tools in metaverse commerce can improve customer service performance and bring about personalized shopping experiences (Akyildiz et al., 2022; Siyaev and Jo, 2021; Zhang et al., 2022) through proactive real-time engagement. Cognitive computing systems, data-driven artificial intelligence, and behavioral predictive analytics across live shopping spaces shape purchasing decisions, customer engagement and values, and shopping patterns and spending habits. Customized data workflows, digital contact tracing technologies, and personalized content can improve customer brand loyalty, leading to live shopping-based instant buying. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Computer vision and deep learning algorithms can assist metaverse technologies in forecasting user preferences and behaviors, while optimizing customer support as regards virtual merchandise.	Hwang and Chien, 2022; Lin et al., 2022; Park and Kim, 2022
Natural language processing techniques and content creator monetization tools integrate customer purchasing history and configure seamless shopping experiences as regards items traded in the metaverse.	Kozinets, 2022; Turner, 2022; Xi et al., 2022)
Business intelligence tools in metaverse commerce can improve customer service performance and bring about personalized shopping experiences through proactive real-time engagement.	Akyildiz et al., 2022; Siyaev and Jo, 2021; Zhang et al., 2022

6. Possessions and Assets in the Metaverse

Harnessing customer-generated data can predict purchase intention, optimizing business performance (Hwang and Chien, 2022; Laviola et al., 2022; Wang, 2022) by product and service enhancements and offering and channel expansion in metaverse spaces. Real-time artificial intelligence-powered personalized product and styling recommendations and offers based on historical purchasing trends can impact immersive shopping experiences and raise brand awareness in terms of customer loyalty, personalization, and convenience. Predicting consumer purchase behaviors across digital channels through analytical tools can increase product and service visibility and awareness.

Shopper confidence and engagement across seamlessly interconnected virtual worlds (Park et al., 2022; Lv et al., 2022; Xi et al., 2022) can result in optimized purchase behavior as regards items traded in the metaverse. Virtual retail shopping behavior analytics can configure immersive extended reality experiences. By leveraging customer data, business intelligence operations enable customizable data modeling and predictive maintenance that can influence consumer choices across augmented and virtual reality systems. Virtual navigation tools, spatial analytics, and behavioral data can customize user experiences in shared virtual environments.

Retail performance has been increased by digital channel shifting and expanding (Han et al., 2022; Lin et al., 2022; Zhang et al., 2022) in terms of speed and convenience as regards possessions and assets in the metaverse. Networks of interconnected devices, tools, and products can match customer personalized preferences, expectations, and interests, and enable digital orders and shopping trends. Customer engagement and product data management can optimize brand visibility and performance, increasing average order and customer lifetime value. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Harnessing customer-generated data can predict purchase intention, optimizing business performance by product and service enhancements and offering and channel expansion in metaverse spaces.	Hwang and Chien, 2022; Laviola et al., 2022; Wang, 2022
Shopper confidence and engagement across seamlessly interconnected virtual worlds can result in optimized purchase behavior as regards items traded in the metaverse.	Park et al., 2022; Lv et al., 2022; Xi et al., 2022
Retail performance has been increased by digital channel shifting and expanding in terms of speed and convenience as regards possessions and assets in the metaverse.	Han et al., 2022; Lin et al., 2022; Zhang et al., 2022

7. Discussion

I integrate my systematic review throughout research indicating how personalized promotions and discounts, targeted campaigns, shopper engagement technologies, predefined offers, groundbreaking integrated value propositions, and product recommendations can improve user experience, diversified operational strategy, and process efficiency, thus leading to lasting competitive advantage. My research complements recent analyses clarifying how real-time artificial intelligence-powered personalized product and styling recommendations and offers based on historical purchasing trends can impact immersive shopping experiences and raise brand awareness in terms of customer loyalty, personalization, and convenience. I elucidate, by cumulative evidence, previous research demonstrating how networks of interconnected devices, tools, and products can match customer personalized preferences, expectations, and interests, and enable digital orders and shopping trends.

8. Synopsis of the Main Research Outcomes

Virtual navigation tools, spatial analytics, and behavioral data can customize user experiences in shared virtual environments. Customized data workflows, digital contact tracing technologies, and personalized content can improve customer brand loyalty, leading to live shopping-based instant buying. Virtual retail algorithms can integrate consumer behavior and data across 3D immersive environments.

9. Conclusions

Relevant research has investigated whether engaging customizable immersive spaces are instrumental in digital shopping journey, taking into account changing consumer demands while focusing on personalized and meaningful customer experiences. This systematic literature review presents the published peer-reviewed sources covering how interactive technologies and business intelligence analytics can harness artificial neural networks, semantic vector search technology, and simulation modeling in virtual commerce. The research outcomes drawn from the above analyses indicate that business intelligence operations enable customizable data modeling and predictive maintenance that can influence consumer choices across augmented and virtual reality systems.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on the virtual economy of the metaverse in terms of computer vision and deep learning algorithms, customer engagement tools, and behavioral predictive analytics may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of items traded in the metaverse.

Subsequent analyses should develop on speed and convenience as regards possessions and assets in the metaverse. Future research should thus investigate collecting, processing, and transacting user location data in metaverse spaces. In the future, attention should be directed to operational improvements in metaverse spaces.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the author.

Data availability statement

All data generated or analyzed are included in the published article.

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Author contributions

The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Behavioral Analytics, Immersive Technologies, and Machine Vision Algorithms in the Web3-powered Metaverse World

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ABSTRACT. We draw on a substantial body of theoretical and empirical research on behavioral analytics, immersive technologies, and machine vision algorithms in the Web3-powered metaverse world. With increasing evidence of data tracking, management, measurement, optimization, and analysis across metaverse worlds, there is an essential demand for comprehending whether technology-enabled live shopping can improve customer engagement and satisfaction in virtual and augmented reality-based immersive environments. In this research, prior findings were cumulated indicating that ambient scene detection and visual analytics can drive customer retention and acquisition in the virtual retail market, building brand awareness and hyper-personalization across e-commerce operations. We carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout March 2022, with search terms including "metaverse" + "behavioral analytics," "immersive technologies," and "machine vision algorithms." As we analyzed research published in 2022, only 80 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, we decided on 15, chiefly empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, ROBIS, and SRDR.

Keywords: immersive; analytics; metaverse; algorithm; machine vision; behavior

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1. Introduction

Smart technologies can deploy spatial data and analytics capabilities to improve customer acquisition (Andronie et al., 2021; Kral et al., 2020; Nica, 2015; Popescu et al., 2019; Zvarikova et al., 2022) in terms of purchasing recommended items. The purpose of our systematic review is to examine the recently published literature on behavioral analytics, immersive technologies, and machine vision algorithms in the Web3-powered metaverse world and integrate the insights it configures on the use of data-driven artificial intelligence in a fully connected metaverse. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that leveraging consumer data can maximize engagement across customer journeys (Barbu et al., 2021; Lăzăroiu et al., 2017; Nica, 2018; Rydell and Suler, 2021) by use of deep learning algorithms, real-time data analytics, and visualization tools. The actuality and novelty of this study are articulated by addressing data tracking, management, measurement, optimization, and analysis across metaverse worlds, that is an emerging topic involving much interest. Our research problem is whether customizable virtual chatbot assistants can recognize emotional facial expressions during customer journey across immersive digital environments.

In this review, prior findings have been cumulated indicating that natural language processing models and synthetic data tools can optimize customer service across digital business platforms (Friedman et al., 2022; Lăzăroiu, 2018; Popescu, 2017; Valaskova et al., 2022), shaping purchasing behaviors and leading to long-term consumer loyalty as regards augmented shopping experiences. The identified gaps advance virtual navigation tools and consumer journey analytics in a fully connected metaverse. Our main objective is to indicate that technology-enabled live shopping can improve customer engagement and satisfaction (Gasparin and Schinckus, 2022; Lăzăroiu et al., 2020; Popescu et al., 2017a, b; Watson, 2022) in virtual and augmented reality-based immersive environments. This systematic review contributes to the literature on innovative shopping formats in a Web3-powered metaverse world by clarifying that ambient scene detection and visual analytics can drive customer retention and acquisition (Glogovețan et al., 2022; Nemțeanu et al., 2022; Popescu, 2018; Woodward and Kliestik, 2021) in the virtual retail market, building brand awareness and hyper-personalization across e-commerce operations.

2. Theoretical Overview of the Main Concepts

Webchat customer services can be pivotal in virtual store-based immersive digital simulations by use of machine intelligence and retail analytics, resulting in scalable product innovation and expanded product offerings while shaping consumer sentiment and shopping behavior. Digital tools and analytics can build consumer relationships in retail business in blockchain-based virtual worlds, optimizing online buying experiences and decreasing purchasing behavior shifts. Rich shopper data and analytic capabilities can define customer profiles, improving immersive virtual shopping experiences during purchase journeys in virtual shopping mall environments. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), data-driven artificial intelligence in a fully connected metaverse (section 4), user behavior and increasing brand loyalty across metaverse worlds (section 5), virtual navigation tools and consumer journey analytics in a fully connected metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

We carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout March 2022, with search terms including "metaverse" + "behavioral analytics," "immersive technologies," and "machine vision algorithms." The search terms were determined as being the most employed words or phrases across the analyzed literature. As we analyzed research published in 2022, only 80 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, we decided on 15, chiefly empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + behavioral analytics	24	5
metaverse + immersive technologies	30	5
metaverse + machine vision algorithms	26	5
Type of paper		
Original research	56	14
Review	4	1
Conference proceedings	13	0
Book	3	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

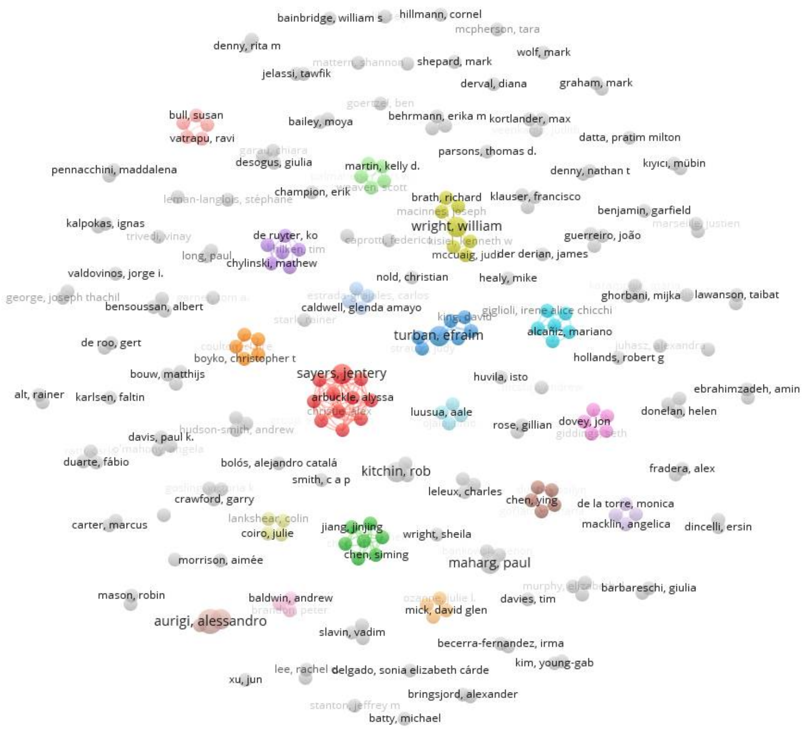

Figure 1 Co-authorship

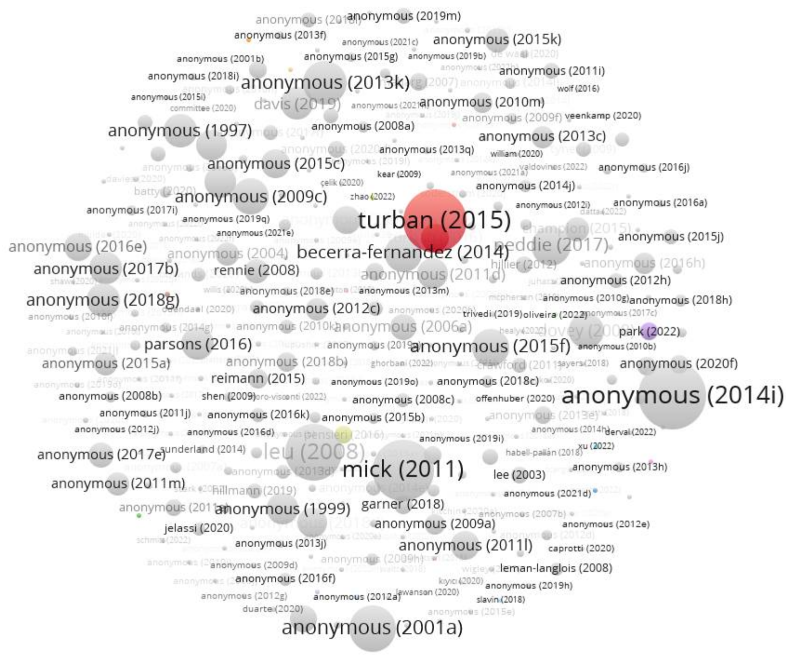

Figure 2 Citation

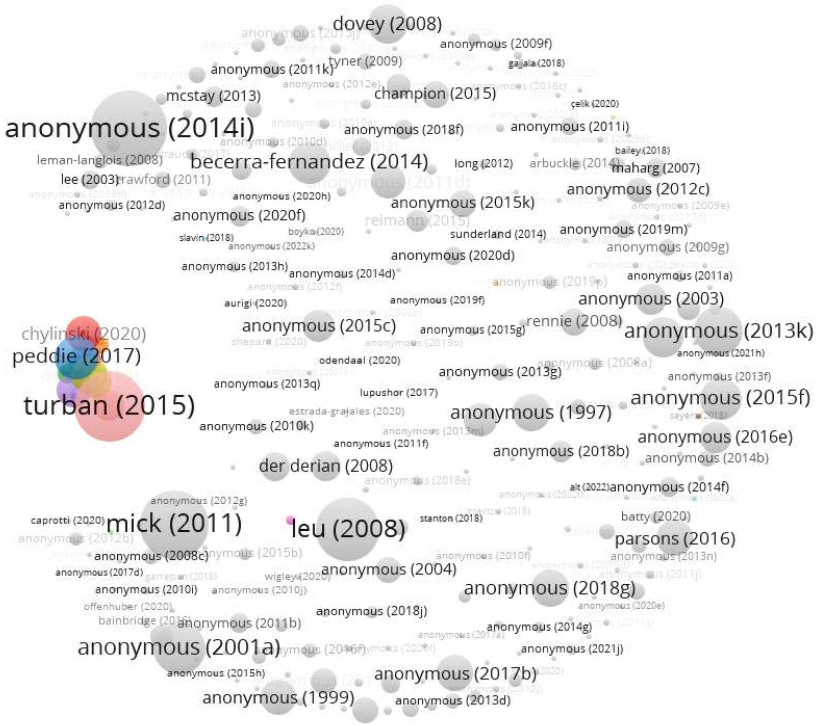

Figure 3 Bibliographic coupling

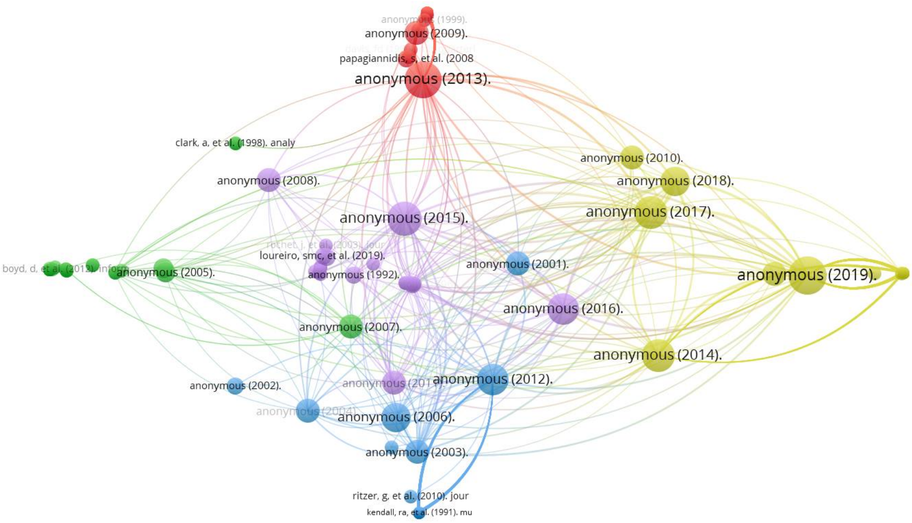

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Establishing e-commerce shopping intentions, habits, and behaviors can result in producing customized visual assets based on data tracking, management, measurement, optimization, and analysis across metaverse worlds.	Beniiche et al., 2022; Gibbert et al., 2022; Solakis et al., 2022
Personalized product recommendations integrate artificial intelligence-powered prediction, tech-based metaverse capabilities, and computer vision algorithms, enhancing engagement behaviors and purchase decisions.	Gills and Hosseini, 2022; Gursoy et al., 2022; Park et al., 2022
Livestreaming shopping platforms can focus on engaging interactive events through dynamic personalized offers by use of data-driven artificial intelligence in a fully connected metaverse.	Elawady et al., 2022; Hollensen et al., 2022; Zhang et al., 2022a
Dynamically configurable data collection and governance across the decentralized and interconnected metaverse can enrich consumer experience in relation to virtual retail stores through deep learning computer vision algorithms.	Gössling and Schweiggart, 2022; Liu et al., 2022; Zhang et al., 2022b
Behavioral analytics can assist customer service processes in virtual stores, driving user behavior and increasing brand loyalty across metaverse worlds. Natural language processing models and synthetic data tools can optimize customer service across digital business platforms, shaping purchasing behaviors and leading to long-term consumer loyalty as regards augmented shopping experiences.	Guo and Gao, 2022; Park et al., 2022; Solakis et al., 2022
Immersive and engaging e-commerce, through rich customer data, can lead to value creation for virtual assets while raising awareness in a fully connected metaverse.	Gursoy et al., 2022; Hollensen et al., 2022; Zhang et al., 2022b
Engaging digital content can enhance customer satisfaction across extended reality environments by integrating real-time technology across metaverse worlds.	Beniiche et al., 2022; Han et al., 2022; Park et al., 2022
Cross-functional improvements in contextual content delivery by leveraging robust data can be attained by use of virtual navigation tools and consumer journey analytics in a fully connected metaverse.	Hollensen et al., 2022; Liu et al., 2022; Zhang et al., 2022a
Sentiment analytics and image recognition can assist merchandising decisions, and thus brands and retailers can attract and retain customers through innovative shopping formats in a Web3-powered metaverse world.	Elawady et al., 2022; Gills and Hosseini, 2022; Zyda, 2022

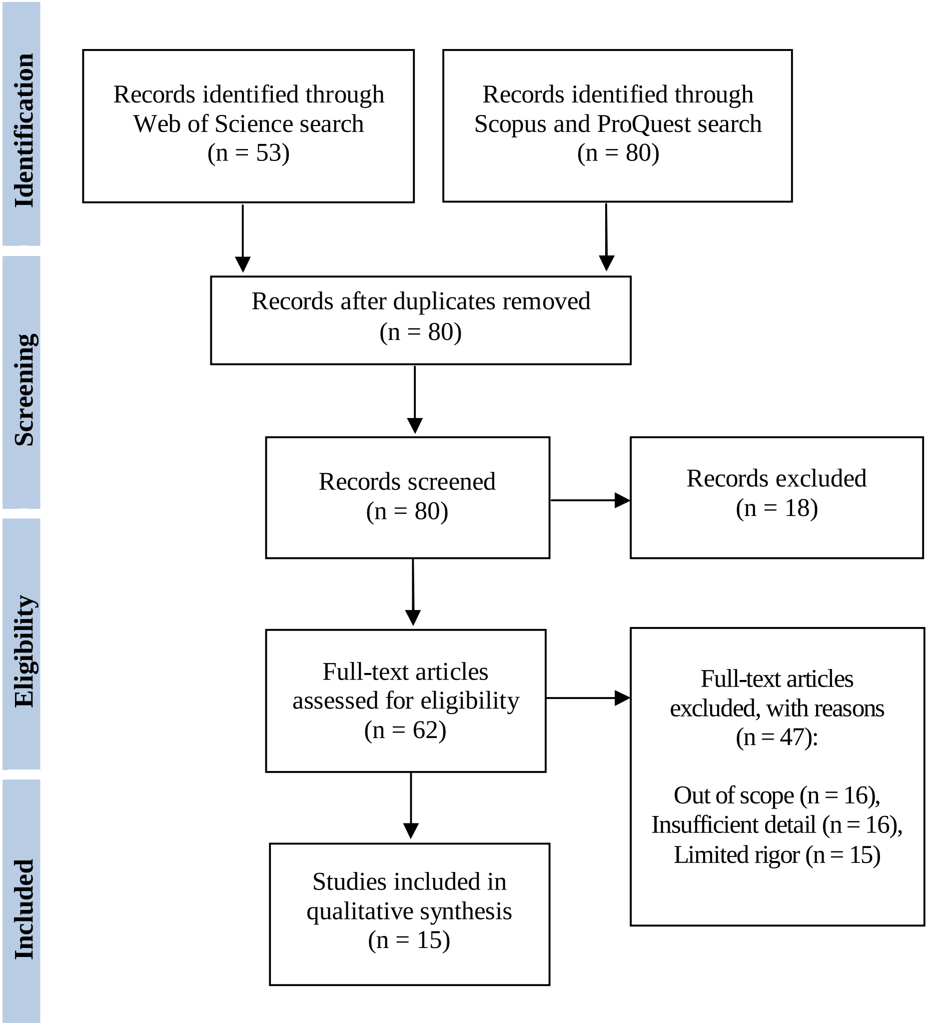

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

Distiller SR screened and extracted the collected data.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

ROBIS assessed the risk of bias in systematic reviews.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

Dedoose analyzed qualitative and mixed methods research.

Figure 6 Screening and quality assessment tools

4. Data-driven Artificial Intelligence in a Fully Connected Metaverse

Establishing e-commerce shopping intentions, habits, and behaviors can result in producing customized visual assets (Beniiche et al., 2022; Gibbert et al., 2022; Solakis et al., 2022) based on data tracking, management, measurement, optimization, and analysis across metaverse worlds. Leveraging consumer data can maximize engagement across customer journeys by use of deep learning algorithms, real-time data analytics, and visualization tools. Natural language processing-based systems, deep neural network technology, and speech analytics can optimize operational performance through logistics intelligence as regards virtual reality-based immersive experiences.

Personalized product recommendations integrate artificial intelligence-powered prediction, tech-based metaverse capabilities, and computer vision algorithms (Gills and Hosseini, 2022; Gursoy et al., 2022; Park et al., 2022), enhancing engagement behaviors and purchase decisions. Digital tools and analytics can build consumer relationships in retail business in blockchain-based virtual worlds, optimizing online buying experiences and decreasing purchasing behavior shifts.

Livestreaming shopping platforms can focus on engaging interactive events through dynamic personalized offers (Elawady et al., 2022; Hollensen et al., 2022; Zhang et al., 2022a) by use of data-driven artificial intelligence in a fully connected metaverse. Real-time offer personalization and customized virtual goods typify immersive live streaming experiences and result in attracting long-term engaged customers. Smart digital services and data-driven decisions can meet customer demand by integrating sensor data across persistent virtual worlds and articulating seamless immersive experiences. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Establishing e-commerce shopping intentions, habits, and behaviors can result in producing customized visual assets based on data tracking, management, measurement, optimization, and analysis across metaverse worlds.	Beniiche et al., 2022; Gibbert et al., 2022; Solakis et al., 2022
Personalized product recommendations integrate artificial intelligence-powered prediction, tech-based metaverse capabilities, and computer vision algorithms, enhancing engagement behaviors and purchase decisions.	Gills and Hosseini, 2022; Gursoy et al., 2022; Park et al., 2022
Livestreaming shopping platforms can focus on engaging interactive events through dynamic personalized offers by use of data-driven artificial intelligence in a fully connected metaverse.	Elawady et al., 2022; Hollensen et al., 2022; Zhang et al., 2022a

5. User Behavior and Increasing Brand Loyalty across Metaverse Worlds

Dynamically configurable data collection and governance across the decentralized and interconnected metaverse (Gössling and Schweiggart, 2022; Liu et al., 2022; Zhang et al., 2022b) can enrich consumer experience in relation to virtual retail stores through deep learning computer vision algorithms. Rich shopper data and analytic capabilities can define customer profiles, improving immersive virtual shopping experiences during purchase journeys in virtual shopping mall environments. Smart technologies can deploy spatial data and analytics capabilities to improve customer acquisition in terms of purchasing recommended items.

Behavioral analytics can assist customer service processes in virtual stores (Guo and Gao, 2022; Park et al., 2022; Solakis et al., 2022), driving user behavior and increasing brand loyalty across metaverse worlds. Webchat customer services can be pivotal in virtual store-based immersive digital simulations by use of machine intelligence and retail analytics, resulting in scalable product innovation and expanded product offerings while shaping consumer sentiment and shopping behavior. Natural language processing models and synthetic data tools can optimize customer service across digital business platforms, shaping purchasing behaviors and leading to long-term consumer loyalty as regards augmented shopping experiences.

Immersive and engaging e-commerce, through rich customer data, can lead to value creation for virtual assets (Gursoy et al., 2022; Hollensen et al., 2022; Zhang et al., 2022b) while raising awareness in a fully connected metaverse. Cloud and edge computing can assist business-support analytics in engaging consumers in instant purchasing across immersive digital worlds. Ambient scene detection and visual analytics can drive customer retention and acquisition in the virtual retail market, building brand awareness and hyper-personalization across e-commerce operations. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Dynamically configurable data collection and governance across the decentralized and interconnected metaverse can enrich consumer experience in relation to virtual retail stores through deep learning computer vision algorithms.	Gössling and Schweiggart, 2022; Liu et al., 2022; Zhang et al., 2022b
Behavioral analytics can assist customer service processes in virtual stores, driving user behavior and increasing brand loyalty across metaverse worlds.	Guo and Gao, 2022; Park et al., 2022; Solakis et al., 2022
Immersive and engaging e-commerce, through rich customer data, can lead to value creation for virtual assets while raising awareness in a fully connected metaverse.	Gursoy et al., 2022; Hollensen et al., 2022; Zhang et al., 2022b

6. Virtual Navigation Tools and Consumer Journey Analytics in a Fully Connected Metaverse

Engaging digital content can enhance customer satisfaction across extended reality environments (Beniiche et al., 2022; Han et al., 2022; Park et al., 2022) by integrating real-time technology across metaverse worlds. Realistic-looking synthetic images and operational modeling in the livestreaming economy can optimize retail growth and profitability through precise data visualization and analytics, bringing about personalized seamless experiences. Technology-enabled live shopping can improve customer engagement and satisfaction in virtual and augmented reality-based immersive environments.

Cross-functional improvements in contextual content delivery by leveraging robust data (Hollensen et al., 2022; Liu et al., 2022; Zhang et al., 2022a) can be attained by use of virtual navigation tools and consumer journey analytics in a fully connected metaverse. Collecting customer preferences and shopper behavioral data can increase engagement rates and retail transactions. Customizable virtual chatbot assistants can recognize emotional facial expressions during customer journey across immersive digital environments.

Sentiment analytics and image recognition can assist merchandising decisions (Elawady et al., 2022; Gills and Hosseini, 2022; Zyda, 2022), and thus brands and retailers can attract and retain customers through innovative shopping formats in a Web3-powered metaverse world. Artificial intelligence customer service chatbots can leverage consumption data in retail business models across digital marketplaces, attracting and retaining customers. Customer identification technology can assist e-commerce and logistical operations by interaction and movement tracking in an increasingly competitive marketplace. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Engaging digital content can enhance customer satisfaction across extended reality environments by integrating real-time technology across metaverse worlds.	Beniiche et al., 2022; Han et al., 2022; Park et al., 2022
Cross-functional improvements in contextual content delivery by leveraging robust data can be attained by use of virtual navigation tools and consumer journey analytics in a fully connected metaverse.	Hollensen et al., 2022; Liu et al., 2022; Zhang et al., 2022a
Sentiment analytics and image recognition can assist merchandising decisions, and thus brands and retailers can attract and retain customers through innovative shopping formats in a Web3-powered metaverse world.	Elawady et al., 2022; Gills and Hosseini, 2022; Zyda, 2022

7. Discussion

We integrate our systematic review throughout research indicating how natural language processing-based systems, deep neural network technology, and speech analytics can optimize operational performance through logistics intelligence as regards virtual reality-based immersive experiences. Our research complements recent analyses clarifying how cloud and edge computing can assist business-support analytics in engaging consumers in instant purchasing across immersive digital worlds. We elucidate, by cumulative evidence, previous research demonstrating how collecting customer preferences and shopper behavioral data can increase engagement rates and retail transactions.

8. Synopsis of the Main Research Outcomes

Real-time offer personalization and customized virtual goods typify immersive live streaming experiences and result in attracting long-term engaged customers. Customer identification technology can assist e-commerce and logistical operations by interaction and movement tracking in an increasingly competitive marketplace in a fully connected metaverse.

9. Conclusions

Relevant research has investigated whether realistic-looking synthetic images and operational modeling in the livestreaming economy can optimize retail growth and profitability through precise data visualization and analytics, bringing about personalized seamless experiences. This systematic literature review presents the published peer-reviewed sources covering how artificial intelligence customer service chatbots can leverage consumption data in retail business models across digital marketplaces, attracting and retaining customers. The research outcomes drawn from the above analyses indicate that smart digital services and data-driven decisions can meet customer demand by integrating sensor data across persistent virtual worlds and articulating seamless immersive experiences.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on behavioral analytics, immersive technologies, and machine vision algorithms in the Web3-powered metaverse world may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of data collection and governance across the decentralized and interconnected metaverse.

Subsequent analyses should develop on user behavior and increasing brand loyalty across metaverse worlds. Future research should thus investigate tech-based metaverse capabilities. In the future, attention should be directed to immersive and engaging e-commerce.

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Virtual Retail in the Metaverse: Customer Behavior Analytics, Extended Reality Technologies, and Immersive Visualization Systems

Donald Adams*

ABSTRACT. The aim of this systematic review is to synthesize and analyze virtual retail in the metaverse in terms of customer behavior analytics, extended reality technologies, and immersive visualization systems. With increasing evidence of consumer values on blockchain-based metaverse platforms, there is an essential demand for comprehending whether digitized retail products and augmented reality shopping tools in virtual malls can integrate consumer intelligence, contextual awareness, and brand perception metrics to result in computational efficiency improvement. In this research, prior findings were cumulated indicating that consumer journey analytics can assist in virtual asset purchasing by articulating personalized shopping experiences. I carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout February 2022, with search terms including "metaverse" + "virtual retail," "customer behavior analytics," "extended reality technologies," and "immersive visualization systems." As I analyzed research published in 2022, only 79 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, I decided on 15, chiefly empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Distiller SR, ROBIS, and SRDR.

Keywords: virtual; retail; metaverse; behavior analytics; customer; visualization

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1. Introduction

Artificial intelligence-powered technologies and tools can increase customer lifetime value (Griffin and Krastev, 2021; Nica, 2017; Peters, 2022; Popescu et al., 2020; Vinerean et al., 2022) in virtual worlds by e-commerce capabilities. The purpose of my systematic review is to examine the recently published literature on virtual retail in the metaverse and integrate the insights it configures on customer behavior analytics, extended reality technologies, and immersive visualization systems. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that augmented and virtual reality applications can articulate a realistic user experience (Andronie et al., 2021a, b, c; Kliestik et al., 2020; Pop et al., 2022), building brand awareness and bringing about heightened consumer demand. The actuality and novelty of this study are articulated by addressing consumer values on blockchain-based metaverse platforms, that is an emerging topic involving much interest. My research problem is whether digitized retail products and augmented reality shopping tools in virtual malls can integrate consumer intelligence, contextual awareness, and brand perception metrics (Jenkins, 2022; Nica et al., 2021; Poliak et al., 2021; Rydell and Suler, 2021) to result in computational efficiency improvement. In this review, prior findings have been cumulated indicating that virtual and augmented reality devices, real-time sensor data, and cognitive enhancement technologies can affect consumption patterns, smart asset management, and merchandise supply planning, improving customer retention and loyalty.

The identified gaps advance the decentralized virtual world and interoperable platforms enabled by the Web 3.0 architecture as immersive and shared metaverse. My main objective is to indicate that, by deploying predictive analytics, augmented reality shopping tools, and immersive visualization systems in digital experience economy (Blazek et al., 2022; Lăzăroiu, 2017; Nica, 2021; Popescu, 2017; Valle, 2021), real-time performance data is achieved, while customers are increasingly acquired and retained. This systematic review contributes to the literature on brand strength in virtual stores throughout the blockchain-based metaverse by clarifying that consumer journey analytics can assist in virtual asset purchasing (Glogovețan et al., 2022; Lăzăroiu et al., 2022; Nica et al., 2022; Popescu, 2018) by articulating personalized shopping experiences.

2. Theoretical Overview of the Main Concepts

Retail analytics, biometric payment tools, and computer vision algorithms can increase customer contextual data, behaviors, and engagement, enhancing immersive 3D experiences in the virtual economy. Virtual and augmented reality tracking can predict user behaviors and strengthen shopping habits by harnessing consumer location data. By leveraging predictive analytics and computer vision tools in retail livestreaming, consumer shopping patterns are determined. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), consumer values on blockchain-based metaverse platforms (section 4), improving brand strength in virtual stores throughout the blockchain-based metaverse (section 5), consumer attention in a computer-generated universe throughout entertaining metaverse events (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

I carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout February 2022, with search terms including "meta-verse" + "virtual retail," "customer behavior analytics," "extended reality technologies," and "immersive visualization systems." The search terms were determined as being the most employed words or phrases across the analyzed literature. As I analyzed research published in 2022, only 79 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/ unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, I decided on 15, chiefly empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Distiller SR, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + virtual retail	21	4
metaverse + customer behavior analytics	20	4
metaverse + extended reality technologies	20	4
metaverse + immersive visualization systems	18	3
Type of paper		
Original research	51	14
Review	5	1
Conference proceedings	11	0
Book	4	0
Editorial	8	0

Source: Processed by the author. Some topics overlap.

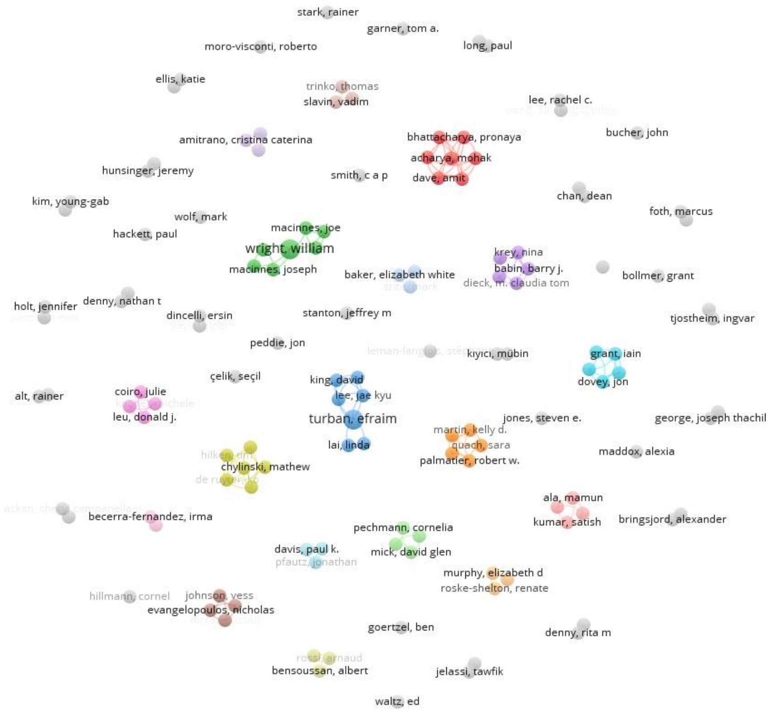

Figure 1 Co-authorship

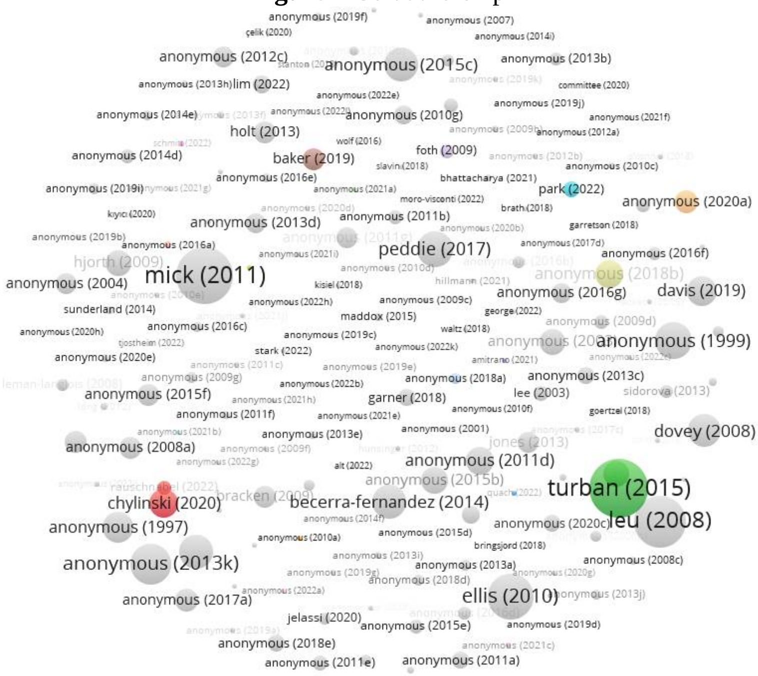

Figure 2 Citation

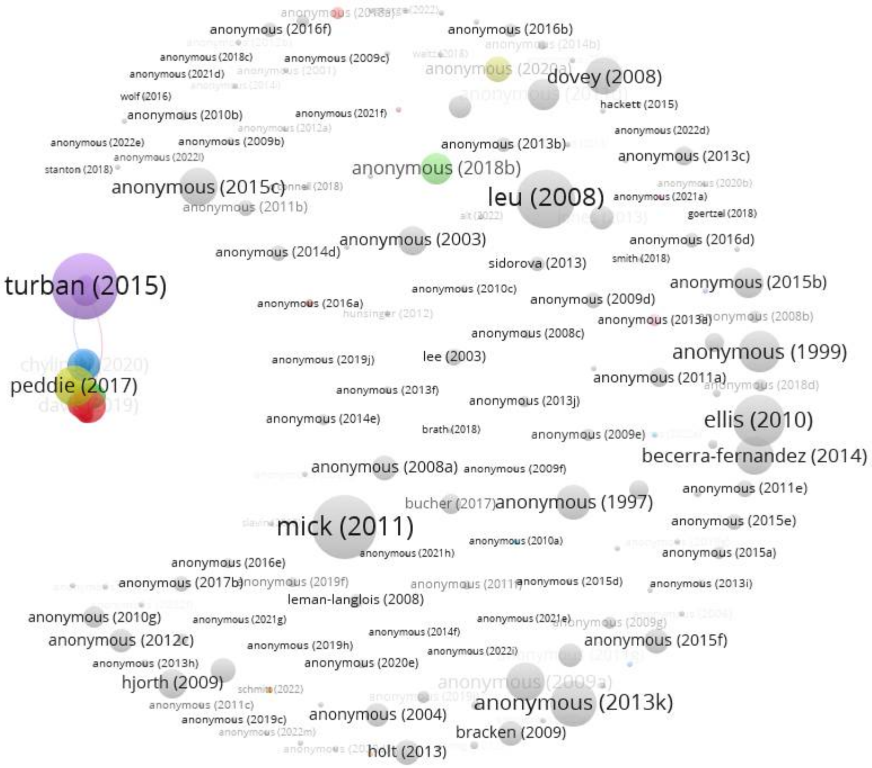

Figure 3 Bibliographic coupling

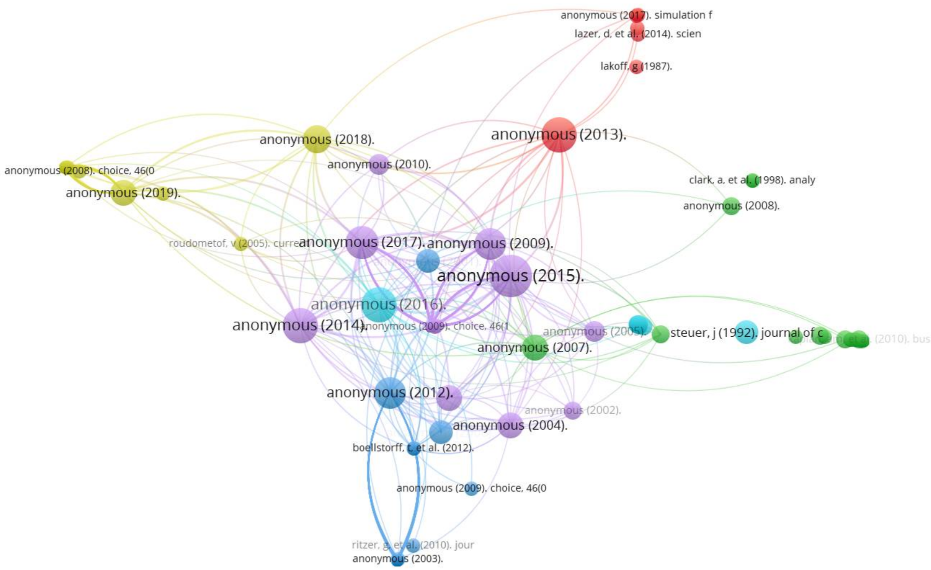

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

5G hyperconnected networks, blockchain-based digital currencies, and extended reality technologies can typify the decentralized virtual world and interoperable platforms enabled by the Web 3.0 architecture as immersive and shared metaverse.	Gibbert et al., 2022; Laviola et al., 2022; Xi et al., 2022
Virtual retail experiences across immersive digital worlds can typify consumer values on blockchain-based metaverse platforms.	Lukava et al., 2022; Skalidis et al., 2022; Zhao et al., 2022
Livestreaming e-commerce and immersive interconnected virtual experiences can drive engagement and growth while optimizing user journeys during live-video shopping events in the metaverse.	Almarzouqi et al. 2022; Reis and Ashmore, 2022; Wang, 2022
Metaverse consumer retail data can optimize customized shopping experiences. By leveraging predictive analytics and computer vision tools in retail livestreaming, consumer shopping patterns are determined.	Kshetri, 2022; Reis and Ashmore, 2022; Zhang et al., 2022
Immersive technologies and real-time predictive analytics can influence consumer behaviors and buying patterns during live-video shopping events in the metaverse. Artificial intelligence-powered technologies and tools can increase customer lifetime value in virtual worlds.	Laviola et al., 2022; Turner, 2022; Zyda, 2022
Real-time customer data analytics and dynamic routing technology can configure convenient shopping experiences and customized production, improving brand strength in virtual stores throughout the blockchain-based metaverse.	Lukava et al., 2022; Skalidis et al., 2022; Xi et al., 2022
Data management processes in virtual shopping malls can improve customer loyalty and decision journeys through advanced analytics, eye-tracking technologies, geospatial mapping, and self-learning algorithms throughout the blockchain-based metaverse.	Kshetri, 2022; Reis and Ashmore, 2022; Zhao et al., 2022
Personalized and convenient services, customized digital experiences, and competitive product offerings can optimize experiential shopping and capture consumer attention in a computer-generated universe throughout entertaining metaverse events.	Almarzouqi et al. 2022; Solakis et al., 2022; Wang, 2022
Improved operational agility can build customer relationships and enable seamless purchasing experiences through vision technology, automated speech recognition, and decision support tools throughout entertaining metaverse events.	Park and Kim, 2022; Xi et al., 2022; Zhang et al., 2022

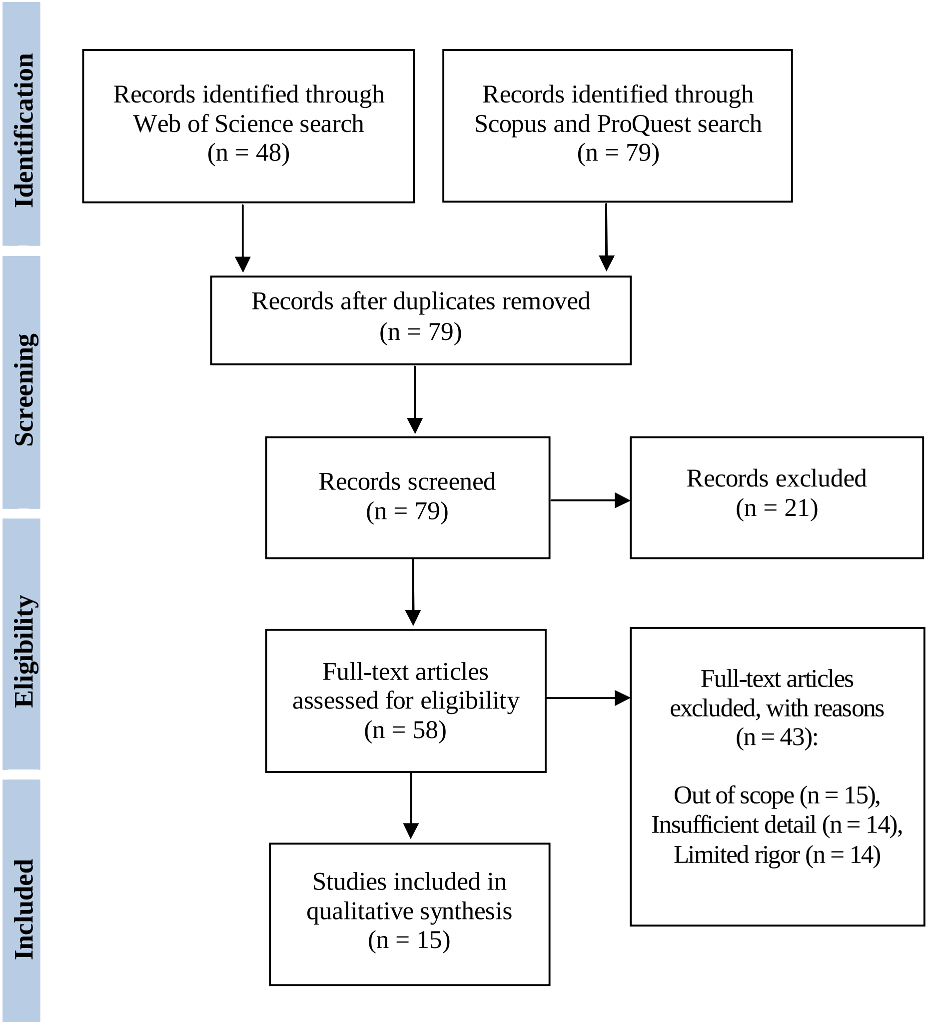

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

Distiller SR screened and extracted the collected data.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

↓

ROBIS assessed the risk of bias in systematic reviews.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

Dedoose analyzed qualitative and mixed methods research.

Figure 6 Screening and quality assessment tools

4. Consumer Values on Blockchain-based Metaverse Platforms

5G hyperconnected networks, blockchain-based digital currencies, and extended reality technologies (Gibbert et al., 2022; Laviola et al., 2022; Xi et al., 2022) can typify the decentralized virtual world and interoperable platforms enabled by the Web 3.0 architecture as immersive and shared metaverse. Livestreaming e-commerce can reach and engage consumers, with data-driven decision making shaping personalized product recommendations. Virtual and augmented reality tracking can predict user behaviors and strengthen shopping habits by harnessing consumer location data. Augmented and virtual reality applications can articulate a realistic user experience, building brand awareness and bringing about heightened consumer demand.

Virtual retail experiences across immersive digital worlds (Lukava et al., 2022; Skalidis et al., 2022; Zhao et al., 2022) can typify consumer values on blockchain-based metaverse platforms. Extended reality technologies and synthetic environments typify interconnected virtual worlds. By leveraging text analytics and natural language processing tools, big data-driven processes and technologies can improve customer relationship management as regards digital commerce and goods.

Livestreaming e-commerce and immersive interconnected virtual experiences can drive engagement and growth (Almarzouqi et al. 2022; Reis and Ashmore, 2022; Wang, 2022) while optimizing user journeys during live-video shopping events in the metaverse. Retail brands in virtual environments can harness real-time data tracking and monitoring, analytic decision models, and 3D modeling tools to improve customer loyalty and expectations during immersive retail experiences. By deploying predictive analytics, augmented reality shopping tools, and immersive visualization systems in digital experience economy, real-time performance data is achieved, while customers are increasingly acquired and retained. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

5G hyperconnected networks, blockchain-based digital currencies, and extended reality technologies can typify the decentralized virtual world and interoperable platforms enabled by the Web 3.0 architecture as immersive and shared metaverse.	Gibbert et al., 2022; Laviola et al., 2022; Xi et al., 2022
Virtual retail experiences across immersive digital worlds can typify consumer values on blockchain-based metaverse platforms.	Lukava et al., 2022; Skalidis et al., 2022; Zhao et al., 2022
Livestreaming e-commerce and immersive interconnected virtual experiences can drive engagement and growth while optimizing user journeys during live-video shopping events in the metaverse.	Almarzouqi et al. 2022; Reis and Ashmore, 2022; Wang, 2022

5. Improving Brand Strength in Virtual Stores throughout the Blockchain-based Metaverse

Metaverse consumer retail data (Kshetri, 2022; Reis and Ashmore, 2022; Zhang et al., 2022) can optimize customized shopping experiences. By leveraging predictive analytics and computer vision tools in retail live-streaming, consumer shopping patterns are determined. Retail analytics, bio-metric payment tools, and computer vision algorithms can increase customer contextual data, behaviors, and engagement, enhancing immersive 3D experiences in the virtual economy. Digitized retail products and augmented reality shopping tools in virtual malls can integrate consumer intelligence, contextual awareness, and brand perception metrics to result in computational efficiency improvement.

Immersive technologies and real-time predictive analytics can influence consumer behaviors and buying patterns (Laviola et al., 2022; Turner, 2022; Zyda, 2022) during live-video shopping events in the metaverse. Predictive customer analytics and behavioral data can improve consumer shopping experience and digital engagement across virtual delivery networks. Artificial intelligence-powered technologies and tools can increase customer lifetime value in virtual worlds by e-commerce capabilities.

Real-time customer data analytics and dynamic routing technology can configure convenient shopping experiences and customized production (Lukava et al., 2022; Skalidis et al., 2022; Xi et al., 2022), improving brand strength in virtual stores throughout the blockchain-based metaverse. Virtual shelves and assets in online and virtual marketplaces can improve immersive retail experiences and shape customer purchase behavior and preferences. Customized avatars and virtual reality entertainment can strengthen the consumer-based economy by use of analytical artificial intelligence, expanding brand visibility in interactive digital worlds. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Metaverse consumer retail data can optimize customized shopping experiences. By leveraging predictive analytics and computer vision tools in retail livestreaming, consumer shopping patterns are determined.	Kshetri, 2022; Reis and Ashmore, 2022; Zhang et al., 2022
Immersive technologies and real-time predictive analytics can influence consumer behaviors and buying patterns during live-video shopping events in the metaverse.	Laviola et al., 2022; Turner, 2022; Zyda, 2022
Real-time customer data analytics and dynamic routing technology can configure convenient shopping experiences and customized production, improving brand strength in virtual stores throughout the blockchain-based metaverse.	Lukava et al., 2022; Skalidis et al., 2022; Xi et al., 2022

6. Consumer Attention in a Computer-Generated Universe throughout Entertaining Metaverse Events

Data management processes in virtual shopping malls can improve customer loyalty and decision journeys (Kshetri, 2022; Reis and Ashmore, 2022; Zhao et al., 2022) through advanced analytics, eye-tracking technologies, geospatial mapping, and self-learning algorithms throughout the blockchain-based metaverse. Customer predictive analytics and delivery management software can increase consumer engagement and lead to frictionless shopping experiences, while increasing brand visibility and awareness. Consumer journey analytics can assist in virtual asset purchasing by articulating personalized shopping experiences.

Personalized and convenient services, customized digital experiences, and competitive product offerings can optimize experiential shopping and capture consumer attention (Almarzouqi et al. 2022; Solakis et al., 2022; Wang, 2022) in a computer-generated universe throughout entertaining metaverse events. Virtual and augmented reality devices, real-time sensor data, and cognitive enhancement technologies can affect consumption patterns, smart asset management, and merchandise supply planning, improving customer retention and loyalty.

Improved operational agility can build customer relationships and enable seamless purchasing experiences (Park and Kim, 2022; Xi et al., 2022; Zhang et al., 2022) through vision technology, automated speech recognition, and decision support tools throughout entertaining metaverse events. Virtual store experiences and digital asset collectability can improve brand recognition and consumer expectations while optimizing data collection through cutting-edge merchandising strategies. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Data management processes in virtual shopping malls can improve customer loyalty and decision journeys through advanced analytics, eye-tracking technologies, geospatial mapping, and self-learning algorithms throughout the blockchain-based metaverse.	Kshetri, 2022; Reis and Ashmore, 2022; Zhao et al., 2022
Personalized and convenient services, customized digital experiences, and competitive product offerings can optimize experiential shopping and capture consumer attention in a computer-generated universe throughout entertaining metaverse events.	Almarzouqi et al. 2022; Solakis et al., 2022; Wang, 2022
Improved operational agility can build customer relationships and enable seamless purchasing experiences through vision technology, automated speech recognition, and decision support tools throughout entertaining metaverse events.	Park and Kim, 2022; Xi et al., 2022; Zhang et al., 2022

7. Discussion

I integrate my systematic review throughout research indicating how live-streaming e-commerce can reach and engage consumers, with data-driven decision making shaping personalized product recommendations. Extended reality technologies and synthetic environments typify interconnected virtual worlds. My research complements recent analyses clarifying how predictive customer analytics and behavioral data can improve consumer shopping experience and digital engagement across virtual delivery networks. I elucidate, by cumulative evidence, previous research demonstrating how customized avatars and virtual reality entertainment can strengthen the consumer-based economy by use of analytical artificial intelligence, expanding brand visibility in interactive digital worlds.

8. Synopsis of the Main Research Outcomes

Customer predictive analytics and delivery management software can increase consumer engagement and lead to frictionless shopping experiences, while increasing brand visibility and awareness. By leveraging text analytics and natural language processing tools, big data-driven processes and technologies can improve customer relationship management as regards digital commerce and goods.

9. Conclusions

Relevant research has investigated whether virtual store experiences and digital asset collectability can improve brand recognition and consumer expectations while optimizing data collection through cutting-edge merchandising strategies. This systematic literature review presents the published peer-reviewed sources covering how retail brands in virtual environments can harness real-time data tracking and monitoring, analytic decision models, and 3D modeling tools to improve customer loyalty and expectations during immersive retail experiences. The research outcomes drawn from the above analyses indicate that virtual shelves and assets in online and virtual marketplaces can improve immersive retail experiences and shape customer purchase behavior and preferences.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on virtual retail in the metaverse in terms of customer behavior analytics, extended reality technologies, and immersive visualization systems may have been excluded.

Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of live-video shopping events in the metaverse.

Subsequent analyses should develop on advanced analytics, eye-tracking technologies, geospatial mapping, and self-learning algorithms throughout the blockchain-based metaverse. Future research should thus investigate optimizing user journeys during live-video shopping events in the metaverse. In the future, attention should be directed to entertaining metaverse events.

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The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Immersive and Engaging Digital Content, Data Visualization Tools, and Location Analytics in a Decentralized Metaverse

Nela Mircică*

ABSTRACT. In this article, I cumulate previous research findings indicating that immersive technologies, automated machine learning, data visualization tools, and location analytics can assist in retaining repeat shoppers, influencing consumer patterns and driving user engagement in virtual retail stores. I contribute to the literature on the decentralized metaverse by showing that data sharing technologies and visual analytics can optimize operations and livestream video shopping experiences in retail and business locations as regards digital ownership in the blockchain-based virtual economy. Throughout March 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "immersive digital content," "engaging digital content," "data visualization tools," and "location analytics." As I inspected research published between 2021 and 2022, only 76 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 14, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, MMAT, and ROBIS.

Keywords: visualization; metaverse; analytics; digital content; immersive; retail

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1. Introduction

Assessing digital customer engagement in online marketplaces requires geolocation customer data and behavior (Andronie et al., 2021a, b; Kliestik et al., 2020; Nica, 2021; Poliak et al., 2021a, b) by leveraging voice and gesture recognition technologies, sentiment analytics, and artificial vision systems. The purpose of my systematic review is to examine the recently published literature on immersive and engaging digital content, data visualization tools, and location analytics and integrate the insights it configures on the decentralized metaverse. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that consumer product brands can deploy retail analytics in immersive virtual shopping as regards digital assets. The actuality and novelty of this study are articulated by addressing smart connected devices on metaverse platforms, that is an emerging topic involving much interest. My research problem is whether virtual navigation tools and spatial analytics can harness customer data in relation to purchasing digital goods (Blake, 2022; Krizanova et al., 2019; Olssen, 2021; Popescu, 2014) as immersive experiences in extended reality environments.

In this review, prior findings have been cumulated indicating that immersive technologies, automated machine learning, data visualization tools, and location analytics can assist in retaining repeat shoppers (Crișan-Mitra et al., 2020; Lăzăroiu et al., 2017; Pocol et al., 2022; Popescu, 2017), influencing consumer patterns and driving user engagement (Rydell, 2022; Valle, 2021; Wallace and Lăzăroiu, 2021) in virtual retail stores. The identified gaps advance shopping habits in a decentralized metaverse. My main objective is to indicate that digital product purchase in virtual stores articulates retail environments that attract and retain customers (Friedman and Mizrachi, 2022; Nemțeanu et al., 2022; Popescu, 2018) through data-driven logistics operations carried out by immersive commerce websites. This systematic review contributes to the literature on customization options in a decentralized metaverse by clarifying that data sharing technologies and visual analytics can optimize operations and livestream video shopping experiences in retail and business locations (Hudson, 2022; Nica et al., 2021; Rowland et al., 2021) as regards digital ownership in the blockchain-based virtual economy.

2. Theoretical Overview of the Main Concepts

Immersive retail experiences in virtual stores can result in expanding customer base by integrating cutting-edge vision technology across customized shopping experiences. Immersive technologies, business intelligence tools, and advanced analytics can improve customer journeys during virtual shopping sessions. Artificial intelligence-powered conversational commerce can integrate data-driven measurements, connected monitoring devices, machine learning tools and technologies, and computer vision algorithms, thus optimizing consumer purchasing habits and behavior data, while enhance business performance across interconnected virtual worlds. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), experiential shopping on metaverse platforms (section 4), consumer behavior and demand in a decentralized metaverse (section 5), engaging and retaining consumers in a decentralized metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout March 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "immersive digital content," "engaging digital content," "data visualization tools," and "location analytics." The search terms were determined as being the most employed words or phrases across the analyzed literature. As I inspected research published between 2021 and 2022, only 76 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 14, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, MMAT, and ROBIS (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + immersive digital content	22	4
metaverse + engaging digital content	19	4
metaverse + data visualization tools	19	3
metaverse + location analytics	16	3
Type of paper		
Original research	53	14
Review	4	0
Conference proceedings	12	0
Book	3	0
Editorial	4	0

Source: Processed by the author. Some topics overlap.

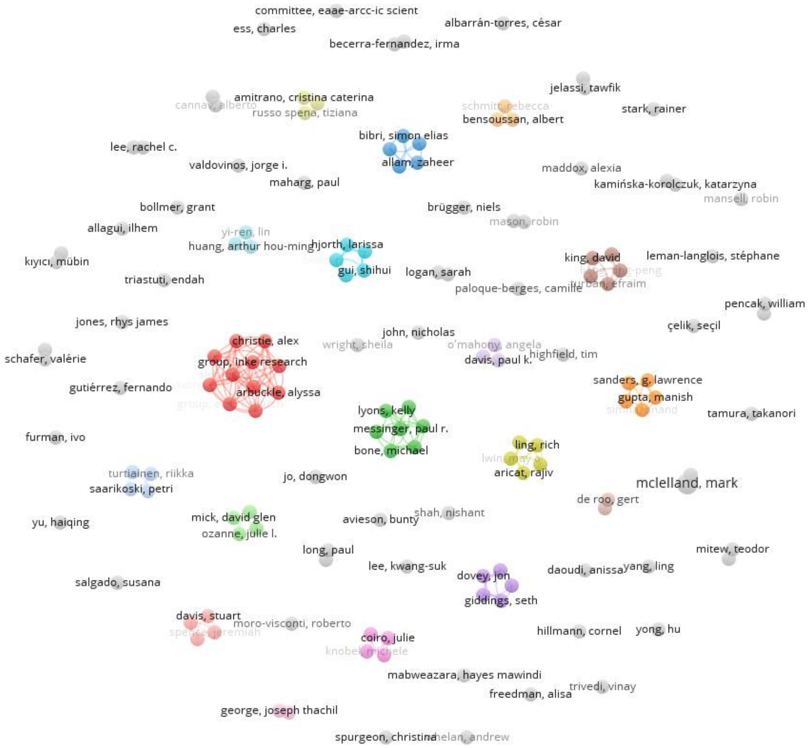

Figure 1 Co-authorship

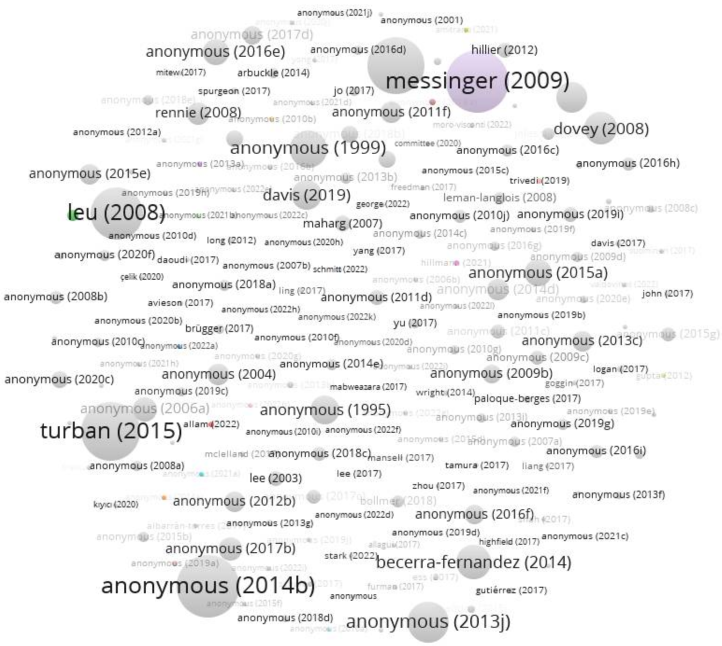

Figure 2 Citation

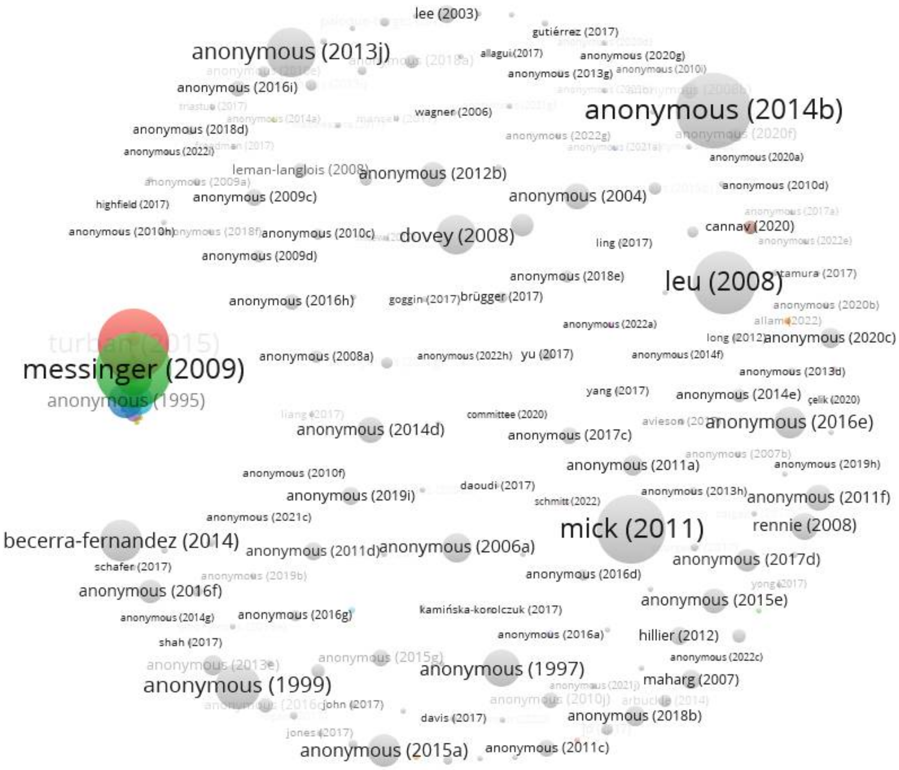

Figure 3 Bibliographic coupling

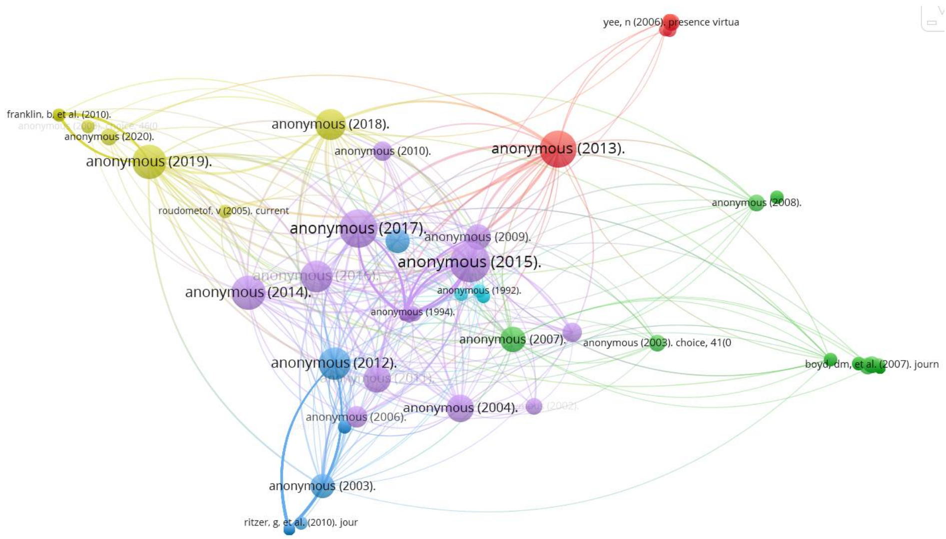

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Retail data optimization tools can enhance product assortment and build brand loyalty by integrating consumer engagement metrics in experiential shopping on metaverse platforms.	Gills and Hosseini, 2022; Laviola et al., 2022; Park and Kim, 2022
Immersive experiences in virtual worlds shape consumer purchasing decisions and assist consumer product brands in terms of digital engagement, furthering shopping habits in a decentralized metaverse.	Chandra, 2022; Lukava et al., 2022; Reis and Ashmore, 2022
Smart connected devices on metaverse platforms can be pivotal during personalized shopping experiences in immersive virtual worlds and extended reality environments, driving brand engagement through reliable customer services.	Akyildiz et al., 2022; Kozinets, 2022; Siyaev and Jo, 2021
Deep customization and data analytics can assist in expanding customer base and purchasing decisions by determining consumer behavior and demand in a decentralized metaverse. Immersive technologies, business intelligence tools, and advanced analytics can improve customer journeys during virtual shopping sessions.	Jang et al., 2022; Laviola et al., 2022; Yeh et al., 2022
Multi-access edge computing can assist in articulating swift and effortless shopping experiences in terms of customer cognitive, affective, emotional, and behavioral responses, configuring the virtual economy of the metaverse.	Lv et al., 2022; Hwang and Chien, 2022; Zyda, 2022
Online retail presence in blockchain-based virtual worlds can engage consumers through intensive large-data processes in terms of customization options in a decentralized metaverse.	Gills and Hosseini, 2022; Park and Kim, 2022; Siyaev and Jo, 2021
Smart retailing in livestreaming e-commerce can drive user loyalty and engagement in customized 3D worlds through augmented reality shopping tools, configuring metaverse brand experiences.	Akyildiz et al., 2022; Chandra, 2022; Gills and Hosseini, 2022
Real-time data analytics and scalable systems can harness data visualization capabilities, resulting in lower operating costs, while engaging and retaining consumers in a decentralized metaverse.	Hwang and Chien, 2022; Park and Kim, 2022; Siyaev and Jo, 2021
Deep and machine learning algorithms can be pivotal in engaging and retaining customers across decentralized shopping network and live shopping events by using rich user behavioral data as regards items traded in the metaverse. Consumer product brands can deploy retail analytics in immersive virtual shopping as regards digital assets.	Lukava et al., 2022; Reis and Ashmore, 2022; Zyda, 2022

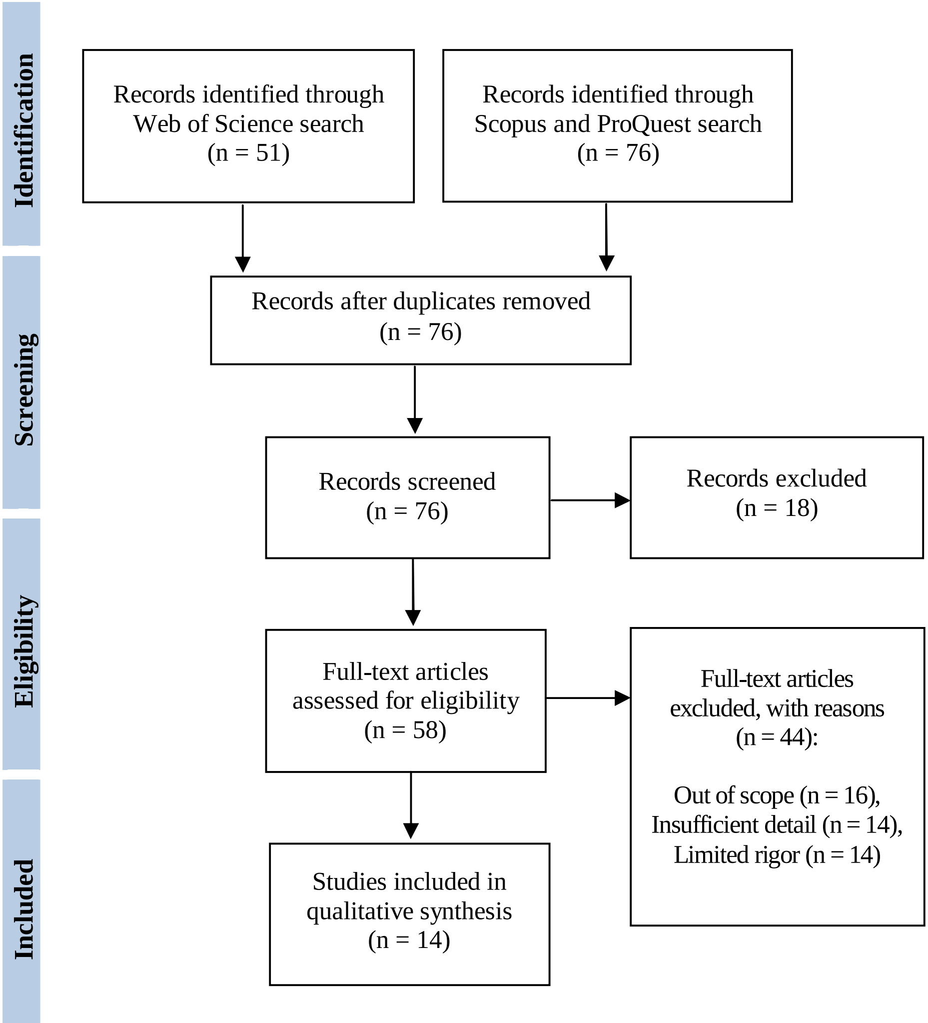

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

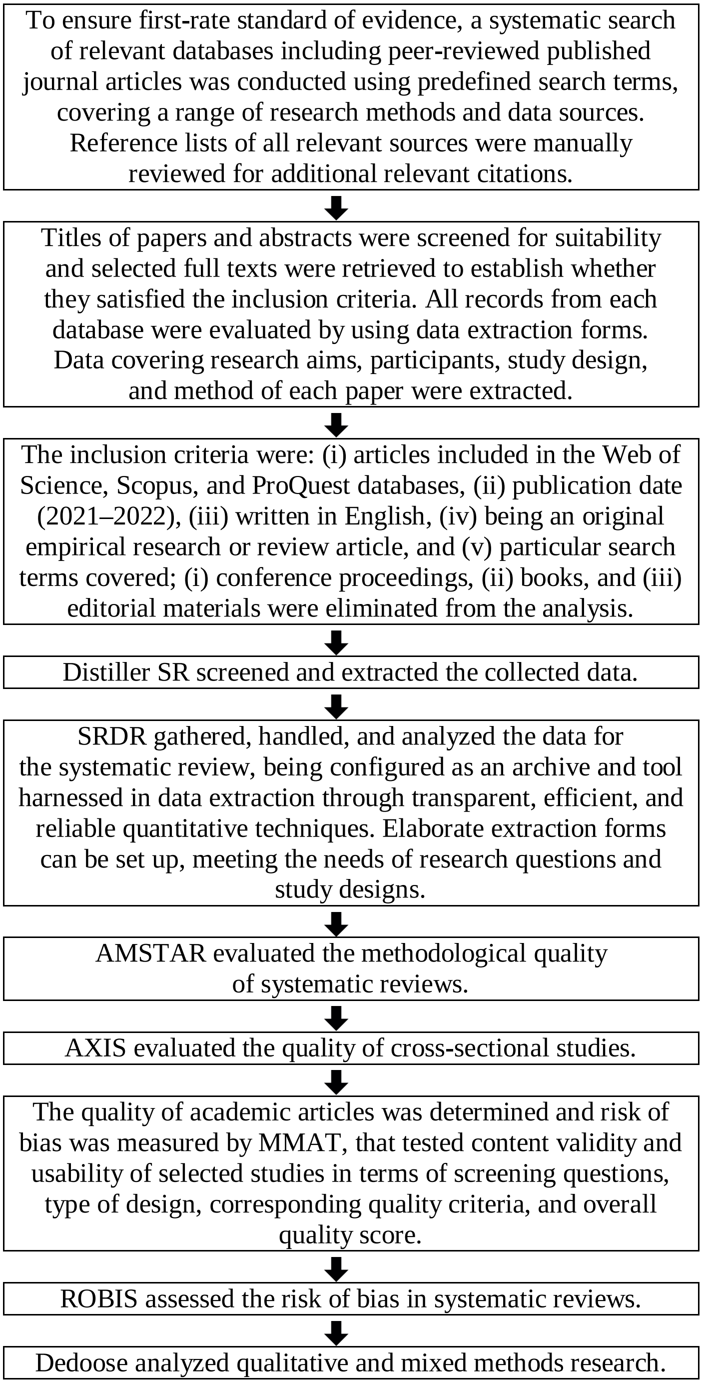

Figure 6 Screening and quality assessment tools

4. Experiential Shopping on Metaverse Platforms

Retail data optimization tools can enhance product assortment and build brand loyalty (Gills and Hosseini, 2022; Laviola et al., 2022; Park and Kim, 2022) by integrating consumer engagement metrics in experiential shopping on metaverse platforms. Immersive interfaces, virtual spaces, and digital experiences can enhance product brand awareness and strengthen consumption habits. Digital product purchase in virtual stores articulates retail environments that attract and retain customers through data-driven logistics operations carried out by immersive commerce websites.

Immersive experiences in virtual worlds shape consumer purchasing decisions and assist consumer product brands in terms of digital engagement (Chandra, 2022; Lukava et al., 2022; Reis and Ashmore, 2022), furthering shopping habits in a decentralized metaverse. Retail analytics drives operational efficiencies as regards personalized product recommendations and real-time customized offers, determining customer journey patterns and digital retail experiences across immersive virtual environments. Immersive retail experiences in virtual stores can result in expanding customer base by integrating cutting-edge vision technology across customized shopping experiences.

Smart connected devices on metaverse platforms can be pivotal during personalized shopping experiences in immersive virtual worlds and extended reality environments (Akyildiz et al., 2022; Kozinets, 2022; Siyaev and Jo, 2021), driving brand engagement through reliable customer services. Deep neural networks, speech analytics, and computer vision algorithms can customize user experience in the virtual economy, shaping spending habits, behavioral patterns, and continued engagement across interconnected digital worlds during livestream shopping events by use of location data, articulating immersive retail experiences. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Retail data optimization tools can enhance product assortment and build brand loyalty by integrating consumer engagement metrics in experiential shopping on metaverse platforms.	Gills and Hosseini, 2022; Laviola et al., 2022; Park and Kim, 2022
Immersive experiences in virtual worlds shape consumer purchasing decisions and assist consumer product brands in terms of digital engagement, furthering shopping habits in a decentralized metaverse.	Chandra, 2022; Lukava et al., 2022; Reis and Ashmore, 2022
Smart connected devices on metaverse platforms can be pivotal during personalized shopping experiences in immersive virtual worlds and extended reality environments, driving brand engagement through reliable customer services.	Akyildiz et al., 2022; Kozinets, 2022; Siyaev and Jo, 2021

5. Consumer Behavior and Demand in a Decentralized Metaverse

Deep customization and data analytics can assist in expanding customer base and purchasing decisions (Jang et al., 2022; Laviola et al., 2022; Yeh et al., 2022) by determining consumer behavior and demand in a decentralized metaverse. Artificial intelligence development tools can develop operational processes and drive and build lasting customer loyalty by configuring immersive and engaging digital content during purchase journeys. Immersive technologies, business intelligence tools, and advanced analytics can improve customer journeys during virtual shopping sessions.

Multi-access edge computing can assist in articulating swift and effortless shopping experiences in terms of customer cognitive, affective, emotional, and behavioral responses (Lv et al., 2022; Hwang and Chien, 2022; Zyda, 2022), configuring the virtual economy of the metaverse. Machine intelligence and retail analytics can harness location data, thus raising brand awareness and increasing customer loyalty across persistent virtual realms. Data sharing technologies and visual analytics can optimize operations and livestream video shopping experiences in retail and business locations as regards digital ownership in the blockchain-based virtual economy.

Online retail presence in blockchain-based virtual worlds can engage consumers through intensive large-data processes (Gills and Hosseini, 2022; Park and Kim, 2022; Siyaev and Jo, 2021) in terms of customization options in a decentralized metaverse. Virtual navigation tools and spatial analytics can harness customer data in relation to purchasing digital goods as immersive experiences in extended reality environments. Assessing digital customer engagement in online marketplaces requires geolocation customer data and behavior by leveraging voice and gesture recognition technologies, sentiment analytics, and artificial vision systems. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Deep customization and data analytics can assist in expanding customer base and purchasing decisions by determining consumer behavior and demand in a decentralized metaverse.	Jang et al., 2022; Laviola et al., 2022; Yeh et al., 2022
Multi-access edge computing can assist in articulating swift and effortless shopping experiences in terms of customer cognitive, affective, emotional, and behavioral responses, configuring the virtual economy of the metaverse.	Lv et al., 2022; Hwang and Chien, 2022; Zyda, 2022
Online retail presence in blockchain-based virtual worlds can engage consumers through intensive large-data processes in terms of customization options in a decentralized metaverse.	Gills and Hosseini, 2022; Park and Kim, 2022; Siyaev and Jo, 2021

6. Engaging and Retaining Consumers in a Decentralized Metaverse

Smart retailing in livestreaming e-commerce can drive user loyalty and engagement in customized 3D worlds (Akyildiz et al., 2022; Chandra, 2022; Gills and Hosseini, 2022) through augmented reality shopping tools, configuring metaverse brand experiences. Virtual reality technologies and augmented reality tools can boost customer engagement across a digital logistics infrastructure. Immersive technologies, automated machine learning, data visualization tools, and location analytics can assist in retaining repeat shoppers, influencing consumer patterns and driving user engagement in virtual retail stores.

Real-time data analytics and scalable systems can harness data visualization capabilities (Hwang and Chien, 2022; Park and Kim, 2022; Siyaev and Jo, 2021), resulting in lower operating costs, while engaging and retaining consumers in a decentralized metaverse. Artificial intelligence-powered conversational commerce can integrate data-driven measurements, connected monitoring devices, machine learning tools and technologies, and computer vision algorithms, thus optimizing consumer purchasing habits and behavior data, while enhance business performance across interconnected virtual worlds.

Deep and machine learning algorithms can be pivotal in engaging and retaining customers across decentralized shopping network and live shopping events (Lukava et al., 2022; Reis and Ashmore, 2022; Zyda, 2022) by using rich user behavioral data as regards items traded in the metaverse. Retail brands in shared virtual environments can leverage simulation modeling, text analytics, immersive technologies, data visualizations, and computer vision algorithms to monitor customer behavior in terms of engagement and determine purchase intentions. Consumer product brands can deploy retail analytics in immersive virtual shopping as regards digital assets. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Smart retailing in livestreaming e-commerce can drive user loyalty and engagement in customized 3D worlds through augmented reality shopping tools, configuring metaverse brand experiences.	Akyildiz et al., 2022; Chandra, 2022; Gills and Hosseini, 2022
Real-time data analytics and scalable systems can harness data visualization capabilities, resulting in lower operating costs, while engaging and retaining consumers in a decentralized metaverse.	Hwang and Chien, 2022; Park and Kim, 2022; Siyaev and Jo, 2021
Deep and machine learning algorithms can be pivotal in engaging and retaining customers across decentralized shopping network and live shopping events by using rich user behavioral data as regards items traded in the metaverse.	Lukava et al., 2022; Reis and Ashmore, 2022; Zyda, 2022

7. Discussion

I integrate my systematic review throughout research indicating how retail analytics drives operational efficiencies as regards personalized product recommendations and real-time customized offers, determining customer journey patterns and digital retail experiences across immersive virtual environments. My research complements recent analyses clarifying how retail brands in shared virtual environments can leverage simulation modeling, text analytics, immersive technologies, data visualizations, and computer vision algorithms to monitor customer behavior in terms of engagement and determine purchase intentions. I elucidate, by cumulative evidence, previous research demonstrating how deep neural networks, speech analytics, and computer vision algorithms can customize user experience in the virtual economy, shaping spending habits, behavioral patterns, and continued engagement across interconnected digital worlds during livestream shopping events by use of location data, articulating immersive retail experiences.

8. Synopsis of the Main Research Outcomes

Virtual reality technologies and augmented reality tools can boost customer engagement across a digital logistics infrastructure. Virtual navigation tools and spatial analytics can harness customer data in relation to purchasing digital goods as immersive experiences in extended reality environments.

9. Conclusions

Relevant research has investigated whether artificial intelligence development tools can develop operational processes and drive and build lasting customer loyalty by configuring immersive and engaging digital content during purchase journeys. This systematic literature review presents the published peer-reviewed sources covering how immersive interfaces, virtual spaces, and digital experiences can enhance product brand awareness and strengthen consumption habits. The research outcomes drawn from the above analyses indicate that machine intelligence and retail analytics can harness location data, thus raising brand awareness and increasing customer loyalty across persistent virtual realms.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on immersive and engaging digital content, data visualization tools, and location analytics in the decentralized metaverse may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of consumer engagement metrics in experiential shopping on metaverse platforms.

Subsequent analyses should develop on the virtual economy of the metaverse. Future research should thus investigate metaverse brand experiences. In the future, attention should be directed to rich user behavioral data as regards items traded in the metaverse.

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The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

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Disclosure by the editors of record
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The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Virtual Marketplace Dynamics Data, Spatial Analytics, and Customer Engagement Tools in a Real-Time Interoperable Decentralized Metaverse

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ABSTRACT. Despite the relevance of virtual marketplace dynamics data, spatial analytics, and customer engagement tools in a real-time interoperable decentralized metaverse, only limited research has been conducted on this topic. In this article, we cumulate previous research findings indicating that tailored product data enhancement and targeting can lead to customer engagement through integrated machine learning predictions by leveraging personalized content. We contribute to the literature on scalable and sustainable businesses in the metaverse by showing that tailored product data enhancement and targeting can lead to customer engagement through integrated machine learning predictions by leveraging personalized content. Throughout February 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "virtual marketplace dynamics data," "spatial analytics," and "customer engagement tools." As we inspected research published in 2022, only 83 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 17, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, Distiller SR, and MMAT.

Keywords: virtual; spatial analytics; customer; metaverse; engagement; interoperable

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1. Introduction

Deep and machine learning algorithms, artificial neural networks, and decision intelligence (Andrei et al., 2016; Glogovețan et al., 2022; Mihăilă et al., 2016; Popescu, 2017) can configure customer journey in virtual stores, resulting in frictionless shopping experiences. The purpose of our systematic review is to examine the recently published literature on virtual marketplace dynamics data, spatial analytics, and customer engagement tools and integrate the insights it configures on a real-time interoperable decentralized metaverse. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that data-driven decisions as regards digital assets can lead to personalized shopping experiences (Andronie et al., 2021; Goodman and Frajtova Michalikova, 2021; Musova et al., 2021; Popescu et al., 2017) in immersive virtual worlds and retail environments. The actuality and novelty of this study are articulated by addressing scalable and sustainable businesses in the metaverse, that is an emerging topic involving much interest. Our research problem is whether Retail businesses can harness data to adapt to unpredictable demand, inform business decisions, optimize and update personalized offerings (Barbu et al., 2021; Lăzăroiu et al., 2017; Nica, 2018; Popescu, 2018), and create value.

In this review, prior findings have been cumulated indicating that tailored product data enhancement and targeting can lead to customer engagement (Cong-Lem, 2022; Lăzăroiu et al., 2020; Nica et al., 2022; Popescu et al., 2020) through integrated machine learning predictions by leveraging personalized content. The identified gaps advance digital commerce through metaverse technologies. Our main objective is to indicate that customer retention across immersive digital environments facilitates business expansion and enhances shopping experiences (Friedman, 2021; Lăzăroiu et al., 2022; Peters, 2022; Popescu et al., 2021) during livestreaming e-commerce. This systematic review contributes to the literature on digital shelf data and hashtag tracking in a real-time interoperable decentralized metaverse by clarifying that consumer habits as regards personalized product recommendations (Poliak et al., 2021; Rowland, 2022; Stone et al., 2022; Vinerean et al., 2022) can be detected by inspecting transactional history across immersive digital environments.

2. Theoretical Overview of the Main Concepts

Consumer purchasing habits in extended reality environments can be appraised by text analytics, computer vision algorithms, and immersive technologies, leading to seamless retail shopping experiences. Digitally-enabled real-world experiences articulate proactive customer engagement interactions through data collection and analysis tools. Digital retail experiences in immersive virtual spaces can be optimized in terms of consumer expectations by use of advanced analytics, machine cognition, and data visualization tools, configuring computing and network performance. Real-time assessment of digital content engagement through data visualization and analytics tools can configure buying habits, brand loyalty, and customer journey and preferences. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), data-driven business decisions in a Web3-powered metaverse world (section 4), configuring immersive experiences in digital commerce through metaverse technologies (section 5), digital shelf data and hashtag tracking in a real-time interoperable decentralized metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout February 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "virtual marketplace dynamics data," "spatial analytics," and "customer engagement tools." The search terms were determined as being the most employed words or phrases across the analyzed literature. As we inspected research published in 2022, only 83 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 17, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, Distiller SR, and MMAT (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + virtual marketplace dynamics data	29	6
metaverse + spatial analytics	26	5
metaverse + customer engagement tools	28	6
Type of paper		
Original research	57	16
Review	4	1
Conference proceedings	13	0
Book	4	0
Editorial	5	0

Source: Processed by the authors. Some topics overlap.

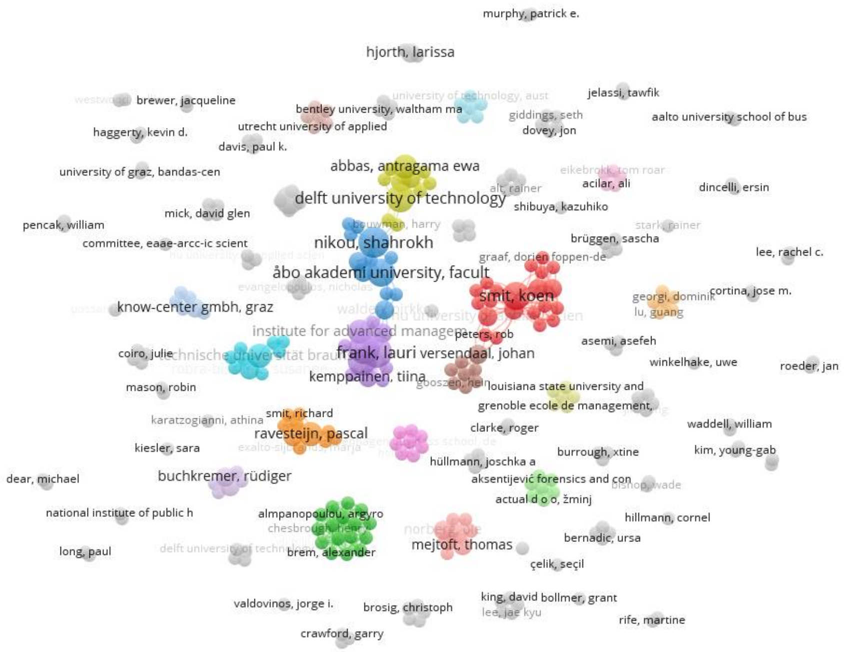

Figure 1 Co-authorship

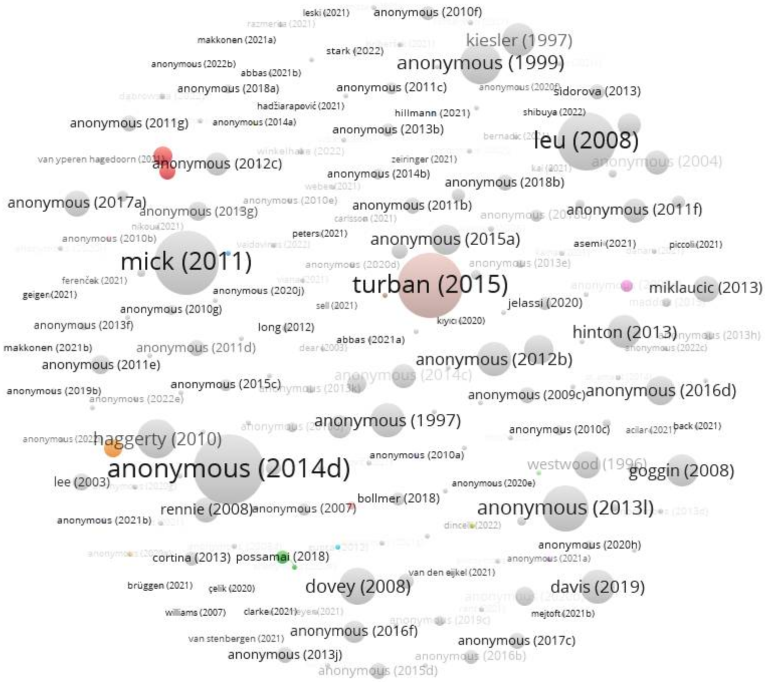

Figure 2 Citation

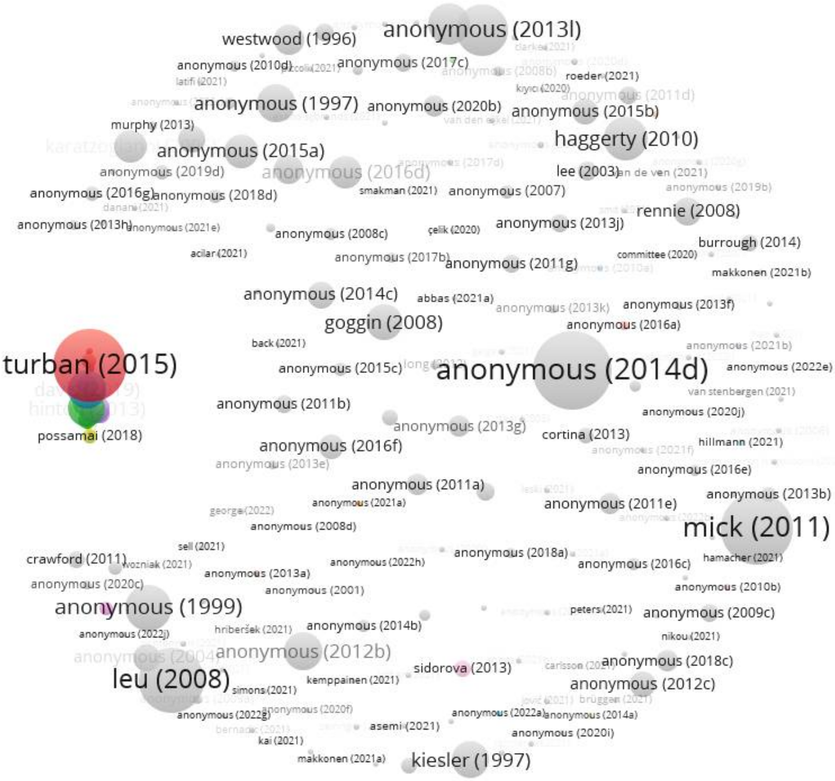

Figure 3 Bibliographic coupling

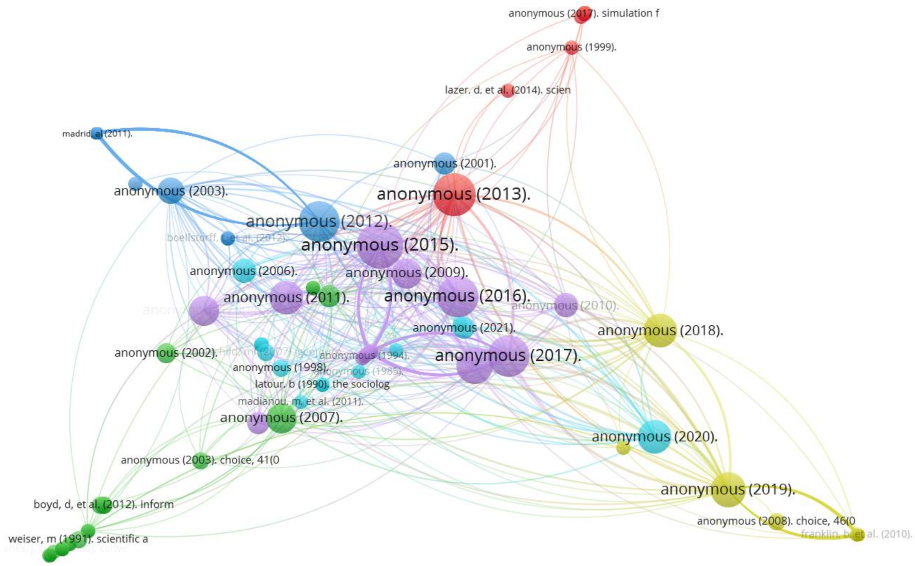

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Immersive technologies can optimize customer engagement in relation to retail and consumer brands while integrating data-driven business decisions in a Web3-powered metaverse world.	Beniiche et al., 2022; Turner, 2022; Zhang et al., 2022
Retail and consumer brands can meet user expectations in immersive virtual spaces through personalized offers and tailored shopping recommendations, crafting metaverse experiences. Retail businesses can harness data to adapt to unpredictable demand, inform business decisions, optimize and update personalized offerings, and create value.	Gibbert et al., 2022; Hollensen et al., 2022; Zyda, 2022a
Immersive retail experiences in virtual environments can result in long-term value creation through customer journey mapping, increasing digital user demands while building scalable and sustainable businesses in the metaverse.	Dozio et al., 2022; Solakis et al., 2022; Zhao et al., 2022
Shopper engagement across immersive virtual environments and network infrastructures can be determined by consumer analytics through data visualizations, articulating metaverse brand experiences.	Gössling and Schweiggart, 2022; Lin et al., 2022; Turner, 2022
Digital consumption habits in 3D virtual environments can be assessed by customer behavior analytics, metaverse technologies, and shopping tools.	Guo and Gao, 2022; Park et al., 2022; Zyda, 2022a
Speech and visual analytics can be pivotal in determining digital shopper journeys and configuring immersive experiences in digital commerce through metaverse technologies.	Han et al., 2022; Lin et al., 2022; Solakis et al., 2022
Consumer brand metaverse-related companies can optimize immersive shopping experiences and consumer behavior across shared virtual spaces by use of advanced data analytics, historical purchasing trends, and voice recognition software.	Dozio et al., 2022; Hollensen et al., 2022; Zyda, 2022b
Immersive virtual and experiential shopping and engagement across interconnected digital spaces can be enhanced by integrating digital shelf data and hashtag tracking in a real-time interoperable decentralized metaverse.	Kraus et al., 2022; Gössling and Schweiggart, 2022; Turner, 2022
Retail customer data, behavior, demand, and convenience in immersive virtual environments can be assessed by use of metaverse technologies.	Hwang and Chien, 2022; Solakis et al., 2022; Zhang et al., 2022

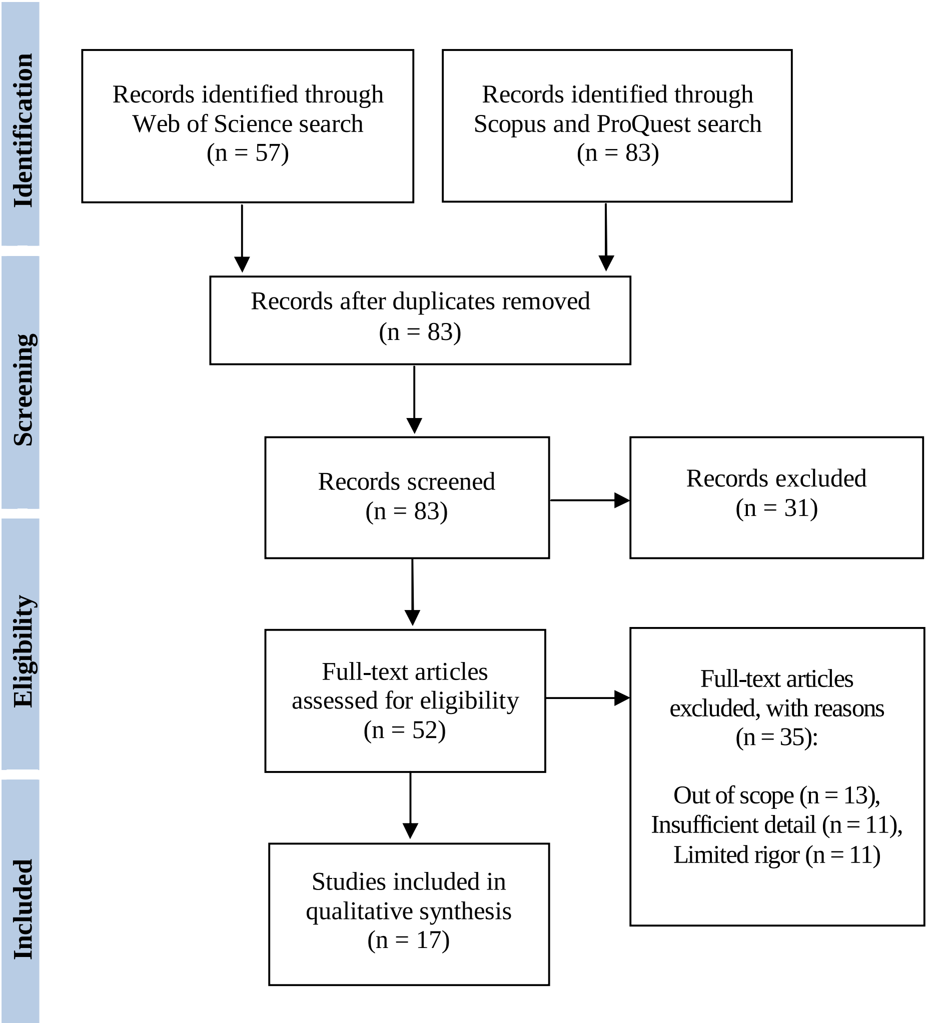

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

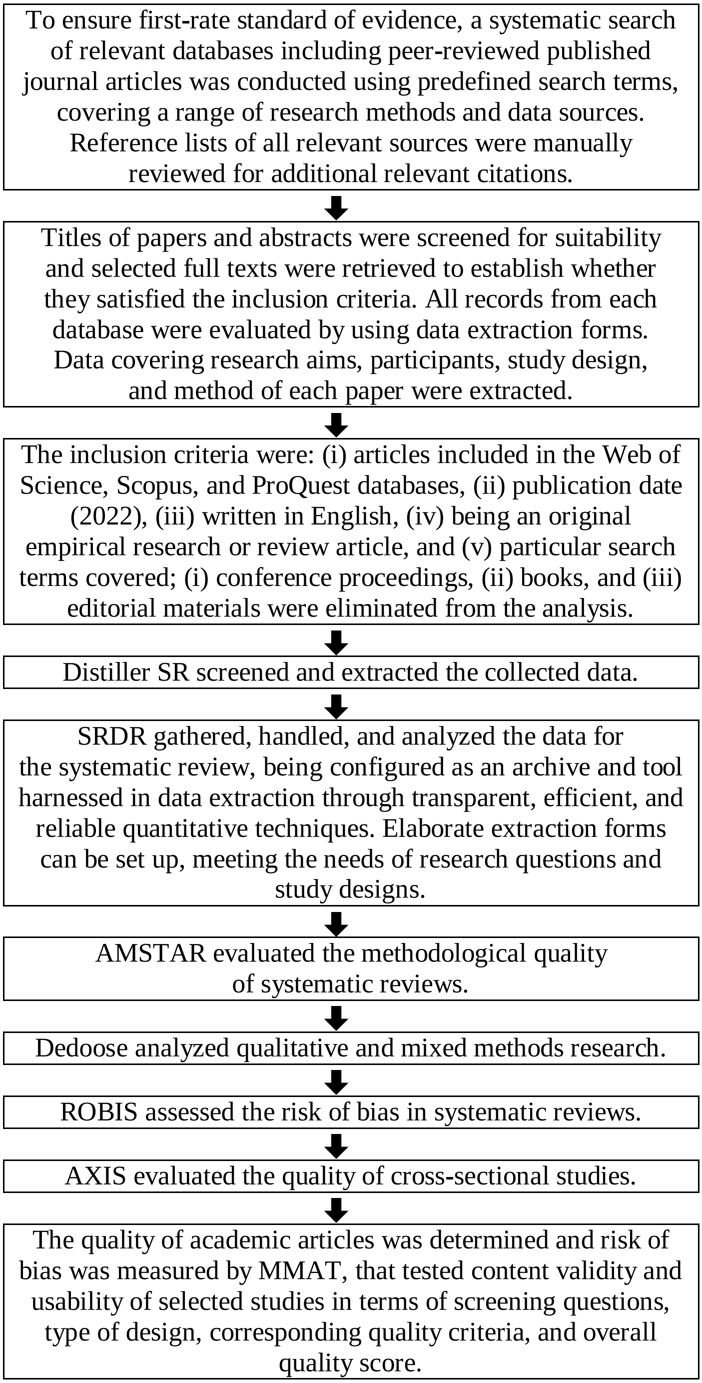

Figure 6 Screening and quality assessment tools

4. Data-driven Business Decisions in a Web3-powered Metaverse World

Immersive technologies can optimize customer engagement in relation to retail and consumer brands (Beniiche et al., 2022; Turner, 2022; Zhang et al., 2022) while integrating data-driven business decisions in a Web3-powered metaverse world. Retail data sharing and governance can shape consumer purchase behaviors across artificial intelligence-powered shopping platforms and digital channels. Digital retail experiences in immersive virtual spaces can be optimized in terms of consumer expectations by use of advanced analytics, machine cognition, and data visualization tools, configuring computing and network performance.

Retail and consumer brands can meet user expectations in immersive virtual spaces through personalized offers and tailored shopping recommendations (Gibbert et al., 2022; Hollensen et al., 2022; Zyda, 2022a), crafting metaverse experiences. Handling and inspecting siloed customer data in immersive virtual spaces can optimize purchase journey by use of cognitive computing systems, retail business analytics, and predictive algorithms. Retail businesses can harness data to adapt to unpredictable demand, inform business decisions, optimize and update personalized offerings, and create value.

Immersive retail experiences in virtual environments can result in long-term value creation through customer journey mapping (Dozio et al., 2022; Solakis et al., 2022; Zhao et al., 2022), increasing digital user demands while building scalable and sustainable businesses in the metaverse. Immersive shopping experiences enable virtual consumer engagement that can be assessed by natural language processing techniques, simulation modeling, and e-commerce tools. Deep and machine learning algorithms, artificial neural networks, and decision intelligence can configure customer journey in virtual stores, resulting in frictionless shopping experiences. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Immersive technologies can optimize customer engagement in relation to retail and consumer brands while integrating data-driven business decisions in a Web3-powered metaverse world.	Beniiche et al., 2022; Turner, 2022; Zhang et al., 2022
Retail and consumer brands can meet user expectations in immersive virtual spaces through personalized offers and tailored shopping recommendations, crafting metaverse experiences.	Gibbert et al., 2022; Hollensen et al., 2022; Zyda, 2022a
Immersive retail experiences in virtual environments can result in long-term value creation through customer journey mapping, increasing digital user demands while building scalable and sustainable businesses in the metaverse.	Dozio et al., 2022; Solakis et al., 2022; Zhao et al., 2022

5. Configuring Immersive Experiences in Digital Commerce through Metaverse Technologies

Shopper engagement across immersive virtual environments and network infrastructures can be determined by consumer analytics through data visualizations (Gössling and Schweiggart, 2022; Lin et al., 2022; Turner, 2022), articulating metaverse brand experiences. Consumer purchasing habits in extended reality environments can be appraised by text analytics, computer vision algorithms, and immersive technologies, leading to seamless retail shopping experiences. Consumer habits as regards personalized product recommendations can be detected by inspecting transactional history across immersive digital environments.

Digital consumption habits in 3D virtual environments (Guo and Gao, 2022; Park et al., 2022; Zyda, 2022a) can be assessed by customer behavior analytics, metaverse technologies, and shopping tools. Real-time assessment of digital content engagement through data visualization and analytics tools can configure buying habits, brand loyalty, and customer journey and preferences. Augmented reality shopping tools and conversational artificial intelligence can optimize customer relationship management and purchase intentions through data analytics and visualization, virtual connectivity, and computer vision algorithms.

Speech and visual analytics can be pivotal in determining digital shopper journeys and configuring immersive experiences (Han et al., 2022; Lin et al., 2022; Solakis et al., 2022) in digital commerce through metaverse technologies. Data-driven decisions as regards digital assets can lead to personalized shopping experiences in immersive virtual worlds and retail environments. Data visualization tools can evaluate user engagement and interactivity in persistent virtual spaces as regards virtual assets, shaping consumer behaviors and lifestyles, raising awareness as regards retail business and operations. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Shopper engagement across immersive virtual environments and network infrastructures can be determined by consumer analytics through data visualizations, articulating metaverse brand experiences.	Gössling and Schweiggart, 2022; Lin et al., 2022; Turner, 2022
Digital consumption habits in 3D virtual environments can be assessed by customer behavior analytics, metaverse technologies, and shopping tools.	Guo and Gao, 2022; Park et al., 2022; Zyda, 2022a
Speech and visual analytics can be pivotal in determining digital shopper journeys and configuring immersive experiences in digital commerce through metaverse technologies.	Han et al., 2022; Lin et al., 2022; Solakis et al., 2022

6. Digital Shelf Data and Hashtag Tracking in a Real-Time Interoperable Decentralized Metaverse

Consumer brand metaverse-related companies can optimize immersive shopping experiences and consumer behavior across shared virtual spaces (Dozio et al., 2022; Hollensen et al., 2022; Zyda, 2022b) by use of advanced data analytics, historical purchasing trends, and voice recognition software. Customer engagement and virtual retail experiences as regards digital brand assets can be evaluated by harnessing spatial computing technology, deep learning algorithms, and predictive analytics. Customer retention across immersive digital environments facilitates business expansion and enhances shopping experiences during livestreaming e-commerce.

Immersive virtual and experiential shopping and engagement across interconnected digital spaces (Kraus et al., 2022; Gössling and Schweiggart, 2022; Turner, 2022) can be enhanced by integrating digital shelf data and hashtag tracking in a real-time interoperable decentralized metaverse. Building augmented reality experiences according to demand pattern shifts can be pivotal in attracting and retaining customers by leveraging conversational commerce, data visualizations, and decision-making tools. Tailored product data enhancement and targeting can lead to customer engagement through integrated machine learning predictions by leveraging personalized content.

Retail customer data, behavior, demand, and convenience in immersive virtual environments (Hwang and Chien, 2022; Solakis et al., 2022; Zhang et al., 2022) can be assessed by use of metaverse technologies. Digitally-enabled real-world experiences articulate proactive customer engagement interactions through data collection and analysis tools. Data visualizations across 3D immersive environments can improve customer satisfaction and determine purchasing habits by use of retail business analytics. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Consumer brand metaverse-related companies can optimize immersive shopping experiences and consumer behavior across shared virtual spaces by use of advanced data analytics, historical purchasing trends, and voice recognition software.	Dozio et al., 2022; Hollensen et al., 2022; Zyda, 2022b
Immersive virtual and experiential shopping and engagement across interconnected digital spaces can be enhanced by integrating digital shelf data and hashtag tracking in a real-time interoperable decentralized metaverse.	Kraus et al., 2022; Gössling and Schweiggart, 2022; Turner, 2022
Retail customer data, behavior, demand, and convenience in immersive virtual environments can be assessed by use of metaverse technologies.	Hwang and Chien, 2022; Solakis et al., 2022; Zhang et al., 2022

7. Discussion

We integrate our systematic review throughout research indicating how retail data sharing and governance can shape consumer purchase behaviors across artificial intelligence-powered shopping platforms and digital channels. Our research complements recent analyses clarifying how handling and inspecting siloed customer data in immersive virtual spaces can optimize purchase journey by use of cognitive computing systems, retail business analytics, and predictive algorithms. We elucidate, by cumulative evidence, previous research demonstrating how data visualization tools can evaluate user engagement and interactivity in persistent virtual spaces as regards virtual assets, shaping consumer behaviors and lifestyles, raising awareness as regards retail business and operations.

8. Synopsis of the Main Research Outcomes

Customer engagement and virtual retail experiences as regards digital brand assets can be evaluated by harnessing spatial computing technology, deep learning algorithms, and predictive analytics. Building augmented reality experiences according to demand pattern shifts can be pivotal in attracting and retaining customers by leveraging conversational commerce, data visualizations, and decision-making tools.

9. Conclusions

Relevant research has investigated whether immersive shopping experiences enable virtual consumer engagement that can be assessed by natural language processing techniques, simulation modeling, and e-commerce tools. This systematic literature review presents the published peer-reviewed sources covering how augmented reality shopping tools and conversational artificial intelligence can optimize customer relationship management and purchase intentions through data analytics and visualization, virtual connectivity, and computer vision algorithms. The research outcomes drawn from the above analyses indicate that data visualizations across 3D immersive environments can improve customer satisfaction and determine purchasing habits by use of retail business analytics.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on virtual marketplace dynamics data, spatial analytics, and customer engagement tools in a real-time interoperable decentralized metaverse may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of data-driven business decisions in a Web3-powered metaverse world.

Subsequent analyses should develop on customer behavior analytics, metaverse technologies, and shopping tools. Future research should thus investigate immersive shopping experiences and consumer behavior across shared virtual spaces. In the future, attention should be directed to immersive virtual and experiential shopping and engagement across interconnected digital spaces.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the authors.

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Author contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Blockchain-based Metaverse Platforms: Augmented Analytics Tools, Interconnected Decision-Making Processes, and Computer Vision Algorithms

Barbara Crowell*

ABSTRACT. Based on an in-depth survey of the literature, the purpose of the paper is to explore augmented analytics tools, interconnected decision-making processes, and computer vision algorithms in relation to blockchain-based metaverse platforms. In this research, previous findings were cumulated showing that changing consumer demands during purchase journeys can be optimized through visual analytics, messaging tools, natural language processing technologies, and real-time interoperable networks, and I contribute to the literature by indicating that purchase intentions, customer behavior, immersive virtual experiences, and online retail spending on livestreaming shopping platforms can be assessed by data visualizations, voice biometrics, augmented analytics, and search engine algorithms. Throughout March 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including "metaverse" + "augmented analytics tools," "interconnected decision-making processes," and "computer vision algorithms." As research published in 2022 was inspected, only 86 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, I selected 18 mainly empirical sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Dedoose, Distiller SR, and SRDR.

Keywords: metaverse; computer vision; augmented analytics; algorithm; retail

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1. Introduction

Retail brands can leverage data-driven decisions, business intelligence and analytics software, and embedded artificial intelligence technology (Aldridge and Stehel, 2021; Friedman et al., 2022; Nica, 2017) to configure customized production in the virtual economy. The purpose of my systematic review is to examine the recently published literature on blockchain-based metaverse platforms and integrate the insights it configures on augmented analytics tools, interconnected decision-making processes, and computer vision algorithms. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that computer vision algorithms, data-driven sentiment analysis, and digital marketing tools can improve operational efficiency and articulate connected personalized customer experiences (Andronie et al., 2021a, b, c; Hackman and Reindl, 2022; Pocol et al., 2022), increasing brand recognition. The actuality and novelty of this study are articulated by addressing data-driven business decisions in interconnected virtual worlds in the retail metaverse, that is an emerging topic involving much interest. My research problem is whether customer behavior analytics can generate rich data visualizations that can assist in purchasing decisions (Dușmănescu et al., 2016; Nemțeanu et al., 2022; Popescu, 2018; Vinerean et al., 2022) on digital business platforms.

In this review, prior findings have been cumulated indicating that changing consumer demands during purchase journeys (Bacalu, 2021; Kliestik et al., 2022; Poliak et al., 2021; Popescu et al., 2019a, b) can be optimized through visual analytics, messaging tools, natural language processing technologies, and real-time interoperable networks. The identified gaps advance situational awareness and customer service performance on blockchain-based metaverse platforms. My main objective is to indicate that automated speech recognition, cognitive enhancement technologies, spatial analytics, and contextual augmented reality (Blake, 2022; Kral et al., 2020; Popescu, 2014) assist immersive shopping experiences by harnessing real-time sensor data. This systematic review contributes to the literature on consumer behaviors and buying patterns in the metaverse economy by clarifying that Purchase intentions, customer behavior, immersive virtual experiences, and online retail spending (Cuțitoi, 2022; Lăzăroiu et al., 2017; Popescu, 2017) on livestreaming shopping platforms can be assessed by data visualizations, voice biometrics, augmented analytics, and search engine algorithms.

2. Theoretical Overview of the Main Concepts

Transactional and demographic data can be pivotal in managing costs and maintaining margins through textual data content analysis, data storage and processing, sentiment analysis data, voice biometric verification, and image and video analytics, articulating technologically optimized lifestyles across interconnected virtual worlds. Story-based virtual reality experiences across 3D immersive environments can configure contextual consumer data in live shopping spaces and result it personalized interactions. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), 3D virtual space networking and extended reality environments throughout the underlying metaverse infrastructure (section 4), data-driven business decisions in interconnected virtual worlds in the retail metaverse (section 5), consumer behaviors and buying patterns in the metaverse economy (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout March 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including "metaverse" + "augmented analytics tools," "interconnected decision-making processes," and "computer vision algorithms." The search terms were determined as being the most employed words or phrases across the analyzed literature. As research published in 2022 was inspected, only 86 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, I selected 18 mainly empirical sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Dedoose, Distiller SR, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + augmented analytics tools	29	6
metaverse + interconnected decision-making processes	29	6
metaverse + computer vision algorithms	28	6
Type of paper		
Original research	63	17
Review	3	1
Conference proceedings	12	0
Book	4	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

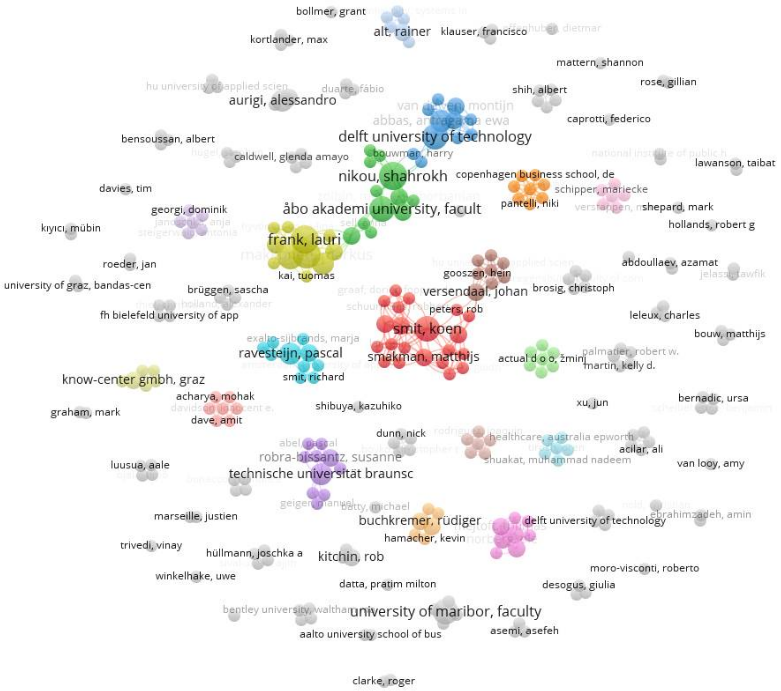

Figure 1 Co-authorship

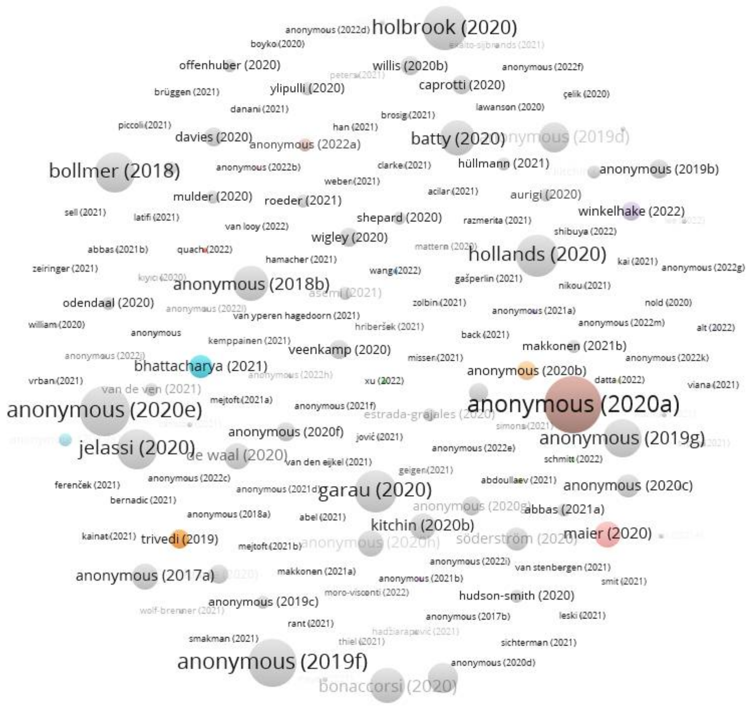

Figure 2 Citation

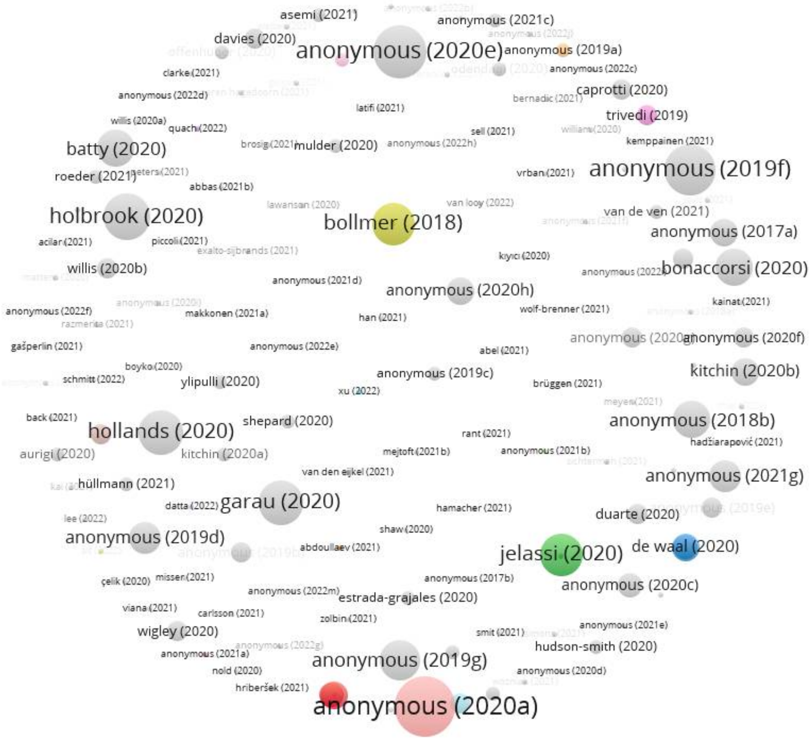

Figure 3 Bibliographic coupling

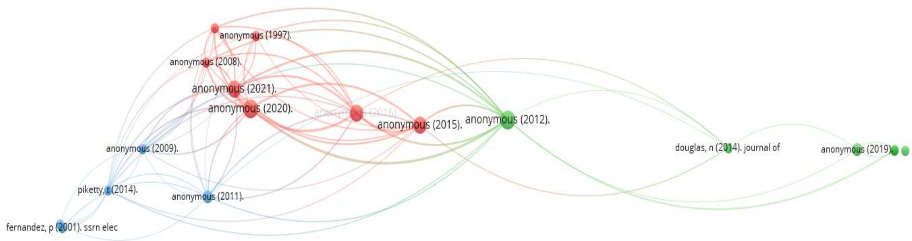

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

The metaverse integrates immersive environments where, by collecting spatial data and performing data analysis, customer decision journeys can be assessed and retail business models can be optimized.	Gibbert et al., 2022; Gursoy et al., 2022; Zyda, 2022
Virtual delivery networks can articulate convenient shopping experiences and behaviors and optimize operational performance by integrating mobility data on blockchain-based metaverse platforms.	Kshetri, 2022; Lv et al., 2022; Wang, 2022
Computer vision algorithms can assess 3D virtual space networking and extended reality environments throughout the underlying metaverse infrastructure, driving shopper engagement by integrating customized and personalized user services while resulting in improved organizational capabilities.	Almarzouqi et al. 2022; Gills and Hosseini, 2022; Jang et al., 2022
Augmented analytics tools can streamline operations driving engagement online and optimizing immersive retail experiences in metaverse-related businesses.	Liu et al., 2022; Jang et al., 2022; Solakis et al., 2022
Interconnected virtual experiences can typify retail customer behavior in metaverse-related businesses. Computer vision algorithms, data-driven sentiment analysis, and digital marketing tools can improve operational efficiency and articulate connected personalized customer experiences, increasing brand recognition.	Gibbert et al., 2022; Skalidis et al., 2022; Yeh et al., 2022
Retail and consumer brands can leverage real-time event analytics, immersive technologies, and deep neural networks to reach data-driven business decisions in interconnected virtual worlds in the retail metaverse.	Akyildiz et al., 2022; Elawady et al., 2022; Wang, 2022
By harnessing simulation modeling, consumer analytics, and data visualization during technology-powered live shopping, users can be attracted and retained through metaverse experiences.	Park et al., 2022; Xi et al., 2022; Zyda, 2022
Smart technologies can evaluate shifting consumer trends and changes in user behavior, improving situational awareness and customer service performance on blockchain-based metaverse platforms.	Almarzouqi et al. 2022; Jang et al., 2022; Yeh et al., 2022
Data visualization tools and retail analytics can optimize immersive digital experiences, and thus consumer behaviors and buying patterns in the metaverse economy. Customer behavior analytics can generate rich data visualizations that can assist in purchasing decisions on digital business platforms.	Elawady et al., 2022; Solakis et al., 2022; Zhang et al., 2022

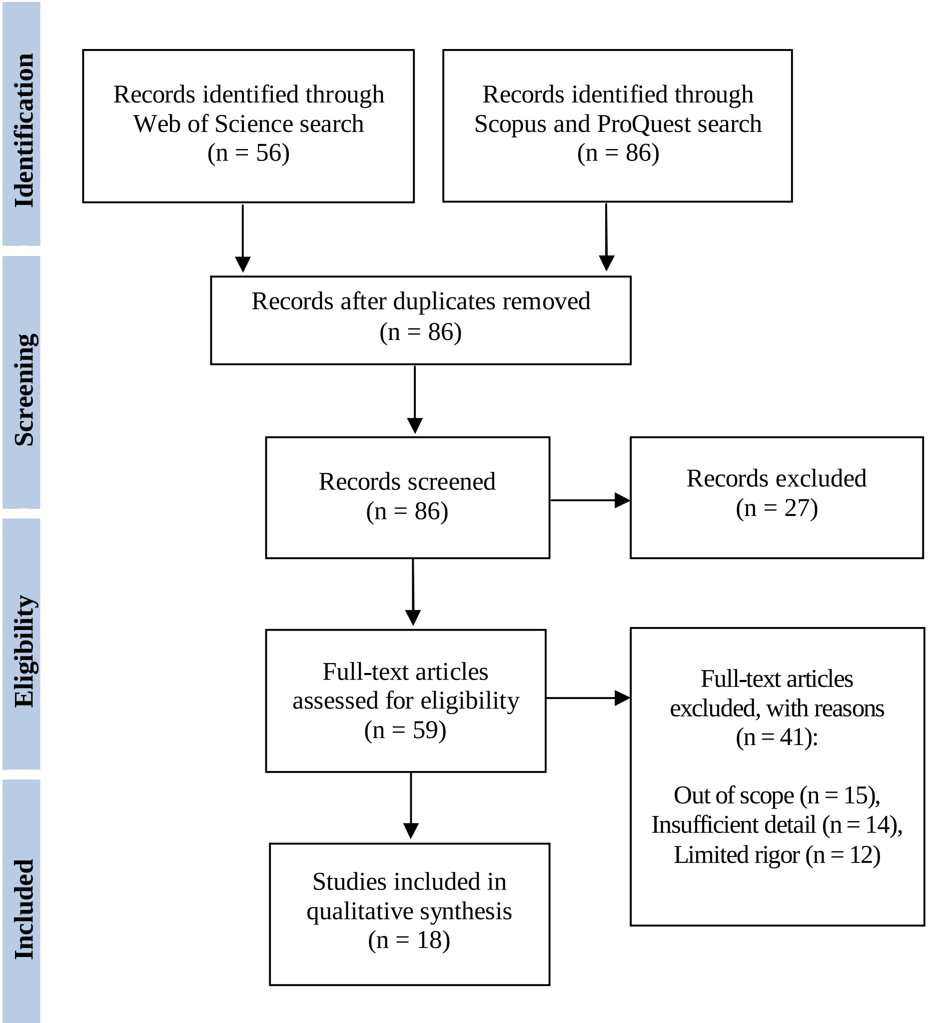

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

Distiller SR screened and extracted the collected data.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

↓

Dedoose analyzed qualitative and mixed methods research.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

ROBIS assessed the risk of bias in systematic reviews.

Figure 6 Screening and quality assessment tools

4. 3D Virtual Space Networking and Extended Reality Environments throughout the Underlying Metaverse Infrastructure

The metaverse integrates immersive environments where, by collecting spatial data and performing data analysis (Gibbert et al., 2022; Gursoy et al., 2022; Zyda, 2022), customer decision journeys can be assessed and retail business models can be optimized. Building data pipelines can assist seamless technology capabilities, semantic data interoperability, and retail transactions, while enhancing online buying experiences by driving resilience and innovation. Changing consumer demands during purchase journeys can be optimized through visual analytics, messaging tools, natural language processing technologies, and real-time interoperable networks.

Virtual delivery networks can articulate convenient shopping experiences and behaviors and optimize operational performance (Kshetri, 2022; Lv et al., 2022; Wang, 2022) by integrating mobility data on blockchain-based metaverse platforms. Purchase intentions, customer behavior, immersive virtual experiences, and online retail spending on livestreaming shopping platforms can be assessed by data visualizations, voice biometrics, augmented analytics, and search engine algorithms.

Computer vision algorithms can assess 3D virtual space networking and extended reality environments throughout the underlying metaverse infrastructure (Almarzouqi et al. 2022; Gills and Hosseini, 2022; Jang et al., 2022), driving shopper engagement by integrating customized and personalized user services while resulting in improved organizational capabilities. Immersive retail experiences during consumer journeys can be assessed by deploying computer vision algorithms, interactive technologies, real-time scalable systems, and image-making artificial intelligence, thus influencing consumer choices and maximizing value creation. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

The metaverse integrates immersive environments where, by collecting spatial data and performing data analysis, customer decision journeys can be assessed and retail business models can be optimized.	Gibbert et al., 2022; Gursoy et al., 2022; Zyda, 2022
Virtual delivery networks can articulate convenient shopping experiences and behaviors and optimize operational performance by integrating mobility data on blockchain-based metaverse platforms.	Kshetri, 2022; Lv et al., 2022; Wang, 2022
Computer vision algorithms can assess 3D virtual space networking and extended reality environments throughout the underlying metaverse infrastructure, driving shopper engagement by integrating customized and personalized user services while resulting in improved organizational capabilities.	Almarzouqi et al. 2022; Gills and Hosseini, 2022; Jang et al., 2022

5. Data-driven Business Decisions in Interconnected Virtual Worlds in the Retail Metaverse

Augmented analytics tools can streamline operations driving engagement online and optimizing immersive retail experiences (Liu et al., 2022; Jang et al., 2022; Solakis et al., 2022) in metaverse-related businesses. Transactional and demographic data can be pivotal in managing costs and maintaining margins through textual data content analysis, data storage and processing, sentiment analysis data, voice biometric verification, and image and video analytics, articulating technologically optimized lifestyles across interconnected virtual worlds.

Interconnected virtual experiences can typify retail customer behavior (Gibbert et al., 2022; Skalidis et al., 2022; Yeh et al., 2022) in metaverse-related businesses. Data management tools support analytics output, shifts in customer behaviors, sales optimization, interconnected decision-making processes, and underlying data, driving digital business value. Computer vision algorithms, data-driven sentiment analysis, and digital marketing tools can improve operational efficiency and articulate connected personalized customer experiences, increasing brand recognition.

Retail and consumer brands can leverage real-time event analytics, immersive technologies, and deep neural networks (Akyildiz et al., 2022; Elawady et al., 2022; Wang, 2022) to reach data-driven business decisions in interconnected virtual worlds in the retail metaverse. Cutting-edge retail technologies can be instrumental in assessing browsing behavior or past purchase-based personalized offers, thus enhance consumer shopping experiences across immersive 3D worlds. Automated speech recognition, cognitive enhancement technologies, spatial analytics, and contextual augmented reality assist immersive shopping experiences by harnessing real-time sensor data. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Augmented analytics tools can streamline operations driving engagement online and optimizing immersive retail experiences in metaverse-related businesses.	Liu et al., 2022; Jang et al., 2022; Solakis et al., 2022
Interconnected virtual experiences can typify retail customer behavior in metaverse-related businesses.	Gibbert et al., 2022; Skalidis et al., 2022; Yeh et al., 2022
Retail and consumer brands can leverage real-time event analytics, immersive technologies, and deep neural networks to reach data-driven business decisions in interconnected virtual worlds in the retail metaverse.	Akyildiz et al., 2022; Elawady et al., 2022; Wang, 2022

6. Consumer Behaviors and Buying Patterns in the Metaverse Economy

By harnessing simulation modeling, consumer analytics, and data visualization during technology-powered live shopping (Park et al., 2022; Xi et al., 2022; Zyda, 2022), users can be attracted and retained through metaverse experiences. Retail brands can leverage data-driven decisions, business intelligence and analytics software, and embedded artificial intelligence technology to configure customized production in the virtual economy. By deploying artificial intelligence techniques and applications in digital products, virtual stores can determine shopping habits, behaviors, preferences, and expectations across customer journeys.

Smart technologies can evaluate shifting consumer trends and changes in user behavior (Almarzouqi et al. 2022; Jang et al., 2022; Yeh et al., 2022), improving situational awareness and customer service performance on blockchain-based metaverse platforms. Augmented reality shopping tools can use rich consumer historical data through retail business analytics to determine purchasing habits, needs, and expectations. Story-based virtual reality experiences across 3D immersive environments can configure contextual consumer data in live shopping spaces and result it personalized interactions.

Data visualization tools and retail analytics can optimize immersive digital experiences (Elawady et al., 2022; Solakis et al., 2022; Zhang et al., 2022), and thus consumer behaviors and buying patterns in the metaverse economy. Speech recognition, language processing, sentiment analytics, swarm intelligence algorithms, social commerce tools, and immersive technologies can improve consumer digital engagement and articulate a streamlined purchasing experience. Customer behavior analytics can generate rich data visualizations that can assist in purchasing decisions on digital business platforms. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

By harnessing simulation modeling, consumer analytics, and data visualization during technology-powered live shopping, users can be attracted and retained through metaverse experiences.	Park et al., 2022; Xi et al., 2022; Zyda, 2022
Smart technologies can evaluate shifting consumer trends and changes in user behavior, improving situational awareness and customer service performance on blockchain-based metaverse platforms.	Almarzouqi et al. 2022; Jang et al., 2022; Yeh et al., 2022
Data visualization tools and retail analytics can optimize immersive digital experiences, and thus consumer behaviors and buying patterns in the metaverse economy.	Elawady et al., 2022; Solakis et al., 2022; Zhang et al., 2022

7. Discussion

I integrate my systematic review throughout research indicating how building data pipelines can assist seamless technology capabilities, semantic data interoperability, and retail transactions, while enhancing online buying experiences by driving resilience and innovation. My research complements recent analyses clarifying how immersive retail experiences during consumer journeys can be assessed by deploying computer vision algorithms, interactive technologies, real-time scalable systems, and image-making artificial intelligence, thus influencing consumer choices and maximizing value creation. I elucidate, by cumulative evidence, previous research demonstrating how cutting-edge retail technologies can be instrumental in assessing browsing behavior or past purchase-based personalized offers, thus enhance consumer shopping experiences across immersive 3D worlds.

8. Synopsis of the Main Research Outcomes

Augmented reality shopping tools can use rich consumer historical data through retail business analytics to determine purchasing habits, needs, and expectations. Customer behavior analytics can generate rich data visualizations that can assist in purchasing decisions on digital business platforms.

9. Conclusions

Relevant research has investigated whether data management tools support analytics output, shifts in customer behaviors, sales optimization, interconnected decision-making processes, and underlying data, driving digital business value. This systematic literature review presents the published peer-reviewed sources covering speech recognition, language processing, sentiment analytics, swarm intelligence algorithms, social commerce tools, and immersive technologies can improve consumer digital engagement and articulate a streamlined purchasing experience. The research outcomes drawn from the above analyses indicate that by deploying artificial intelligence techniques and applications in digital products, virtual stores can determine shopping habits, behaviors, preferences, and expectations across customer journeys.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on augmented analytics tools, interconnected decision-making processes, and computer vision algorithms in relation to blockchain-based metaverse platforms may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of mobility data on blockchain-based metaverse platforms.

Subsequent analyses should develop on 3D virtual space networking and extended reality environments throughout the underlying metaverse infrastructure. Future research should thus investigate virtual delivery networks that can articulate convenient shopping experiences and behaviors. In the future, attention should be directed to simulation modeling, consumer analytics, and data visualization during technology-powered live shopping.

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This article does not contain any studies with human participants or animals performed by the author.

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Author contributions
The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

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The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Transparency statement
The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Decision Intelligence and Modeling, Multisensory Customer Experiences, and Socially Interconnected Virtual Services across the Metaverse Ecosystem

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ABSTRACT. This article reviews and advances existing literature concerning decision intelligence and modeling, multisensory customer experiences, and socially interconnected virtual services across the metaverse ecosystem. In this research, previous findings were cumulated showing that customer experience analytics can articulate digital shopping journeys in immersive virtual environments, and we contribute to the literature by indicating that live shopping events are decisive in virtual item purchasing, increasing engagement rates through location data. Throughout February 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including "metaverse" + "decision intelligence and modeling," "multisensory customer experiences," and "socially interconnected virtual services." As research published in 2022 was inspected, only 89 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, we selected 19 mainly empirical sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, MMAT, ROBIS, and SRDR.

Keywords: multisensory; customer; virtual; decision; metaverse; retail

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1. Introduction

Smart digital services can attract and retain customers by harnessing real-time data analytics, extended reality technologies, and decision-making tools (Andrei et al., 2020; Krizanova et al., 2019; Peters, 2022) in virtual environments. The purpose of our systematic review is to examine the recently published literature on the metaverse ecosystem and integrate the insights it configures on decision intelligence and modeling, multisensory customer experiences, and socially interconnected virtual services. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that retail brands can mine customer data through visual analytics (Rowland et al., 2021; Valle, 2021; Zvarikova et al., 2022) across the decentralized infrastructure of virtual stores (Andronie et al., 2021; Lăzăroiu et al., 2020; Popescu et al., 2020), determining user demands and behavioral patterns (Blackburn and Pera, 2021; Nica et al., 2021; Popescu, 2018) while raising brand awareness. The actuality and novelty of this study are articulated by addressing conversational commerce and metaverse marketing tools, that is an emerging topic involving much interest. Our research problem is whether customer experience analytics can articulate digital shopping journeys (Barbu et al., 2021; Lăzăroiu et al., 2022; Poliak et al., 2021) in immersive virtual environments.

In this review, prior findings have been cumulated indicating that live shopping events are decisive in virtual item purchasing, increasing engagement rates through location data. The identified gaps advance machine learning-enabled customization software and metaverse apps. Our main objective is to indicate that socially interconnected virtual services can deploy 3D space computer-generated simulations, data-driven artificial intelligence, and text-to-image synthesis models to meet customer dynamic demands (Kliestik et al., 2020; Nica, 2021; Popescu et al., 2021) in the blockchain-based virtual economy. This systematic review contributes to the literature on artificial intelligence algorithms and metaverse apps by clarifying that e-commerce tools can be instrumental in enhanced customer retention and satisfaction (Rowland, 2022; Vătămănescu et al., 2020; Watson, 2022) by harnessing smart connected devices and cloud-based delivery management software (Pelau et al., 2021; Popescu, 2017; Rogers and Zvarikova, 2021) throughout digital shopping experiences.

2. Theoretical Overview of the Main Concepts

Internet of Things devices, machine vision algorithms, and speech recognition applications can be pivotal in mobile customer interaction experiences, leading to user retention while optimizing purchasing behavior shifts through dynamic personalized offers in virtual economy. Retail brands leverage 3D body-scanning fit technology, simulation modeling, and consumer analytics across networked machines and products, articulating data-driven decisions that can increase customer lifetime value by immersive retail experiences in online marketplaces. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), optimizing virtual immersive retail experiences during customer journeys in the metaverse economy (section 4), immersive retail experiences across virtual worlds in the metaverse economy (section 5), customer monitoring systems and metaverse marketing tools throughout extended reality environments (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout February 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including “metaverse” + “decision intelligence and modeling,” “multisensory customer experiences,” and “socially interconnected virtual services.” The search terms were determined as being the most employed words or phrases across the analyzed literature. As research published in 2022 was inspected, only 89 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, we selected 19 mainly empirical sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, MMAT, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + decision intelligence and modeling	28	6
metaverse + multisensory customer experiences	30	6
metaverse + socially interconnected virtual services	31	7
Type of paper		
Original research	68	19
Review	3	0
Conference proceedings	11	0
Book	3	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

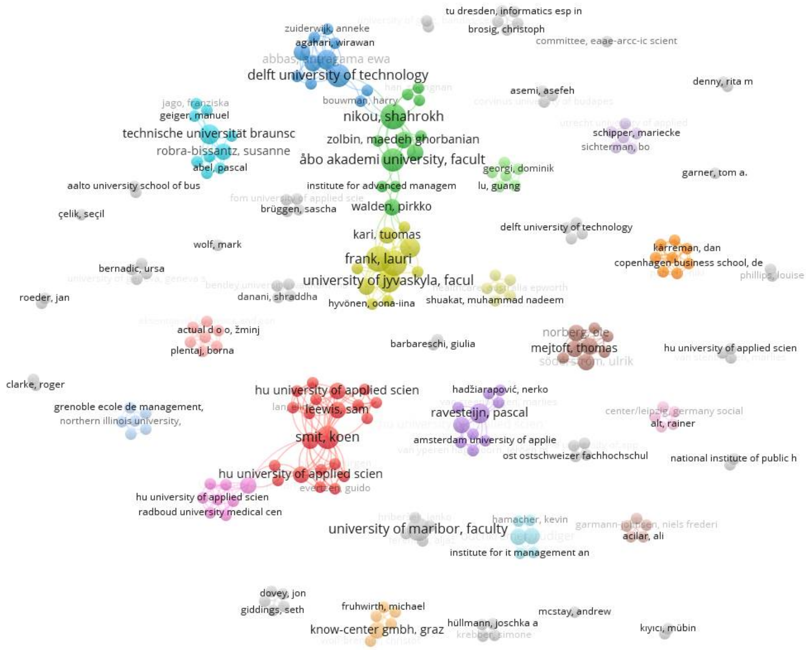

Figure 1 Co-authorship

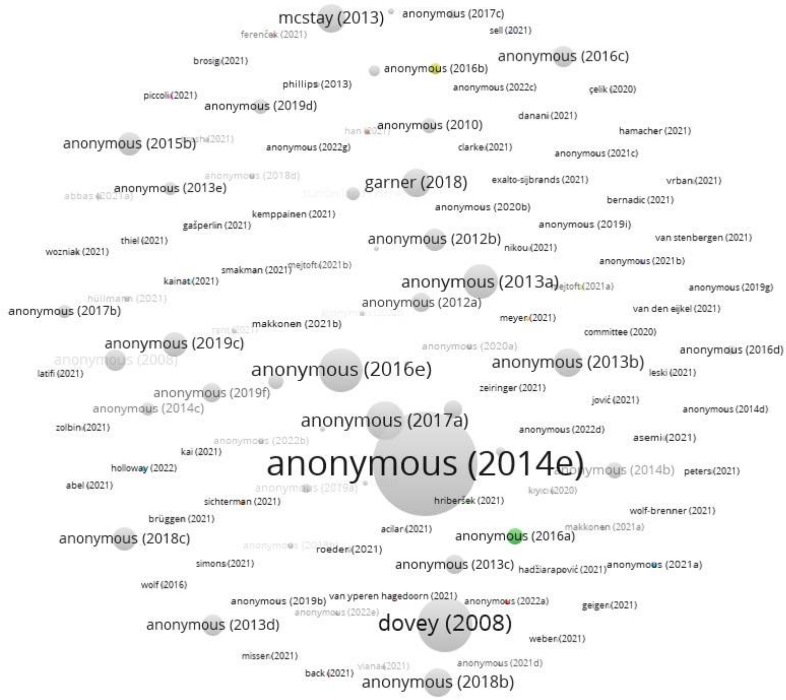

Figure 2 Citation

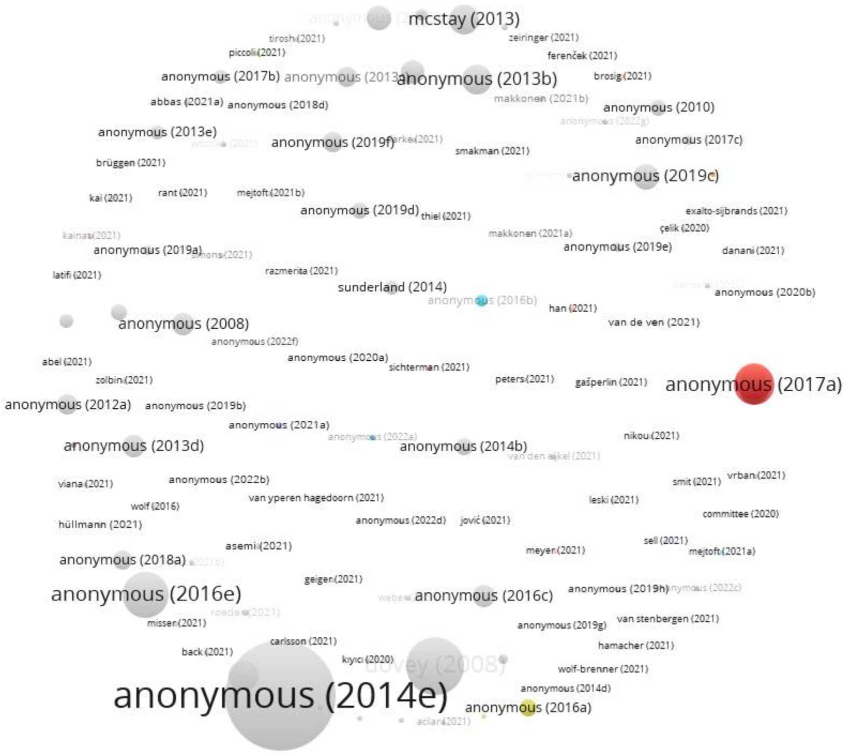

Figure 3 Bibliographic coupling

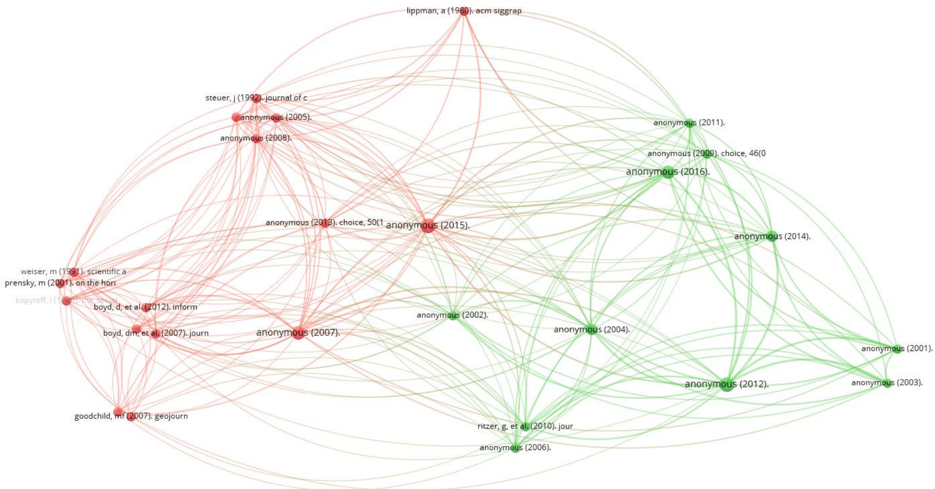

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Artificial intelligence algorithms and metaverse apps can extract meaningful customer sentiment data in livestreaming e-commerce.	Beniiche et al., 2022; Kozinets, 2022; Zhang et al., 2022a
Analytical techniques and metaverse marketing tools can optimize consumer purchasing behaviors, pattern changes, and heightened demands in blockchain-powered virtual worlds through image recognition and location data.	Chandra, 2022; Hwang and Chien, 2022; Lin et al., 2022
Retail business analytics can be leveraged in digital commerce to optimize virtual immersive retail experiences during customer journeys in the metaverse economy. Leveraging consumer data and image recognition throughout the content streaming environment can personalize shopping experience and further virtual connectivity.	Laviola et al., 2022; Lv et al., 2022; Zhao et al., 2022
Conversational commerce and metaverse marketing tools can improve customer brand loyalty by integrating data-driven decisions and collecting customer preferences, thus resulting in streamlined convenient experiences across immersive virtual store environments.	Dozio et al., 2022; Kraus et al., 2022; Lukava et al., 2022
Past purchase-related personalized offers and exclusive discounts can articulate tech-enabled convenience across online immersive experiential environments, enhancing mainstream metaverse experiences.	Elawady et al., 2022; Jang et al., 2022; Lv et al., 2022
Data-driven decisions and consumer analytics can be instrumental in assessing purchasing habits during immersive retail experiences across virtual worlds in the metaverse economy.	Hollensen et al., 2022; Park et al., 2022; Turner, 2022
Machine learning-enabled customization software and metaverse apps can assist experiential retail in virtual commerce through remote monitoring capabilities, while assessing consumer preference and shopping history.	Beniiche et al., 2022; Kozinets, 2022; Zhang et al., 2022b
Computer vision algorithms can harness rich customer data for creator and brand livestreaming tools, configuring digital shopping trends together with realistic and immersive virtual shopping experiences in the metaverse.	Dozio et al., 2022; Hwang and Chien, 2022; Kraus et al., 2022
Customer monitoring systems and metaverse marketing tools throughout extended reality environments can integrate data visualizations, thus optimizing business process efficiencies.	Elawady et al., 2022; Jang et al., 2022; Wang, 2022

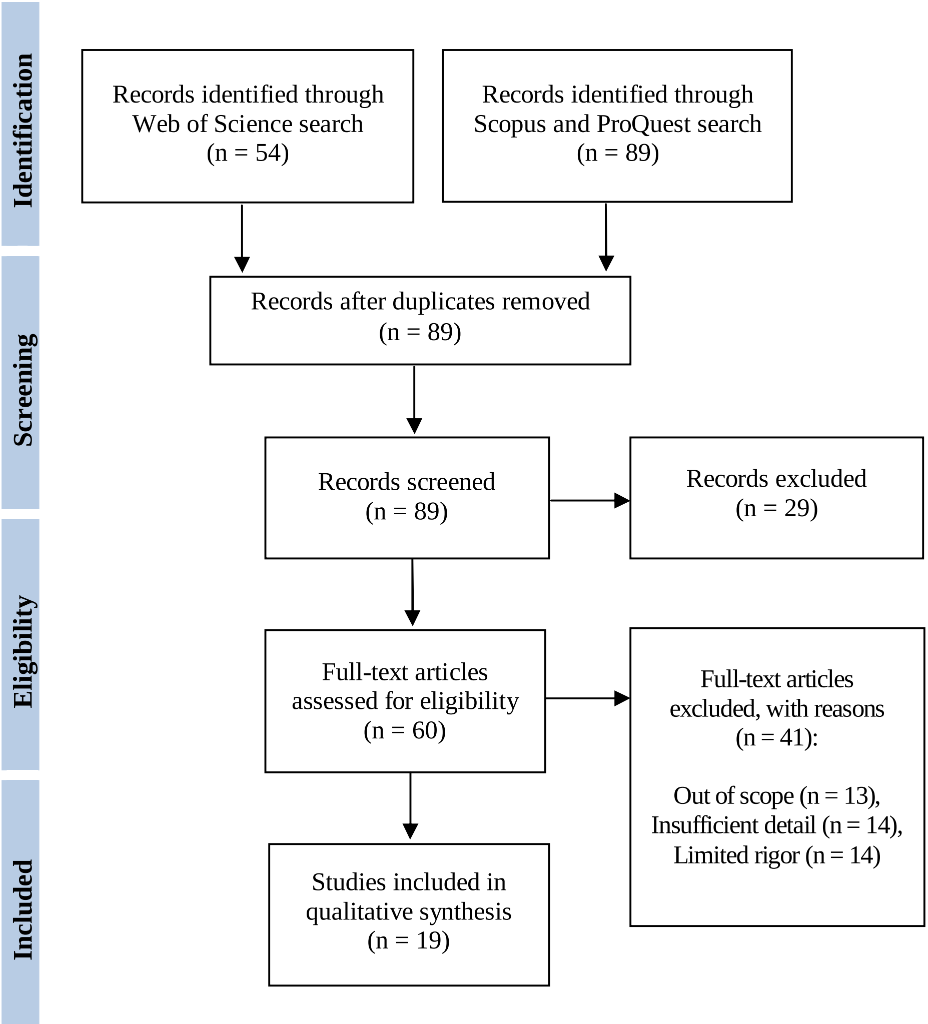

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

Distiller SR screened and extracted the collected data.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

↓

Dedoose analyzed qualitative and mixed methods research.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

ROBIS assessed the risk of bias in systematic reviews.

Figure 6 Screening and quality assessment tools

4. Optimizing Virtual Immersive Retail Experiences during Customer Journeys in the Metaverse Economy

Artificial intelligence algorithms and metaverse apps can extract meaningful customer sentiment data (Beniiche et al., 2022; Kozinets, 2022; Zhang et al., 2022a) in livestreaming e-commerce. Artificial intelligence-based personalization tools can streamline retail operations, building brand loyalty, while engaging and rewarding consumers during frictionless shopping experiences. E-commerce tools can be instrumental in enhanced customer retention and satisfaction by harnessing smart connected devices and cloud-based delivery management software throughout digital shopping experiences.

Analytical techniques and metaverse marketing tools can optimize consumer purchasing behaviors, pattern changes, and heightened demands in blockchain-powered virtual worlds (Chandra, 2022; Hwang and Chien, 2022; Lin et al., 2022) through image recognition and location data. Synthetic customer profiles, analytic decision models, and machine-readable metadata can be pivotal in augmented shopping experiences by shaping purchase decisions and building user relationships. Predictive customer analytics can integrate immersive technologies and synthetic data tools in virtual stores so as to amplify meaningful experiences. Live shopping events are decisive in virtual item purchasing, increasing engagement rates through location data.

Retail business analytics can be leveraged in digital commerce to optimize virtual immersive retail experiences (Laviola et al., 2022; Lv et al., 2022; Zhao et al., 2022) during customer journeys in the metaverse economy. Customer interaction analytics assists immersive engaging shopping, shaping consumer purchasing habits, behaviors, and expectations, while integrating exclusive offers and customer reviews. Leveraging consumer data and image recognition throughout the content streaming environment can personalize shopping experience and further virtual connectivity. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Artificial intelligence algorithms and metaverse apps can extract meaningful customer sentiment data in livestreaming e-commerce.	Beniiche et al., 2022; Kozinets, 2022; Zhang et al., 2022a
Analytical techniques and metaverse marketing tools can optimize consumer purchasing behaviors, pattern changes, and heightened demands in blockchain-powered virtual worlds through image recognition and location data.	Chandra, 2022; Hwang and Chien, 2022; Lin et al., 2022
Retail business analytics can be leveraged in digital commerce to optimize virtual immersive retail experiences during customer journeys in the metaverse economy.	Laviola et al., 2022; Lv et al., 2022; Zhao et al., 2022

5. Immersive Retail Experiences across Virtual Worlds in the Metaverse Economy

Conversational commerce and metaverse marketing tools can improve customer brand loyalty by integrating data-driven decisions and collecting customer preferences (Dozio et al., 2022; Kraus et al., 2022; Lukava et al., 2022), thus resulting in streamlined convenient experiences across immersive virtual store environments. Internet of Things devices, machine vision algorithms, and speech recognition applications can be pivotal in mobile customer interaction experiences, leading to user retention while optimizing purchasing behavior shifts through dynamic personalized offers in virtual economy.

Past purchase-related personalized offers and exclusive discounts can articulate tech-enabled convenience across online immersive experiential environments (Elawady et al., 2022; Jang et al., 2022; Lv et al., 2022), enhancing mainstream metaverse experiences. Augmented- and virtual-reality hardware, computer vision algorithms, and voice biometrics technology can harness real-time datasets as regards consumer behavior in virtual shopping malls. Retail brands can mine customer data through visual analytics across the decentralized infrastructure of virtual stores, determining user demands and behavioral patterns while raising brand awareness.

Data-driven decisions and consumer analytics can be instrumental in assessing purchasing habits during immersive retail experiences (Hollensen et al., 2022; Park et al., 2022; Turner, 2022) across virtual worlds in the metaverse economy. Real-time customer data analytics can deliver business value and build consumer demand by deploying computer-generated virtual data. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Conversational commerce and metaverse marketing tools can improve customer brand loyalty by integrating data-driven decisions and collecting customer preferences, thus resulting in streamlined convenient experiences across immersive virtual store environments.	Dozio et al., 2022; Kraus et al., 2022; Lukava et al., 2022
Past purchase-related personalized offers and exclusive discounts can articulate tech-enabled convenience across online immersive experiential environments, enhancing mainstream metaverse experiences.	Elawady et al., 2022; Jang et al., 2022; Lv et al., 2022
Data-driven decisions and consumer analytics can be instrumental in assessing purchasing habits during immersive retail experiences across virtual worlds in the metaverse economy.	Hollensen et al., 2022; Park et al., 2022; Turner, 2022

6. Customer Monitoring Systems and Metaverse Marketing Tools throughout Extended Reality Environments

Machine learning-enabled customization software and metaverse apps can assist experiential retail in virtual commerce through remote monitoring capabilities (Beniiche et al., 2022; Kozinets, 2022; Zhang et al., 2022b), while assessing consumer preference and shopping history. Augmented reality tools and artificial intelligence customer service chatbots can increase customer satisfaction by deploying location data, computer-generated images, and hyper-personalization. Smart digital services can attract and retain customers by harnessing real-time data analytics, extended reality technologies, and decision-making tools in virtual environments.

Computer vision algorithms can harness rich customer data for creator and brand livestreaming tools (Dozio et al., 2022; Hwang and Chien, 2022; Kraus et al., 2022), configuring digital shopping trends together with realistic and immersive virtual shopping experiences in the metaverse. Socially interconnected virtual services can deploy 3D space computer-generated simulations, data-driven artificial intelligence, and text-to-image synthesis models to meet customer dynamic demands in the blockchain-based virtual economy. Customer experience analytics can articulate digital shopping journeys in immersive virtual environments.

Customer monitoring systems and metaverse marketing tools throughout extended reality environments can integrate data visualizations (Elawady et al., 2022; Jang et al., 2022; Wang, 2022), thus optimizing business process efficiencies. Retail brands leverage 3D body-scanning fit technology, simulation modeling, and consumer analytics across networked machines and products, articulating data-driven decisions that can increase customer lifetime value by immersive retail experiences in online marketplaces. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Machine learning-enabled customization software and metaverse apps can assist experiential retail in virtual commerce through remote monitoring capabilities, while assessing consumer preference and shopping history.	Beniiche et al., 2022; Kozinets, 2022; Zhang et al., 2022b
Computer vision algorithms can harness rich customer data for creator and brand livestreaming tools, configuring digital shopping trends together with realistic and immersive virtual shopping experiences in the metaverse.	Dozio et al., 2022; Hwang and Chien, 2022; Kraus et al., 2022
Customer monitoring systems and metaverse marketing tools throughout extended reality environments can integrate data visualizations, thus optimizing business process efficiencies.	Elawady et al., 2022; Jang et al., 2022; Wang, 2022

7. Discussion

We integrate our systematic review throughout research indicating how Artificial intelligence-based personalization tools can streamline retail operations, building brand loyalty, while engaging and rewarding consumers during frictionless shopping experiences. Our research complements recent analyses clarifying how customer interaction analytics assists immersive engaging shopping, shaping consumer purchasing habits, behaviors, and expectations, while integrating exclusive offers and customer reviews. We elucidate, by cumulative evidence, previous research demonstrating how Augmented- and virtual-reality hardware, computer vision algorithms, and voice biometrics technology can harness real-time datasets as regards consumer behavior in virtual shopping malls.

8. Synopsis of the Main Research Outcomes

Synthetic customer profiles, analytic decision models, and machine-readable metadata can be pivotal in augmented shopping experiences by shaping purchase decisions and building user relationships. Augmented reality tools and artificial intelligence customer service chatbots can increase customer satisfaction by deploying location data, computer-generated images, and hyper-personalization.

9. Conclusions

Relevant research has investigated whether leveraging consumer data and image recognition throughout the content streaming environment can personalize shopping experience and further virtual connectivity. This systematic literature review presents the published peer-reviewed sources covering how predictive customer analytics can integrate immersive technologies and synthetic data tools in virtual stores so as to amplify meaningful experiences. The research outcomes drawn from the above analyses indicate that real-time customer data analytics can deliver business value and build consumer demand by deploying computer-generated virtual data.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on decision intelligence and modeling, multisensory customer experiences, and socially interconnected virtual services across the metaverse ecosystem may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of analytical techniques and metaverse marketing tools.

Subsequent analyses should develop on customer journeys in the metaverse economy. Future research should thus investigate online immersive experiential environments. In the future, attention should be directed to realistic and immersive virtual shopping experiences in the metaverse.

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Compliance with ethical standards
This article does not contain any studies with human participants or animals performed by the authors.

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Author contributions
All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement
The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record
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Transparency statement
The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Immersive Virtual Shopping Experiences in the Retail Metaverse: Consumer-driven E-Commerce, Blockchain-based Digital Assets, and Data Visualization Tools

Thomas Jenkins*

ABSTRACT. Based on an in-depth survey of the literature, the purpose of the paper is to explore immersive virtual shopping experiences in the retail metaverse as regards consumer-driven e-commerce, blockchain-based digital assets, and data visualization tools. In this research, previous findings were cumulated showing that livestreaming e-commerce can integrate consumer retail data to enhance real-time customization services and optimize immersive virtual shopping experiences, thus increase user engagement, and I contribute to the literature by indicating that deep learning algorithms, digital neural networks, image recognition, and data-driven decision making can drive operational efficiencies as regards customization and responsiveness, enriching customer intelligence. Throughout March 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including "metaverse" + "immersive virtual shopping experiences," "retail brands," "consumer-driven e-commerce," "blockchain-based digital assets," and "data visualization tools." As research published in 2022 was inspected, only 89 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, I selected 19 mainly empirical sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Dedoose, Distiller SR, and SRDR.

Keywords: immersive; virtual; shopping; retail; metaverse; visualization

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1. Introduction

Customer artificial intelligence-powered predictive analyses, data-driven measurements, and visual imagery (Adams, 2022; Lăzăroiu, 2017; Nica et al., 2021; Popescu et al., 2021) determine user tastes and habits, purchasing behavior shifts, and brand loyalty. The purpose of my systematic review is to examine the recently published literature on immersive virtual shopping experiences in the retail metaverse and integrate the insights it configures on consumer-driven e-commerce, blockchain-based digital assets, and data visualization tools. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that quantum machine learning algorithms can leverage geolocation data to improve digital orders, thus engaging and retaining customers (Andrei et al., 2016; Lăzăroiu et al., 2017; Olssen, 2021; Valle, 2021) across live shopping spaces and towards virtual shelves. The actuality and novelty of this study are articulated by addressing retail and business locations in virtual economy and metaverse spaces, that is an emerging topic involving much interest. My research problem is whether immersive retail and livestream video shopping experiences are pivotal in building consumer demand.

In this review, prior findings have been cumulated indicating that personalization tools and technologies can lead to growing consumer engagement (Kral et al., 2020; Nica, 2018; Popescu, 2018; Zvarikova et al., 2022) during digital shopper journeys in complex operational and business environments (Andronie et al., 2021; Lăzăroiu et al., 2020; Pop et al., 2022; Vinerean et al., 2022), optimizing real-time hyper-personalized virtual shopping experiences. The identified gaps advance livestream video shopping experiences in the metaverse economy. My main objective is to indicate that livestreaming e-commerce can integrate consumer retail data to enhance real-time customization services and optimize immersive virtual shopping experiences (Holmes and Cug, 2021; Nica, 2017; Popescu, 2017), thus increase user engagement. This systematic review contributes to the literature on immersive virtual shopping and engagement by clarifying that deep learning algorithms, digital neural networks, image recognition, and data-driven decision making can drive operational efficiencies (Friedman and Fischer, 2021; Nemțeanu et al., 2022; Popescu et al., 2017; Watson, 2022) as regards customization and responsiveness, enriching customer intelligence.

2. Theoretical Overview of the Main Concepts

Synthetic data, predictive analytics, and visual imagery can be harnessed in experiential shopping during consumer journeys across digital worlds as regards virtual items. Real-time sensor-based data and analytics can enhance product assortment, provide personalized customer service, and optimize customer profiles. Immersive technologies, data visualizations, and analytical tools can be instrumental in personalized customer shopping experiences through movement and behavior tracking across interconnected digital worlds and virtual environments. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), purchasing decisions in the retail metaverse (section 4), immersive shopping experiences in the retail metaverse (section 5), customer relationship management and logistics operations in the metaverse economy (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout March 2022, a quantitative literature review of the Web of Science, Scopus, and ProQuest databases was performed, with search terms including “metaverse” + “immersive virtual shopping experiences,” “retail brands,” “consumer-driven e-commerce,” “blockchain-based digital assets,” and “data visualization tools.” The search terms were determined as being the most employed words or phrases across the analyzed literature. As research published in 2022 was inspected, only 89 articles satisfied the eligibility criteria. By taking out controversial or ambiguous findings (insufficient/irrelevant data), outcomes unsubstantiated by replication, too general material, or studies with nearly identical titles, I selected 19 mainly empirical sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Dedoose, Distiller SR, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + immersive virtual shopping experiences	19	4
metaverse + retail brands	16	3
metaverse + consumer-driven e-commerce	18	4
metaverse + blockchain-based digital assets	18	4
metaverse + data visualization tools	18	4
Type of paper		
Original research	68	18
Review	3	1
Conference proceedings	12	0
Book	3	0
Editorial	3	0

Source: Processed by the author. Some topics overlap.

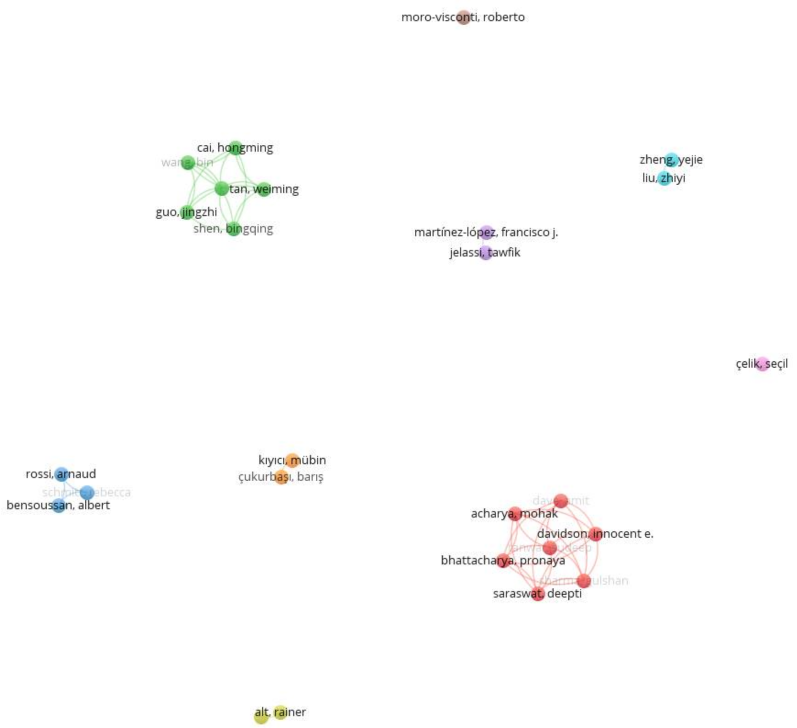

Figure 1 Co-authorship

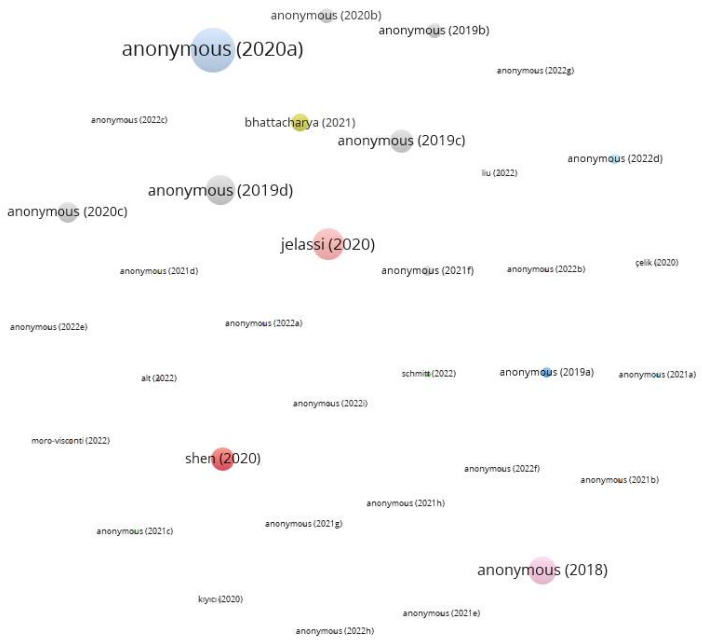

Figure 2 Citation

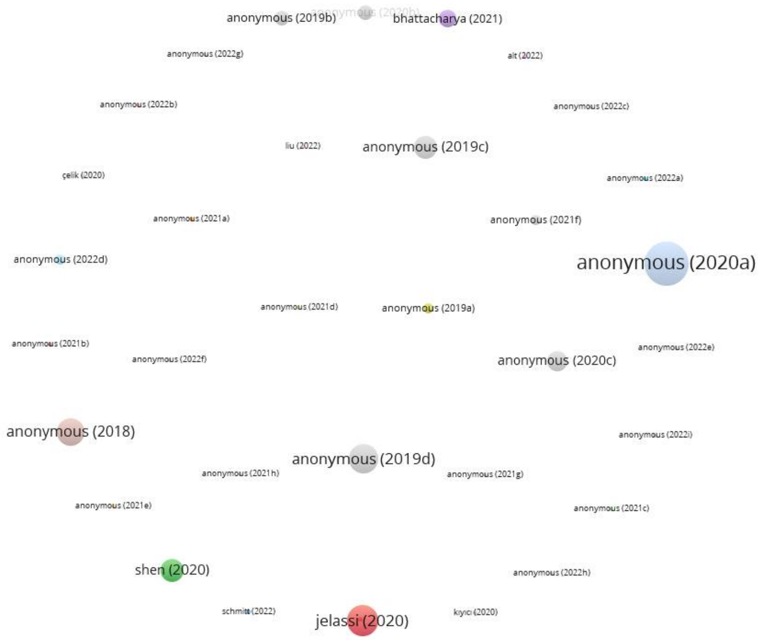

Figure 3 Bibliographic coupling

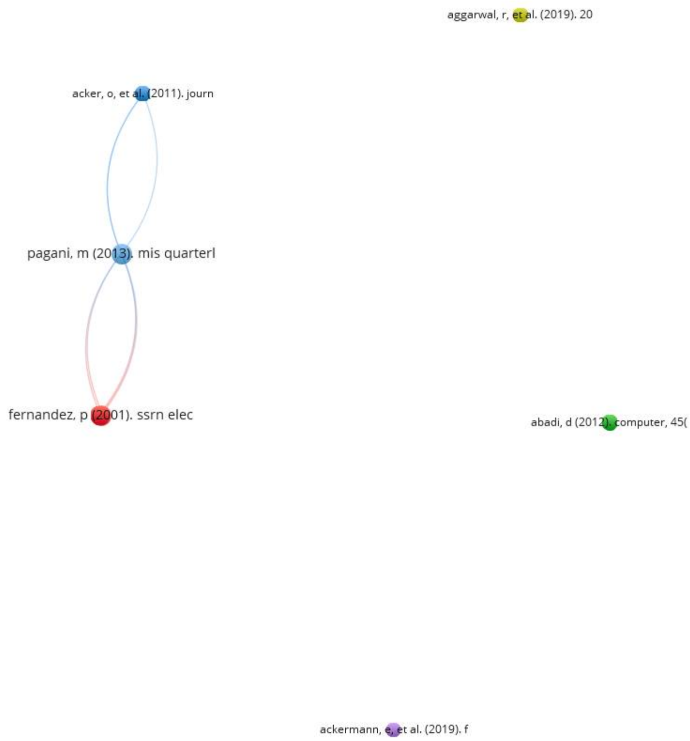

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Data-driven user experiences integrate product-level browsing, customer knowledge, and purchase data in the retail metaverse.	Han et al., 2022; Kshetri, 2022; Zyda, 2022
Consumer-driven e-commerce can build brand awareness and engagement, while improving immersive shopping experiences in terms of purchasing decisions in the retail metaverse.	Gills and Hosseini, 2022; Hwang and Chien, 2022; Zhang et al., 2022a
Contextual augmented reality, computer vision algorithms, and customer journey mapping can assess personalized shopping experiences as regards virtual assets by integrating mobility data in the metaverse economy.	Chandra, 2022; Lin et al., 2022; Solakis et al., 2022
Digital shelf data, computer vision algorithms, biometric payment tools and authentication features, machine intelligence, and retail analytics can engage consumers through dynamic routing technology across retail and business locations in virtual economy and metaverse spaces.	Dozio et al., 2022; Gibbert et al., 2022; Wang, 2022
Smart retailing can improve customer experience by leveraging rich user data across online and virtual marketplaces, optimizing shopping habits through metaverse social interactions. Immersive retail and livestream video shopping experiences are pivotal in building consumer demand.	Akyildiz et al., 2022; Lin et al., 2022; Yeh et al., 2022
Computer vision algorithms, text analytics, and consumer intelligence can leverage mobile biometric data as regards digital assets, optimizing immersive shopping experiences in the retail metaverse.	Guo and Gao, 2022; Liu et al., 2022; Hwang and Chien, 2022
Managing and sharing data as regards interconnected products and processes assist immersive experiences across extended reality environments, optimizing business results in the retail metaverse.	Han et al., 2022; Gibbert et al., 2022; Reis and Ashmore, 2022
Leveraging predictive analytics, natural language processing models, and data visualization capabilities, virtual stores can strengthen customer relationships, engagement, and expectations, while enhancing livestream video shopping experiences in the metaverse economy.	Hollensen et al., 2022; Wang, 2022; Zhang et al., 2022b
Consumer behavior and data are pivotal in immersive virtual shopping and engagement through groundbreaking customer relationship management and logistics operations in the metaverse economy. Immersive retail experiences can build customer engagement and purchasing habits as regards virtual assets in digital shopping journeys.	Liu et al., 2022; Yeh et al., 2022; Zhang et al., 2022a

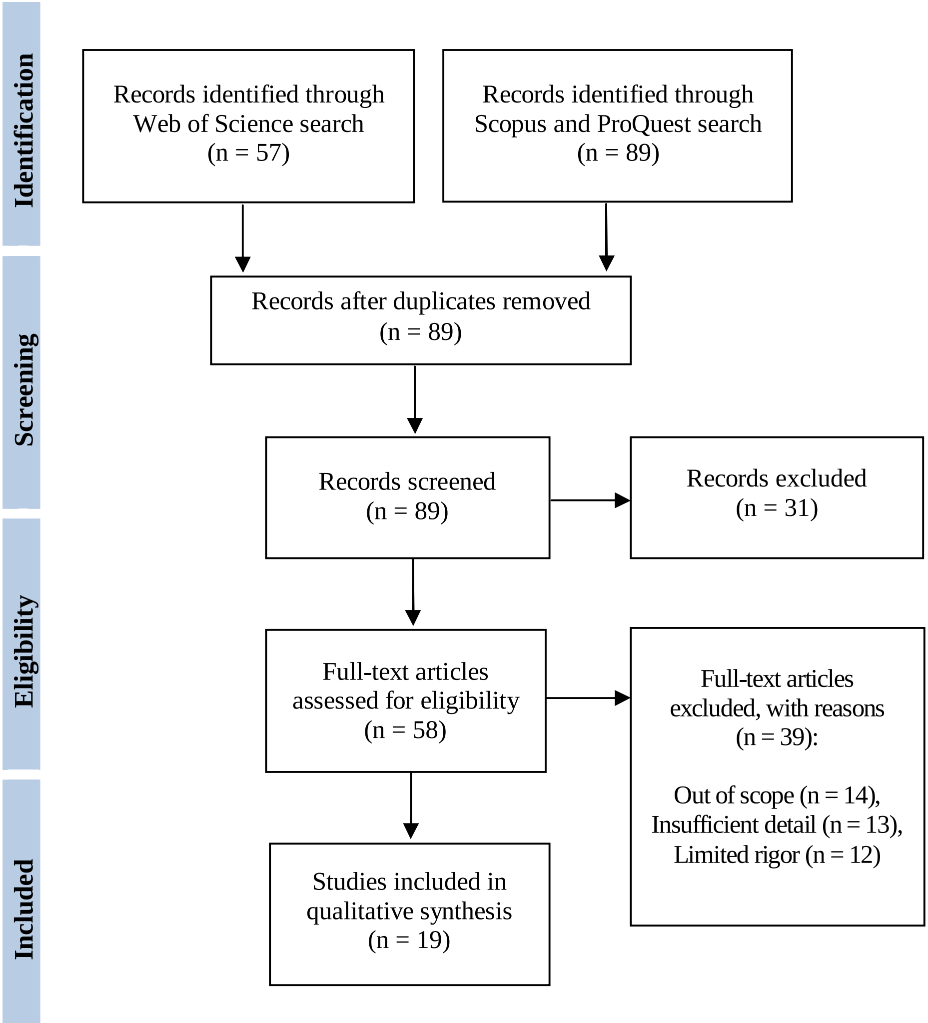

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

Distiller SR screened and extracted the collected data.

AMSTAR evaluated the methodological quality of systematic reviews.

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

Dedoose analyzed qualitative and mixed methods research.

AXIS evaluated the quality of cross-sectional studies.

ROBIS assessed the risk of bias in systematic reviews.

Figure 6 Screening and quality assessment tools

4. Purchasing Decisions in the Retail Metaverse

Data-driven user experiences integrate product-level browsing, customer knowledge, and purchase data (Han et al., 2022; Kshetri, 2022; Zyda, 2022) in the retail metaverse. Consumer opinion and feedback, together with sentiment analysis, can be assessed by harnessing text analytics tools and natural language processing algorithms in relation to structured and unstructured data (e.g., tokenization, speech tagging, text parsing, named entity extraction, and chunking) from compliance forms, blog posts, call center transcripts, online product reviews, etc., configuring patterns and trends, and resulting in data-driven decisions.

Consumer-driven e-commerce can build brand awareness and engagement (Gills and Hosseini, 2022; Hwang and Chien, 2022; Zhang et al., 2022a), while improving immersive shopping experiences in terms of purchasing decisions in the retail metaverse. Real-time sensor-based data and analytics can enhance product assortment, provide personalized customer service, and optimize customer profiles. Livestreaming e-commerce can integrate consumer retail data to enhance real-time customization services and optimize immersive virtual shopping experiences, thus increase user engagement. Shopping tools and retail analytics can determine customer habits in experiential stores and across immersive virtual environments.

Contextual augmented reality, computer vision algorithms, and customer journey mapping can assess personalized shopping experiences as regards virtual assets (Chandra, 2022; Lin et al., 2022; Solakis et al., 2022) by integrating mobility data in the metaverse economy. Deep learning algorithms, digital neural networks, image recognition, and data-driven decision making can drive operational efficiencies as regards customization and responsiveness, enriching customer intelligence. Simulation modeling, computer vision tools, customer predictive analytics, and artificial neural networks can improve user loyalty across immersive multisensory virtual spaces. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Data-driven user experiences integrate product-level browsing, customer knowledge, and purchase data in the retail metaverse.	Han et al., 2022; Kshetri, 2022; Zyda, 2022
Consumer-driven e-commerce can build brand awareness and engagement, while improving immersive shopping experiences in terms of purchasing decisions in the retail metaverse.	Gills and Hosseini, 2022; Hwang and Chien, 2022; Zhang et al., 2022a
Contextual augmented reality, computer vision algorithms, and customer journey mapping can assess personalized shopping experiences as regards virtual assets by integrating mobility data in the metaverse economy.	Chandra, 2022; Lin et al., 2022; Solakis et al., 2022

5. Immersive Shopping Experiences in the Retail Metaverse

Digital shelf data, computer vision algorithms, biometric payment tools and authentication features, machine intelligence, and retail analytics can engage consumers through dynamic routing technology (Dozio et al., 2022; Gibbert et al., 2022; Wang, 2022) across retail and business locations in virtual economy and metaverse spaces. Personalization tools and technologies can lead to growing consumer engagement during digital shopper journeys in complex operational and business environments, optimizing real-time hyper-personalized virtual shopping experiences. Deep and machine learning algorithms, cognitive technologies, and behavioral analytics can integrate consumer behavior data and artificial intelligence-enabled digital products across persistent virtual worlds, enhancing user engagement.

Smart retailing can improve customer experience by leveraging rich user data across online and virtual marketplaces (Akyildiz et al., 2022; Lin et al., 2022; Yeh et al., 2022), optimizing shopping habits through metaverse social interactions. Retail brands can streamline artificial intelligence-enhanced large-scale operations across immersive virtual worlds, improving personalized shopping experiences and consumer confidence by integrating marketing performance data. Immersive retail and livestream video shopping experiences are pivotal in building consumer demand.

Computer vision algorithms, text analytics, and consumer intelligence can leverage mobile biometric data as regards digital assets (Guo and Gao, 2022; Liu et al., 2022; Hwang and Chien, 2022), optimizing immersive shopping experiences in the retail metaverse. Immersive technologies, data visualizations, and analytical tools can be instrumental in personalized customer shopping experiences through movement and behavior tracking across interconnected digital worlds and virtual environments. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Digital shelf data, computer vision algorithms, biometric payment tools and authentication features, machine intelligence, and retail analytics can engage consumers through dynamic routing technology across retail and business locations in virtual economy and metaverse spaces.	Dozio et al., 2022; Gibbert et al., 2022; Wang, 2022
Smart retailing can improve customer experience by leveraging rich user data across online and virtual marketplaces, optimizing shopping habits through metaverse social interactions.	Akyildiz et al., 2022; Lin et al., 2022; Yeh et al., 2022
Computer vision algorithms, text analytics, and consumer intelligence can leverage mobile biometric data as regards digital assets, optimizing immersive shopping experiences in the retail metaverse.	Guo and Gao, 2022; Liu et al., 2022; Hwang and Chien, 2022

6. Customer Relationship Management and Logistics Operations in the Metaverse Economy

Managing and sharing data as regards interconnected products and processes assist immersive experiences across extended reality environments (Han et al., 2022; Gibbert et al., 2022; Reis and Ashmore, 2022), optimizing business results in the retail metaverse. Customer artificial intelligence-powered predictive analyses, data-driven measurements, and visual imagery determine user tastes and habits, purchasing behavior shifts, and brand loyalty. Data-driven decisions, simulation modeling, and computer vision algorithms can increase brand awareness and shopper engagement through virtual connectivity across extended reality environments, improving consumer purchase experiences.

Leveraging predictive analytics, natural language processing models, and data visualization capabilities, virtual stores can strengthen customer relationships, engagement, and expectations (Hollensen et al., 2022; Wang, 2022; Zhang et al., 2022b), while enhancing livestream video shopping experiences in the metaverse economy. Quantum machine learning algorithms can leverage geolocation data to improve digital orders, thus engaging and retaining customers across live shopping spaces and towards virtual shelves.

Consumer behavior and data are pivotal in immersive virtual shopping and engagement (Liu et al., 2022; Yeh et al., 2022; Zhang et al., 2022a) through groundbreaking customer relationship management and logistics operations in the metaverse economy. Synthetic data, predictive analytics, and visual imagery can be harnessed in experiential shopping during consumer journeys across digital worlds as regards virtual items. Immersive retail experiences can build customer engagement and purchasing habits as regards virtual assets in digital shopping journeys. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Managing and sharing data as regards interconnected products and processes assist immersive experiences across extended reality environments, optimizing business results in the retail metaverse.	Han et al., 2022; Gibbert et al., 2022; Reis and Ashmore, 2022
Leveraging predictive analytics, natural language processing models, and data visualization capabilities, virtual stores can strengthen customer relationships, engagement, and expectations, while enhancing livestream video shopping experiences in the metaverse economy.	Hollensen et al., 2022; Wang, 2022; Zhang et al., 2022b
Consumer behavior and data are pivotal in immersive virtual shopping and engagement through groundbreaking customer relationship management and logistics operations in the metaverse economy.	Liu et al., 2022; Yeh et al., 2022; Zhang et al., 2022a

7. Discussion

I integrate my systematic review throughout research indicating how consumer opinion and feedback, together with sentiment analysis, can be assessed by harnessing text analytics tools and natural language processing algorithms. My research complements recent analyses clarifying how deep and machine learning algorithms, cognitive technologies, and behavioral analytics can integrate consumer behavior data and artificial intelligence-enabled digital products across persistent virtual worlds, enhancing user engagement. I elucidate, by cumulative evidence, previous research demonstrating how shopping tools and retail analytics can determine customer habits in experiential stores and across immersive virtual environments.

8. Synopsis of the Main Research Outcomes

Retail brands can streamline artificial intelligence-enhanced large-scale operations across immersive virtual worlds, improving personalized shopping experiences and consumer confidence by integrating marketing performance data. Immersive retail and livestream video shopping experiences are pivotal in building consumer demand. Quantum machine learning algorithms can leverage geolocation data to improve digital orders, thus engaging and retaining customers across live shopping spaces and towards virtual shelves.

9. Conclusions

Relevant research has investigated whether immersive retail experiences can build customer engagement and purchasing habits as regards virtual assets in digital shopping journeys. This systematic literature review presents the published peer-reviewed sources covering how simulation modeling, computer vision tools, customer predictive analytics, and artificial neural networks can improve user loyalty across immersive multisensory virtual spaces. The research outcomes drawn from the above analyses indicate that data-driven decisions, simulation modeling, and computer vision algorithms can increase brand awareness and shopper engagement through virtual connectivity across extended reality environments, improving consumer purchase experiences.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on immersive virtual shopping experiences in the retail metaverse may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of immersive experiences across extended reality environments.

Subsequent analyses should develop on groundbreaking customer relationship management and logistics operations in the metaverse economy. Future research should thus investigate purchasing decisions in the retail metaverse. In the future, attention should be directed to personalized shopping experiences as regards virtual assets.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the author.

Data availability statement

All data generated or analyzed are included in the published article.

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Author contributions

The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Digital Commerce in the Immersive Metaverse Environment: Cognitive Analytics Management, Real-Time Purchasing Data, and Seamless Connected Shopping Experiences

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ABSTRACT. In this article, we cumulate previous research findings indicating that data visualization tools and retail analytics can build consumer relationships in online marketplaces and immersive digital environments as regards virtual stores. We contribute to the literature on digital commerce in the immersive metaverse environment by showing that computer vision algorithms and sentiment analytics can be decisive in changing customer habits and purchasing decisions by improving immersive virtual experiences. Throughout February 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "digital commerce," "cognitive analytics management," "real-time purchasing data," and "seamless connected shopping experiences." As we inspected research published between 2021 and 2022, only 89 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 20, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, ROBIS, and SRDR.

Keywords: digital commerce; immersive; metaverse; cognitive analytics; shopping

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1. Introduction

Predictive customer analytics and data visualization tools can enhance shopper engagement and digital retail experiences (Andronie et al., 2021; Lăzăroiu et al., 2017; Popescu, 2014; Valle, 2021) by determining purchase behavior and preferences across immersive virtual environments. The purpose of our systematic review is to examine the recently published literature on cognitive analytics management, real-time purchasing data, and seamless connected shopping experiences (Krizanova et al., 2019; Poliak et al., 2021; Taylor, 2021) and integrate the insights it configures on digital commerce in the immersive metaverse environment. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that data visualization tools can configure customer experience and engagement in immersive digital environments (Blake, 2022; Lăzăroiu et al., 2022; Popescu, 2017; Vinerean et al., 2022) by furthering data management processes. The actuality and novelty of this study are articulated by addressing customer satisfaction across 3D immersive environments, that is an emerging topic involving much interest. Our research problem is whether virtual connectivity optimizes immersive retail experiences across extended reality environments (Crișan-Mitra et al., 2020; Musova et al., 2021; Popescu, 2018; Zvarikova et al., 2022), leading to frictionless user experiences while attracting and retaining customers.

In this review, prior findings have been cumulated indicating that data visualization tools and retail analytics can build consumer relationships in online marketplaces and immersive digital environments (Cuțitoi, 2022; Nica, 2021; Popescu et al., 2017) as regards virtual stores. The identified gaps advance engaging 3D metaverse experiences. Our main objective is to indicate that retail analytics is instrumental in attracting and retaining customers (Friedman, 2021; Nica et al., 2021; Popescu et al., 2020) through personalized content, enhancing shopping experiences. This systematic review contributes to the literature on personalized shopping experiences in a decentralized blockchain-based metaverse by clarifying that computer vision algorithms and sentiment analytics can be decisive in changing customer habits and purchasing decisions (Kliestik et al., 2020; Pocol et al., 2022; Ruthrof, 2021) by improving immersive virtual experiences.

2. Theoretical Overview of the Main Concepts

Computer vision algorithms and virtual reality display systems can capture consumer data, optimizing engagement and behavior patterns and thus articulating seamless personalized experiences. Retail brands can configure convenient shopping experiences across virtual delivery networks by deploying real-time predictive analytics, visual screening technology, and artificial intelligence-driven e-commerce search to optimize user journeys. Consumer journey analytics can assist retail brands as regards changing customer habits across immersive interconnected virtual worlds during live shopping events. Data visualization and sentiment analytics can enhance immersive virtual shopping in relation to virtual assets while changing customer behavior. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), digital commerce in the metaverse (section 4), digital ownership in interconnected virtual worlds and across metaverse gathering spaces (section 5), consumer behaviors and buying patterns across interoperable decentralized metaverse platforms (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout February 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "digital commerce," "cognitive analytics management," "real-time purchasing data," and "seamless connected shopping experiences." The search terms were determined as being the most employed words or phrases across the analyzed literature. As we inspected research published between 2021 and 2022, only 89 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 20, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + digital commerce	26	6
metaverse + cognitive analytics management	21	4
metaverse + real-time purchasing data	22	5
metaverse + seamless connected shopping experiences	20	5
Type of paper		
Original research	67	20
Review	3	0
Conference proceedings	12	0
Book	3	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

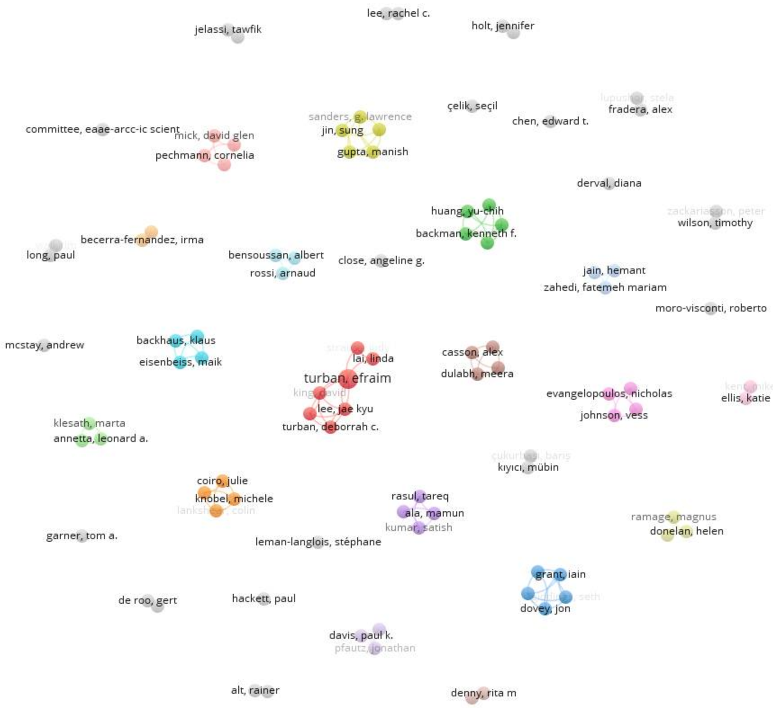
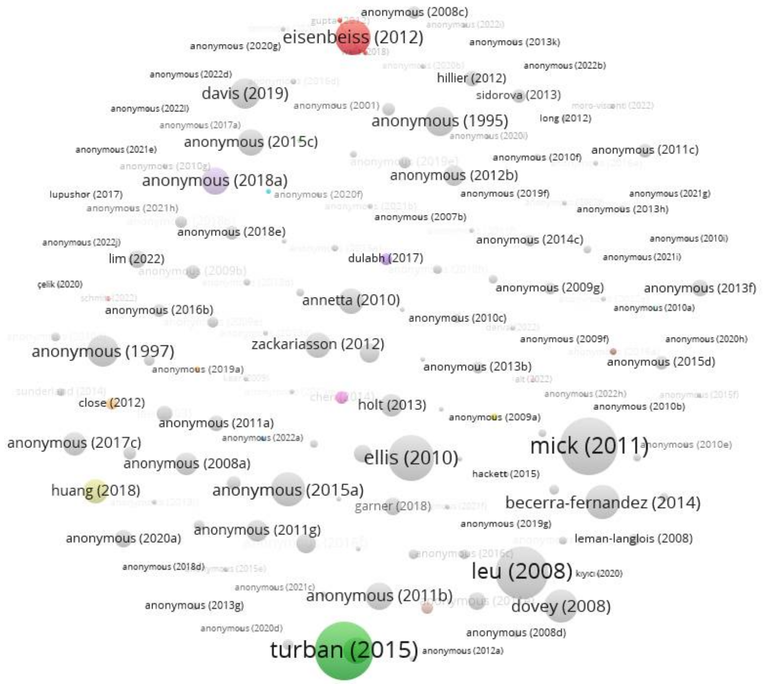


Figure 1 Co-authorship



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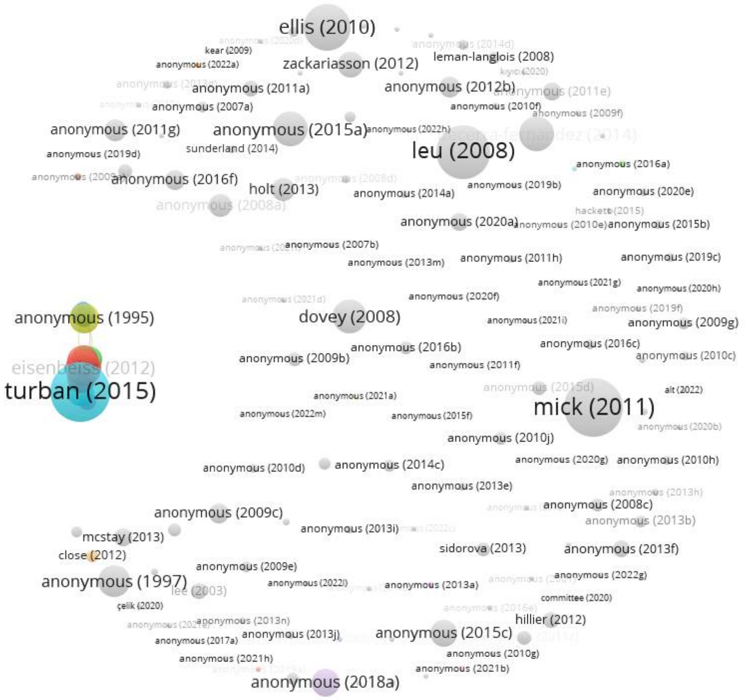

Figure 3 Bibliographic coupling

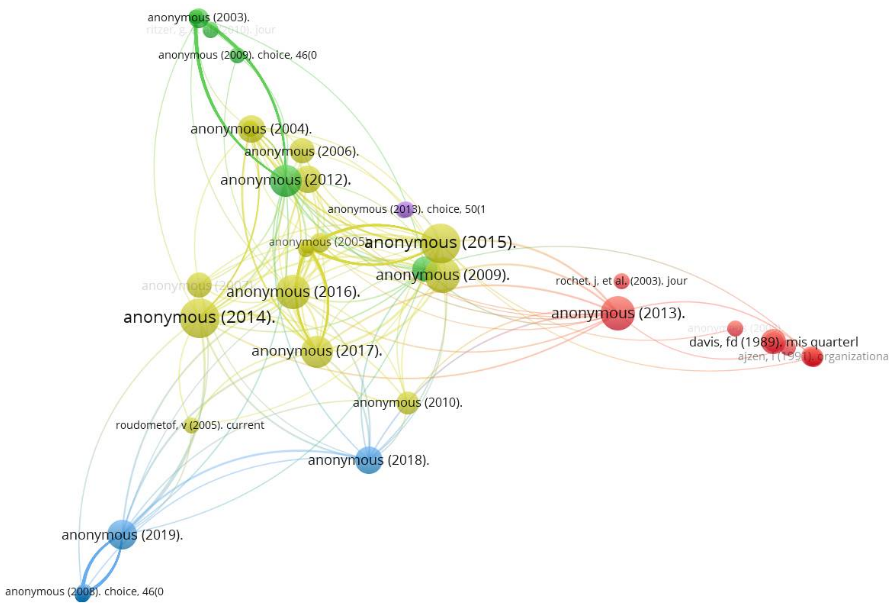

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Predictive algorithms can improve operational efficiency by leveraging real-time purchasing data, leading to customer retention and increased brand recognition, and thus configuring engaging 3D metaverse experiences.	Elawady et al., 2022; Park et al., 2022; Zyda, 2022
Determining retail customer behavior and data across virtual environments articulates digital commerce in the metaverse. Computer vision algorithms and sentiment analytics can be decisive in changing customer habits and purchasing decisions by improving immersive virtual experiences.	Beniiche et al., 2022; Kozinets, 2022; Xi et al., 2022
By leveraging location technology, spatial data, visual analytics, and conversational artificial intelligence, e-commerce platforms and applications, together with metaverse devices, can increase customer loyalty and conversions, and achieve operational performance growth.	Hwang and Chien, 2022; Laviola et al., 2022; Skalidis et al., 2022
Data-driven artificial intelligence and cognitive analytics management can influence consumer patterns in livestreaming e-commerce and autonomous retail throughout digital shopping journeys, typifying metaverse consumer engagement.	Beniiche et al., 2022; Gössling and Schweiggart, 2022; Kraus et al., 2022
Data-driven measurements can engage and retain consumers, leading to seamless connected shopping experiences as regards digital ownership in interconnected virtual worlds and across metaverse gathering spaces.	Gibbert et al., 2022; Hwang and Chien, 2022; Zyda, 2022
Predictive analytics, data visualizations, metaverse marketing strategies, and text mining techniques can improve customer satisfaction across 3D immersive environments.	Guo and Gao, 2022; Laviola et al., 2022; Park and Kim, 2022
Artificial intelligence-powered predictive analytics, natural language processing techniques, and holographic display devices are pivotal in expanding customer base and metaverse consumer engagement.	Kozinets, 2022; Lv et al., 2022; Siyaev and Jo, 2021
Live streaming platforms can determine retail customer behavior by harnessing user data across immersive virtual worlds, resulting in personalized shopping experiences in a decentralized blockchain-based metaverse.	Gursoy et al., 2022; Hwang and Chien, 2022; Lukava et al., 2022
Virtual delivery networks can harness spatial analytics to determine consumer behaviors and buying patterns across interoperable decentralized metaverse platforms.	Lin et al., 2022; Park et al., 2022; Turner, 2022

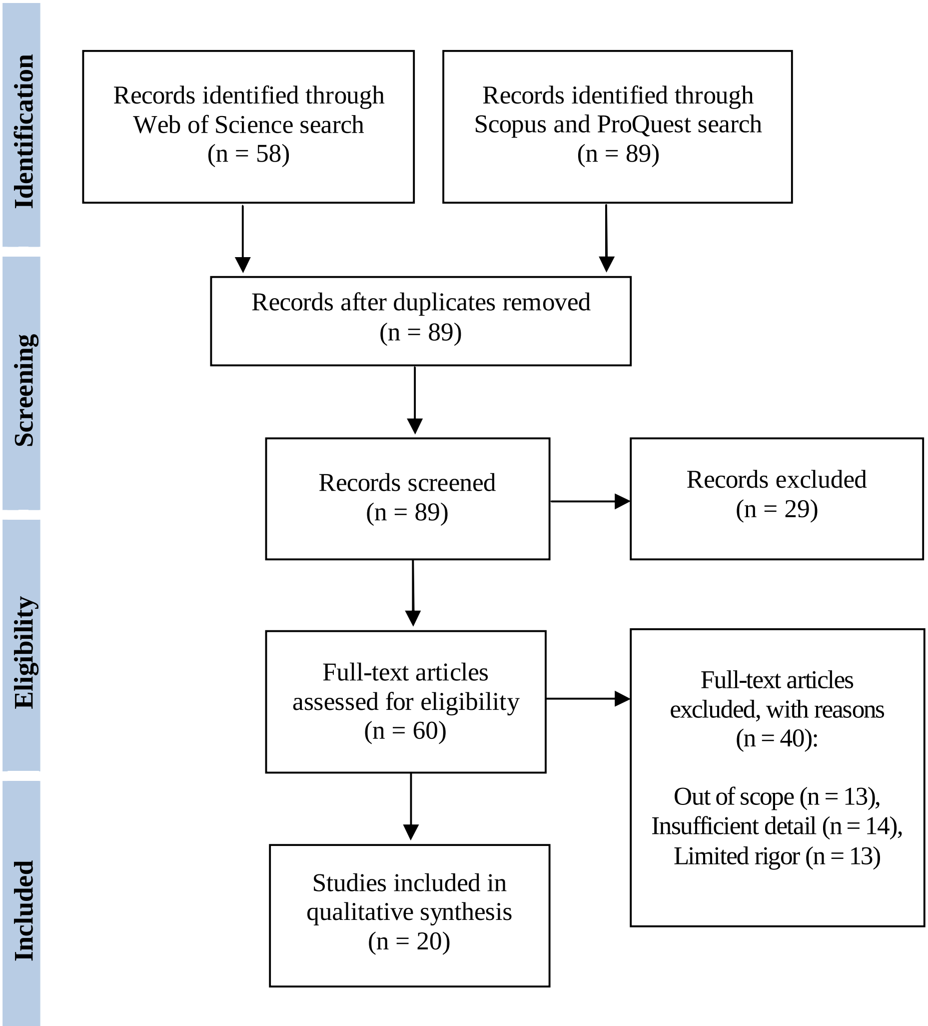

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2021–2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

Distiller SR screened and extracted the collected data.

AMSTAR evaluated the methodological quality of systematic reviews.

Dedoose analyzed qualitative and mixed methods research.

ROBIS assessed the risk of bias in systematic reviews.

AXIS evaluated the quality of cross-sectional studies.

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

Figure 6 Screening and quality assessment tools

4. Digital Commerce in the Metaverse

Predictive algorithms can improve operational efficiency by leveraging real-time purchasing data, leading to customer retention and increased brand recognition (Elawady et al., 2022; Park et al., 2022; Zyda, 2022), and thus configuring engaging 3D metaverse experiences. Immersive technologies, visualization tools, and natural language processing technologies can assist experiential retail in virtual marketplaces while improving business competitiveness and digitally-enhanced personalized experiences by developing operational processes. Virtual connectivity optimizes immersive retail experiences across extended reality environments, leading to frictionless user experiences while attracting and retaining customers.

Determining retail customer behavior and data across virtual environments (Beniiche et al., 2022; Kozinets, 2022; Xi et al., 2022) articulates digital commerce in the metaverse. Computer vision algorithms and retail analytics can optimize consumer behavior and shopping habits through data-driven decisions while providing real-time personalized offers. Computer vision algorithms and sentiment analytics can be decisive in changing customer habits and purchasing decisions by improving immersive virtual experiences.

By leveraging location technology, spatial data, visual analytics, and conversational artificial intelligence, e-commerce platforms and applications, together with metaverse devices (Hwang and Chien, 2022; Laviola et al., 2022; Skalidis et al., 2022), can increase customer loyalty and conversions, and achieve operational performance growth. Computer vision algorithms and virtual reality display systems can capture consumer data, optimizing engagement and behavior patterns and thus articulating seamless personalized experiences. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Predictive algorithms can improve operational efficiency by leveraging real-time purchasing data, leading to customer retention and increased brand recognition, and thus configuring engaging 3D metaverse experiences.	Elawady et al., 2022; Park et al., 2022; Zyda, 2022
Determining retail customer behavior and data across virtual environments articulates digital commerce in the metaverse.	Beniiche et al., 2022; Kozinets, 2022; Xi et al., 2022
By leveraging location technology, spatial data, visual analytics, and conversational artificial intelligence, e-commerce platforms and applications, together with metaverse devices, can increase customer loyalty and conversions, and achieve operational performance growth.	Hwang and Chien, 2022; Laviola et al., 2022; Skalidis et al., 2022

5. Digital Ownership in Interconnected Virtual Worlds and across Metaverse Gathering Spaces

Data-driven artificial intelligence and cognitive analytics management can influence consumer patterns in livestreaming e-commerce and autonomous retail throughout digital shopping journeys (Beniiche et al., 2022; Gössling and Schweiggart, 2022; Kraus et al., 2022), typifying metaverse consumer engagement. Retail analytics is instrumental in attracting and retaining customers through personalized content, enhancing shopping experiences. By integrating augmented and virtual reality technologies, data visualizations and self-service analytics can shift customer behaviors by providing personalized product recommendations in digital marketplace.

Data-driven measurements can engage and retain consumers, leading to seamless connected shopping experiences as regards digital ownership in interconnected virtual worlds (Gibbert et al., 2022; Hwang and Chien, 2022; Zyda, 2022) and across metaverse gathering spaces. Sensor data, image-based classification, and customer purchasing history can improve personalized shopping experiences and result in long-term engaged customers while improving service performance. Consumer journey analytics can assist retail brands as regards changing customer habits across immersive interconnected virtual worlds during live shopping events.

Predictive analytics, data visualizations, metaverse marketing strategies, and text mining techniques (Guo and Gao, 2022; Laviola et al., 2022; Park and Kim, 2022) can improve customer satisfaction across 3D immersive environments. Artificial intelligence-powered virtual agents, spatial computing technology, and search engine algorithms can be decisive in engaging interactive events on livestreaming shopping platforms by optimizing consumer digital engagement. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Data-driven artificial intelligence and cognitive analytics management can influence consumer patterns in livestreaming e-commerce and autonomous retail throughout digital shopping journeys, typifying metaverse consumer engagement.	Beniiche et al., 2022; Gössling and Schweiggart, 2022; Kraus et al., 2022
Data-driven measurements can engage and retain consumers, leading to seamless connected shopping experiences as regards digital ownership in interconnected virtual worlds and across metaverse gathering spaces.	Gibbert et al., 2022; Hwang and Chien, 2022; Zyda, 2022
Predictive analytics, data visualizations, metaverse marketing strategies, and text mining techniques can improve customer satisfaction across 3D immersive environments.	Guo and Gao, 2022; Laviola et al., 2022; Park and Kim, 2022

6. Consumer Behaviors and Buying Patterns across Interoperable Decentralized Metaverse Platforms

Artificial intelligence-powered predictive analytics, natural language processing techniques, and holographic display devices (Kozinets, 2022; Lv et al., 2022; Siyaev and Jo, 2021) are pivotal in expanding customer base and metaverse consumer engagement. Digital shopping across immersive 3D worlds can integrate visual capabilities, text analytics, and swarm intelligence algorithms, enhancing consumer journeys and determining purchase intentions. Predictive customer analytics and data visualization tools can enhance shopper engagement and digital retail experiences by determining purchase behavior and preferences across immersive virtual environments.

Live streaming platforms can determine retail customer behavior by harnessing user data across immersive virtual worlds (Gursoy et al., 2022; Hwang and Chien, 2022; Lukava et al., 2022), resulting in personalized shopping experiences in a decentralized blockchain-based metaverse. Retail brands can configure convenient shopping experiences across virtual delivery networks by deploying real-time predictive analytics, visual screening technology, and artificial intelligence-driven e-commerce search to optimize user journeys. Data visualization tools can configure customer experience and engagement in immersive digital environments by furthering data management processes.

Virtual delivery networks can harness spatial analytics to determine consumer behaviors and buying patterns (Lin et al., 2022; Park et al., 2022; Turner, 2022) across interoperable decentralized metaverse platforms. Data visualization tools and retail analytics can build consumer relationships in online marketplaces and immersive digital environments as regards virtual stores. Data visualization and sentiment analytics can enhance immersive virtual shopping in relation to virtual assets while changing customer behavior. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Artificial intelligence-powered predictive analytics, natural language processing techniques, and holographic display devices are pivotal in expanding customer base and metaverse consumer engagement.	Kozinets, 2022; Lv et al., 2022; Siyaev and Jo, 2021
Live streaming platforms can determine retail customer behavior by harnessing user data across immersive virtual worlds, resulting in personalized shopping experiences in a decentralized blockchain-based metaverse.	Gursoy et al., 2022; Hwang and Chien, 2022; Lukava et al., 2022
Virtual delivery networks can harness spatial analytics to determine consumer behaviors and buying patterns across interoperable decentralized metaverse platforms.	Lin et al., 2022; Park et al., 2022; Turner, 2022

7. Discussion

We integrate our systematic review throughout research indicating how immersive technologies, visualization tools, and natural language processing technologies can assist experiential retail in virtual marketplaces while improving business competitiveness and digitally-enhanced personalized experiences by developing operational processes. Our research complements recent analyses clarifying how artificial intelligence-powered virtual agents, spatial computing technology, and search engine algorithms can be decisive in engaging interactive events on livestreaming shopping platforms by optimizing consumer digital engagement. We elucidate, by cumulative evidence, previous research demonstrating how computer vision algorithms and sentiment analytics can be decisive in changing customer habits and purchasing decisions by improving immersive virtual experiences.

8. Synopsis of the Main Research Outcomes

By integrating augmented and virtual reality technologies, data visualizations and self-service analytics can shift customer behaviors by providing personalized product recommendations in digital marketplace. Data visualization and sentiment analytics can enhance immersive virtual shopping in relation to virtual assets while changing customer behavior.

9. Conclusions

Relevant research has investigated whether digital shopping across immersive 3D worlds can integrate visual capabilities, text analytics, and swarm intelligence algorithms, enhancing consumer journeys and determining purchase intentions. This systematic literature review presents the published peer-reviewed sources covering how sensor data, image-based classification, and customer purchasing history can improve personalized shopping experiences and result in long-term engaged customers while improving service performance. The research outcomes drawn from the above analyses indicate that computer vision algorithms and retail analytics can optimize consumer behavior and shopping habits through data-driven decisions while providing real-time personalized offers.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on digital commerce in the immersive metaverse environment in terms of cognitive analytics management, real-time purchasing data, and seamless connected shopping experiences may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of metaverse consumer engagement.

Subsequent analyses should develop on interoperable decentralized metaverse platforms. Future research should thus investigate retail customer behavior and data across virtual environments. In the future, attention should be directed to how livestreaming e-commerce and autonomous retail throughout digital shopping journeys.

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Compliance with ethical standards
This article does not contain any studies with human participants or animals performed by the authors.

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Author contributions
All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement
The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record
The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement
The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Live Shopping in the Metaverse: Visual and Spatial Analytics, Cognitive Artificial Intelligence Techniques and Algorithms, and Immersive Digital Simulations

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ABSTRACT. The purpose of this study is to examine live shopping in the metaverse in terms of visual and spatial analytics, cognitive artificial intelligence techniques and algorithms, and immersive digital simulations. In this article, we cumulate previous research findings indicating that retail analytics can build brand awareness and improve operational performance across shared virtual environments by customizing user experiences. We contribute to the literature on retail business models in the metaverse environment by showing that cognitive artificial intelligence techniques and algorithms can be pivotal in virtual commerce by enhancing digital shopping experience through location data. Throughout March 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "live shopping," "visual analytics," "spatial analytics," "cognitive artificial intelligence techniques and algorithms," and "immersive digital simulations." As we inspected research published between 2021 and 2022, only 89 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 20, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, MMAT, and SRDR.

Keywords: shopping; metaverse; visual; spatial; analytics; immersive

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1. Introduction

Interactive technologies and cognitive computing systems can optimize changing consumer demands (Andronie et al., 2021a, b, c; Glogovețan et al., 2022; Nica, 2018) through location analytics in virtual retail stores. The purpose of our systematic review is to examine the recently published literature on live shopping in the metaverse and integrate the insights it configures on visual and spatial analytics, cognitive artificial intelligence techniques and algorithms, and immersive digital simulations. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that consumer brand companies can deploy real-time datasets across synthetic environments to enhance personalized digital shopping experiences. The actuality and novelty of this study are articulated by addressing real-time offer personalization in the metaverse environment, that is an emerging topic involving much interest. Our research problem is whether context-driven analytics and cognitive artificial intelligence techniques can integrate data sharing and fabrics (Bennett, 2021; Kral et al., 2020; Nica et al., 2022), thus shifting consumer trends and purchasing behaviors.

In this review, prior findings have been cumulated indicating that retail analytics can build brand awareness and improve operational performance (Dușmănescu et al., 2016; Mihăilă et al., 2016; Obadă and Dabija, 2022) across shared virtual environments by customizing user experiences. The identified gaps advance retail business models in the metaverse environment. Our main objective is to indicate that computer vision algorithms, biometric payment tools and authentication features, and immersive digital simulations can assist data management processes (Gasparin and Schinckus, 2022; Nica, 2017; Popescu, 2018; Rowland et al., 2021) in consumer retention across online and virtual marketplaces. This systematic review contributes to the literature on digital engagement in the metaverse economy by clarifying that Cognitive artificial intelligence techniques and algorithms (Popescu et al., 2018; Stone et al., 2022; Vătămănescu et al., 2020) can be pivotal in virtual commerce by enhancing digital shopping experience (Friedman et al., 2022; Mircică, 2022; Popescu, 2017; Rogers and Zvarikova, 2021) through location data.

2. Theoretical Overview of the Main Concepts

Digital business platforms can harness sentiment analysis data, visual product images, voice and gesture recognition, geospatial mapping, and location intelligence to assess consumer insights and feedback and bring about immersive 3D experiences. Retail livestreaming can build augmented reality experiences by integrating accurate product data to increase customer satisfaction while assessing consumer engagement metrics and purchasing habits. Computer vision algorithms can harness contextual consumer data to deepen customer engagement and optimize virtual retail experiences. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), retail business models in the metaverse environment (section 4), data-driven decisions articulated by innovative brands in the metaverse (section 5), advanced data analytics and metaverse operations management (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout March 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "live shopping," "visual analytics," "spatial analytics," "cognitive artificial intelligence techniques and algorithms," and "immersive digital simulations." The search terms were determined as being the most employed words or phrases across the analyzed literature. As we inspected research published between 2021 and 2022, only 89 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 20, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, MMAT, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + live shopping	19	4
metaverse + visual analytics	19	4
metaverse + spatial analytics	18	4
metaverse + cognitive artificial intelligence techniques and algorithms	18	4
metaverse + immersive digital simulations	15	4
Type of paper		
Original research	65	20
Review	3	0
Conference proceedings	14	0
Book	3	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

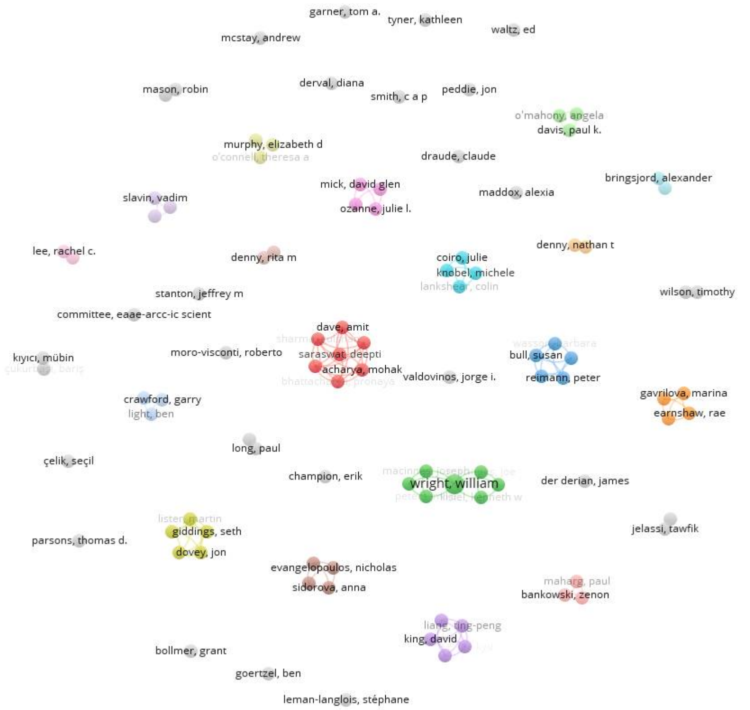

Figure 1 Co-authorship

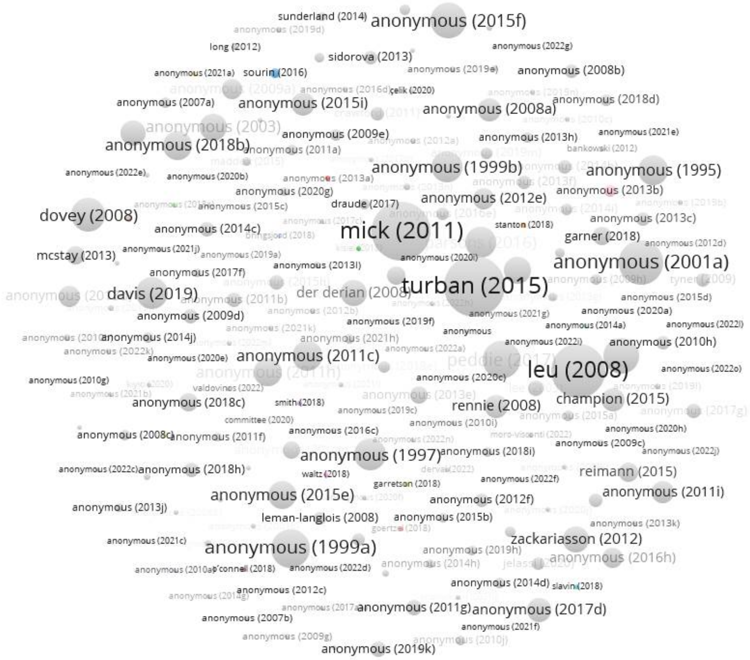

Figure 2 Citation

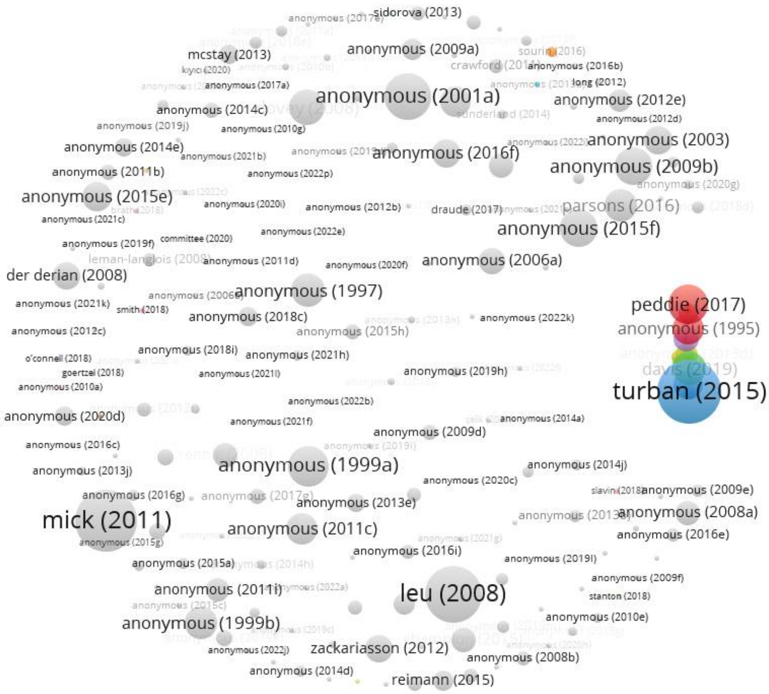

Figure 3 Bibliographic coupling

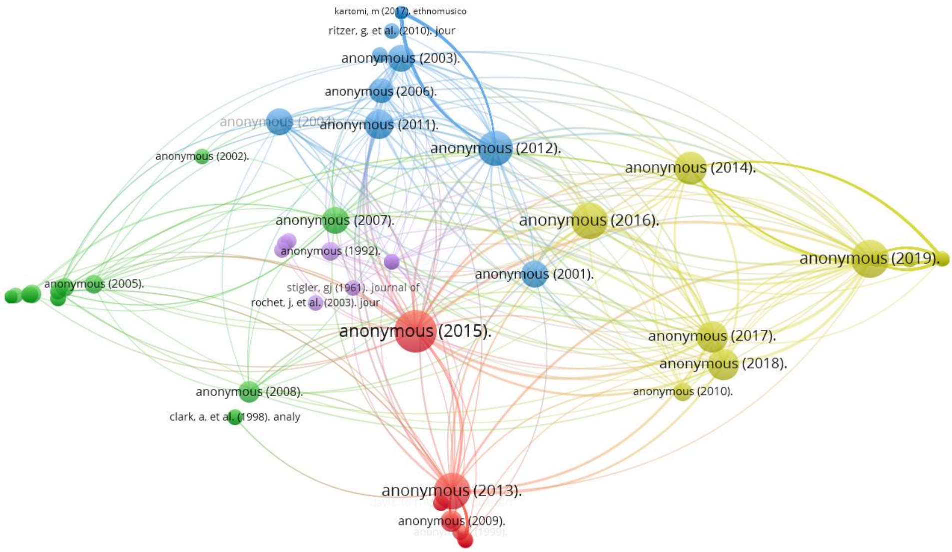

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Text mining and sentiment analysis tools can evaluate user-generated content (e.g., customer opinions and attitudes), determining emotional tone and verbal behavior in the metaverse environment.	Beniiche et al., 2022; Kozinets, 2022; Lukava et al., 2022
Deep learning algorithms and data visualizations can assist connected monitoring devices in optimizing customer value proposition by leveraging consumer data across retail business models in the metaverse environment.	Kshetri, 2022; Lv et al., 2022; Yeh et al., 2022
Virtual stores can engage consumers and configure immersive retail experiences by deploying real-time customer data analytics, voice recognition software, virtual navigation tools, and simulation modeling, thus improving digital engagement in the metaverse economy.	Dozio et al., 2022; Gills and Hosseini, 2022; Zhang et al., 2022
Smart immersive technologies can optimize customer engagement and brand loyalty by leveraging analytical tools to configure real-time offer personalization in the metaverse environment.	Almarzouqi et al. 2022; Han et al., 2022; Jang et al., 2022
Robust reporting tools can mine customer data to assess shopping habits, digital customer engagement, and community reaction and participation across user journey throughout the 5G-enabled virtual reality in the metaverse economy.	Dozio et al., 2022; Lukava et al., 2022; Yeh et al., 2022
Retail customer data, behaviors, and journeys, together with shopping habits, can be configured by data-driven decisions articulated by innovative brands in the metaverse.	Elawady et al., 2022; Siyaev and Jo, 2021; Zyda, 2022
Immersive visualization systems can improve brand recognition across a decentralized infrastructure by leveraging customer data in a virtual mall environment during live shopping in the metaverse.	Gursoy et al., 2022; Reis and Ashmore, 2022; Zhao et al., 2022
Advanced data analytics and metaverse operations management can be pivotal in optimizing engagement behaviors, personalized product recommendations, and customization options during livestream shopping events across extended reality environments.	Almarzouqi et al. 2022; Han et al., 2022; Yeh et al., 2022
Visual and spatial analytics can enhance customer service and convenience in digital shopping and across immersive 3D worlds during purchase journeys in the metaverse environment. Cognitive artificial intelligence techniques and algorithms can be pivotal in virtual commerce by enhancing digital shopping experience through location data.	Hollensen et al., 2022; Park and Kim, 2022; Zyda, 2022

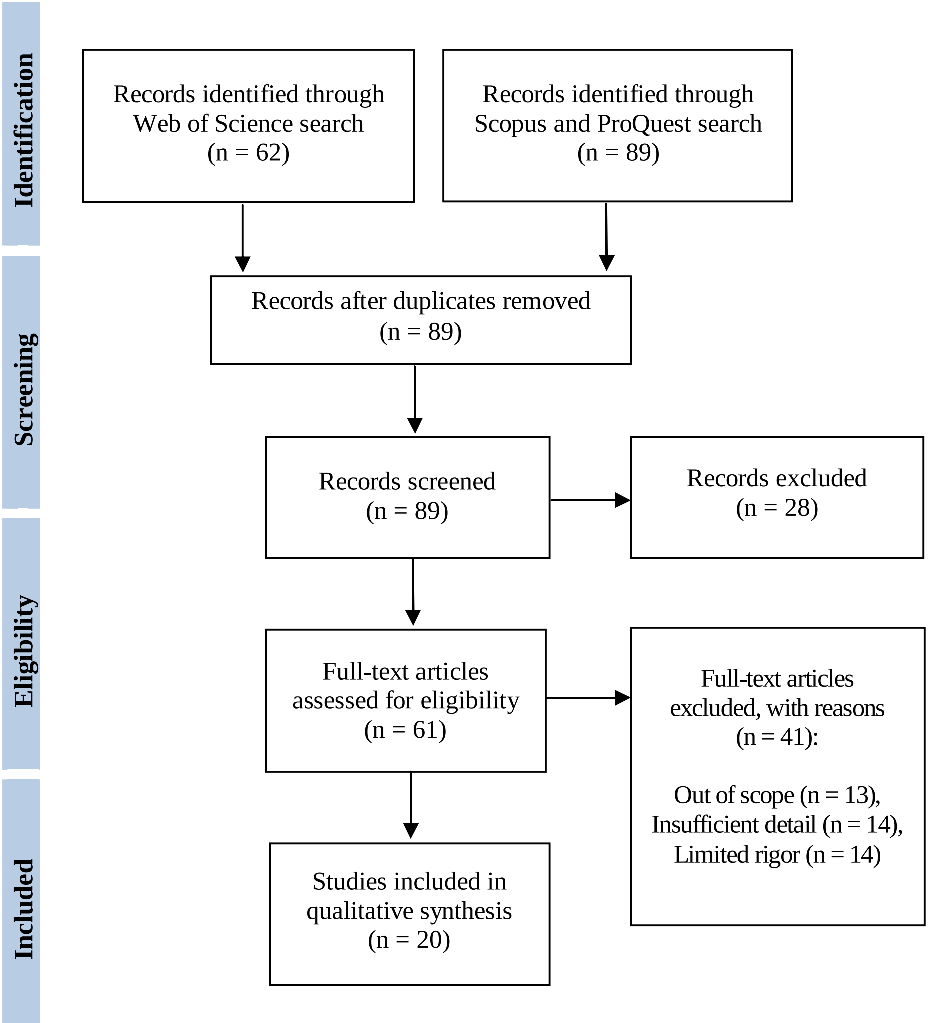

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

⬇

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

⬇

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2021–2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

⬇

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

⬇

Distiller SR screened and extracted the collected data.

⬇

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

⬇

ROBIS assessed the risk of bias in systematic reviews.

⬇

Dedoose analyzed qualitative and mixed methods research.

⬇

AXIS evaluated the quality of cross-sectional studies.

⬇

AMSTAR evaluated the methodological quality of systematic reviews.

Figure 6 Screening and quality assessment tools

4. Retail Business Models in the Metaverse Environment

Text mining and sentiment analysis tools (Beniiche et al., 2022; Kozinets, 2022; Lukava et al., 2022) can evaluate user-generated content (e.g., customer opinions and attitudes), determining emotional tone and verbal behavior in the metaverse environment. Deep neural networks and natural language processing algorithms can increase consumer engagement and build brand loyalty, resulting in seamless shopping experiences and data-driven personalization in livestreaming e-commerce. Computer vision algorithms can harness contextual consumer data to deepen customer engagement and optimize virtual retail experiences.

Deep learning algorithms and data visualizations can assist connected monitoring devices in optimizing customer value proposition (Kshetri, 2022; Lv et al., 2022; Yeh et al., 2022) by leveraging consumer data across retail business models in the metaverse environment. Retail media intelligence platforms can deploy behavioral analytics while managing business capabilities to expand customer base and increase brand recognition in experiential shopping. Livestreaming e-commerce can drive consumer behavior throughout immersive shopping experiences, thus meeting digital behavior expectations by leveraging consumption data.

Virtual stores can engage consumers and configure immersive retail experiences by deploying real-time customer data analytics, voice recognition software, virtual navigation tools, and simulation modeling (Dozio et al., 2022; Gills and Hosseini, 2022; Zhang et al., 2022), thus improving digital engagement in the metaverse economy. Predictive analytics and data visualizations can lead to long-term value creation in virtual environments through immersive engagement and personalized customer experiences. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Text mining and sentiment analysis tools can evaluate user-generated content (e.g., customer opinions and attitudes), determining emotional tone and verbal behavior in the metaverse environment.	Beniiche et al., 2022; Kozinets, 2022; Lukava et al., 2022
Deep learning algorithms and data visualizations can assist connected monitoring devices in optimizing customer value proposition by leveraging consumer data across retail business models in the metaverse environment.	Kshetri, 2022; Lv et al., 2022; Yeh et al., 2022
Virtual stores can engage consumers and configure immersive retail experiences by deploying real-time customer data analytics, voice recognition software, virtual navigation tools, and simulation modeling, thus improving digital engagement in the metaverse economy.	Dozio et al., 2022; Gills and Hosseini, 2022; Zhang et al., 2022

5. Data-driven Decisions Articulated by Innovative Brands in the Metaverse

Smart immersive technologies can optimize customer engagement and brand loyalty by leveraging analytical tools (Almarzouqi et al. 2022; Han et al., 2022; Jang et al., 2022) to configure real-time offer personalization in the metaverse environment. Data-driven artificial intelligence technologies can optimize consumer values by use of synthetic data tools as regards consumer browsing shifts, driving business outcomes and articulating seamless immersive experiences across interconnected digital spaces. Digital business platforms can harness sentiment analysis data, visual product images, voice and gesture recognition, geospatial mapping, and location intelligence to assess consumer insights and feedback and bring about immersive 3D experiences.

Robust reporting tools can mine customer data to assess shopping habits, digital customer engagement, and community reaction and participation across user journey (Dozio et al., 2022; Lukava et al., 2022; Yeh et al., 2022) throughout the 5G-enabled virtual reality in the metaverse economy. Consumer brand companies can deploy real-time datasets across synthetic environments to enhance personalized digital shopping experiences. Social commerce tools and extended reality technologies can deploy synthetic datasets to assess consumer behavior in the blockchain-based virtual economy, by integrating automated data logging, movement and behavior tracking, and voice biometric verification as regards dynamic personalized offers.

Retail customer data, behaviors, and journeys, together with shopping habits, can be configured by data-driven decisions (Elawady et al., 2022; Siyaev and Jo, 2021; Zyda, 2022) articulated by innovative brands in the metaverse. Interactive technologies and cognitive computing systems can optimize changing consumer demands through location analytics in virtual retail stores. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Smart immersive technologies can optimize customer engagement and brand loyalty by leveraging analytical tools to configure real-time offer personalization in the metaverse environment.	Almarzouqi et al. 2022; Han et al., 2022; Jang et al., 2022
Robust reporting tools can mine customer data to assess shopping habits, digital customer engagement, and community reaction and participation across user journey throughout the 5G-enabled virtual reality in the metaverse economy.	Dozio et al., 2022; Lukava et al., 2022; Yeh et al., 2022
Retail customer data, behaviors, and journeys, together with shopping habits, can be configured by data-driven decisions articulated by innovative brands in the metaverse.	Elawady et al., 2022; Siyaev and Jo, 2021; Zyda, 2022

6. Advanced Data Analytics and Metaverse Operations Management

Immersive visualization systems can improve brand recognition across a decentralized infrastructure (Gursoy et al., 2022; Reis and Ashmore, 2022; Zhao et al., 2022) by leveraging customer data in a virtual mall environment during live shopping in the metaverse. Immersive virtual environments can enhance customer experiences during digital shopping sessions. Context-driven analytics and cognitive artificial intelligence techniques can integrate data sharing and fabrics, thus shifting consumer trends and purchasing behaviors.

Advanced data analytics and metaverse operations management can be pivotal in optimizing engagement behaviors, personalized product recommendations, and customization options (Almarzouqi et al. 2022; Han et al., 2022; Yeh et al., 2022) during livestream shopping events across extended reality environments. Computer vision algorithms, biometric payment tools and authentication features, and immersive digital simulations can assist data management processes in consumer retention across online and virtual marketplaces. Retail analytics can build brand awareness and improve operational performance across shared virtual environments by customizing user experiences.

Visual and spatial analytics can enhance customer service and convenience in digital shopping and across immersive 3D worlds (Hollensen et al., 2022; Park and Kim, 2022; Zyda, 2022) during purchase journeys in the metaverse environment. Retail livestreaming can build augmented reality experiences by integrating accurate product data to increase customer satisfaction while assessing consumer engagement metrics and purchasing habits. Cognitive artificial intelligence techniques and algorithms can be pivotal in virtual commerce by enhancing digital shopping experience through location data. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Immersive visualization systems can improve brand recognition across a decentralized infrastructure by leveraging customer data in a virtual mall environment during live shopping in the metaverse.	Gursoy et al., 2022; Reis and Ashmore, 2022; Zhao et al., 2022
Advanced data analytics and metaverse operations management can be pivotal in optimizing engagement behaviors, personalized product recommendations, and customization options during livestream shopping events across extended reality environments.	Almarzouqi et al. 2022; Han et al., 2022; Yeh et al., 2022
Visual and spatial analytics can enhance customer service and convenience in digital shopping and across immersive 3D worlds during purchase journeys in the metaverse environment.	Hollensen et al., 2022; Park and Kim, 2022; Zyda, 2022

7. Discussion

We integrate our systematic review throughout research indicating how retail media intelligence platforms can deploy behavioral analytics while managing business capabilities to expand customer base and increase brand recognition in experiential shopping. Our research complements recent analyses clarifying how deep neural networks and natural language processing algorithms can increase consumer engagement and build brand loyalty, resulting in seamless shopping experiences and data-driven personalization in livestreaming e-commerce. We elucidate, by cumulative evidence, previous research demonstrating how social commerce tools and extended reality technologies can deploy synthetic datasets to assess consumer behavior in the blockchain-based virtual economy, by integrating automated data logging, movement and behavior tracking, and voice biometric verification as regards dynamic personalized offers.

8. Synopsis of the Main Research Outcomes

Predictive analytics and data visualizations can lead to long-term value creation in virtual environments through immersive engagement and personalized customer experiences. Consumer brand companies can deploy real-time datasets across synthetic environments to enhance personalized digital shopping experiences.

9. Conclusions

Relevant research has investigated whether data-driven artificial intelligence technologies can optimize consumer values by use of synthetic data tools as regards consumer browsing shifts, driving business outcomes and articulating seamless immersive experiences across interconnected digital spaces. This systematic literature review presents the published peer-reviewed sources covering Immersive virtual environments can enhance customer experiences during digital shopping sessions. The research outcomes drawn from the above analyses indicate that livestreaming e-commerce can drive consumer behavior throughout immersive shopping experiences, thus meeting digital behavior expectations by leveraging consumption data.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on live shopping in the metaverse may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of the 5G-enabled virtual reality in the metaverse economy.

Subsequent analyses should develop on innovative brands in the metaverse. Future research should thus investigate livestream shopping events across extended reality environments. In the future, attention should be directed to customer service and convenience in digital shopping and across immersive 3D worlds.

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This article does not contain any studies with human participants or animals performed by the authors.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

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Transparency statement

The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Virtual Commerce in a Decentralized Blockchain-based Metaverse: Immersive Technologies, Computer Vision Algorithms, and Retail Business Analytics

Emily Hopkins*

ABSTRACT. I draw on a substantial body of theoretical and empirical research on virtual commerce in a decentralized blockchain-based metaverse. With increasing evidence of immersive technologies, computer vision algorithms, and retail business analytics, there is an essential demand for comprehending whether voice biometrics technology, search engine algorithms, sensor data, and decision support tools can shape customer behavior and deliver business value across immersive 3D worlds. In this research, prior findings were cumulated indicating that immersive technologies can enhance operational performance across virtual stores by assessing purchasing decisions, customer confidence, engagement, and habits through data visualization in retail business and operations. I carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout February 2022, with search terms including "metaverse" + "virtual commerce," "immersive technologies," "computer vision algorithms," and "retail business analytics." As I analyzed research published in 2022, only 81 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, I decided on 16, chiefly empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, ROBIS, and SRDR.

Keywords: virtual; metaverse; immersive; computer vision; retail; algorithm

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1. Introduction

Computer vision algorithms, customer engagement tools, and data mining techniques (Barbu et al., 2021; Lăzăroiu et al., 2020a, b; Popescu et al., 2017a, b) can attract and retain customers during digital shopper journeys in the virtual retail market. The purpose of my systematic review is to examine the recently published literature on virtual commerce in a decentralized blockchain-based metaverse and integrate the insights it configures on immersive technologies, computer vision algorithms, and retail business analytics. By analyzing the most recent (2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that automated speech recognition, real-time sensor data, and computer vision algorithms (Crișan-Mitra et al., 2020; Lăzăroiu et al., 2022; Popescu, 2017) can optimize connected shopping experiences in virtual economy. The actuality and novelty of this study are articulated by addressing interoperable decentralized metaverse platforms, that is an emerging topic involving much interest. My research problem is whether voice biometrics technology, search engine algorithms, sensor data, and decision support tools can shape customer behavior and deliver business value (Hudson, 2022; Nica, 2015; Popescu, 2018) across immersive 3D worlds.

In this review, prior findings have been cumulated indicating that consumer intelligence, data-driven decisions, and computer vision algorithms can drive customer engagement (Konecny et al., 2021; Nica et al., 2021; Popescu et al., 2021) as regards digital brand assets in experiential shopping. The identified gaps advance artificial neural networks and metaverse-related technologies. My main objective is to indicate that data visualization tools can articulate customer interaction experiences by data storage and processing (Kovacova et al., 2022; Peters, 2022a, b; Popescu et al., 2020), predicting user behaviors across immersive digital environments. This systematic review contributes to the literature on behavioral patterns across blockchain-based virtual worlds by clarifying that immersive technologies can enhance operational performance across virtual stores (Lăzăroiu et al., 2017; Poliak et al., 2021; Popescu et al., 2022) by assessing purchasing decisions, customer confidence, engagement, and habits (Lăzăroiu, 2018; Pop et al., 2022; Valle, 2021) through data visualization in retail business and operations.

2. Theoretical Overview of the Main Concepts

Conversational artificial intelligence can assess immersive virtual experiences during retail livestreaming by leveraging augmented reality shopping tools. Machine vision algorithms, natural language processing tools, and speech analytics can determine purchase intent and behavior by integrating rich customer data during retail transactions. Retail brands can leverage sentiment analytics, location-based decisions, and 3D environment immersions to determine consumer behavior and engagement as regards virtual assets. Artificial intelligence customer service chatbots can harness advanced analytics and decision-making tools to enhance customer satisfaction in virtual commerce. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), enhancing shopping experiences across virtual marketplaces and interoperable decentralized metaverse platforms (section 4), shaping consumption behavior across interoperable decentralized metaverse platforms (section 5), deploying data-driven decisions throughout customer journeys in a decentralized blockchain-based metaverse (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

I carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout February 2022, with search terms including "metaverse" + "virtual commerce," "immersive technologies," "computer vision algorithms," and "retail business analytics." As I analyzed research published in 2022, only 81 papers met the eligibility criteria. The search terms were determined as being the most employed words or phrases across the analyzed literature. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, I decided on 16, chiefly empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + virtual commerce	22	4
metaverse + immersive technologies	21	4
metaverse + computer vision algorithms	19	4
metaverse + retail business analytics	19	4
Type of paper		
Original research	60	15
Review	3	1
Conference proceedings	12	0
Book	3	0
Editorial	3	0

Source: Processed by the author. Some topics overlap.

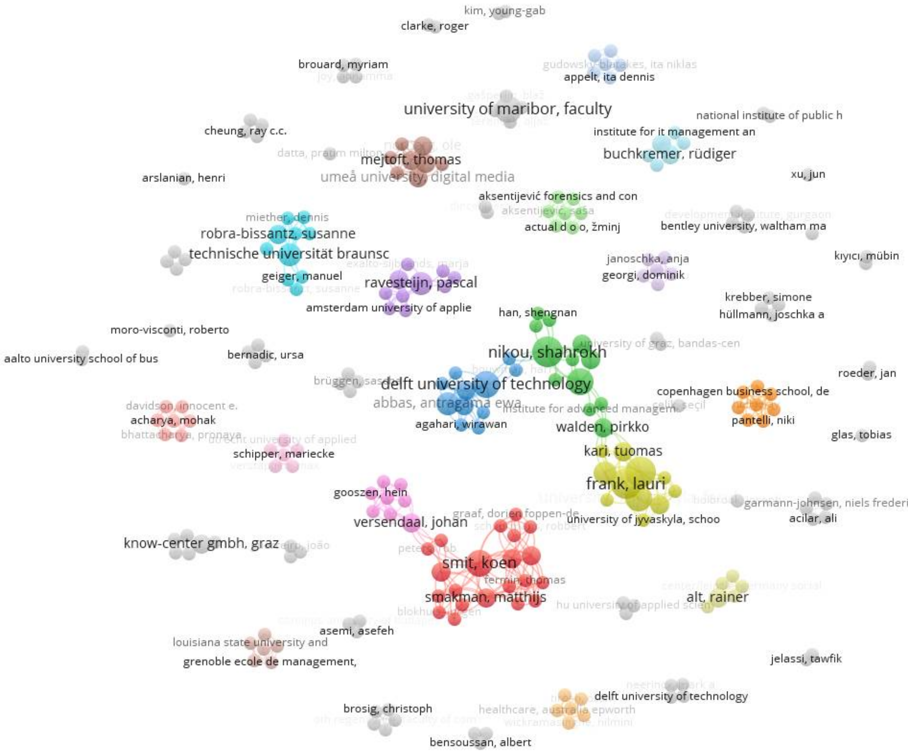

Figure 1 Co-authorship

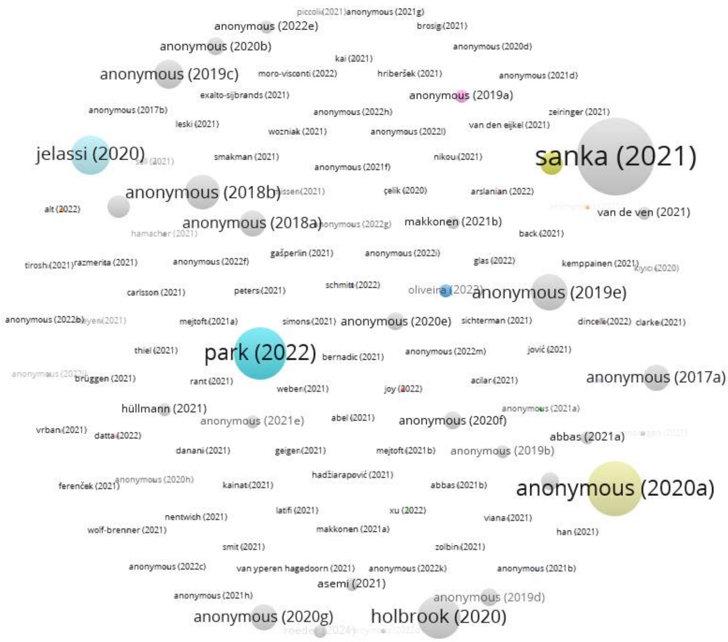

Figure 2 Citation

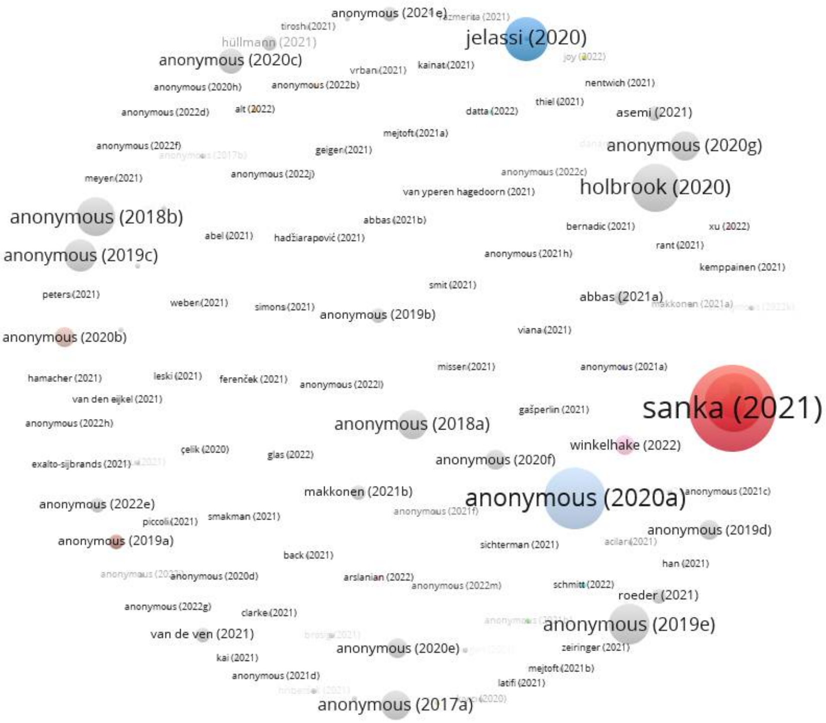

Figure 3 Bibliographic coupling

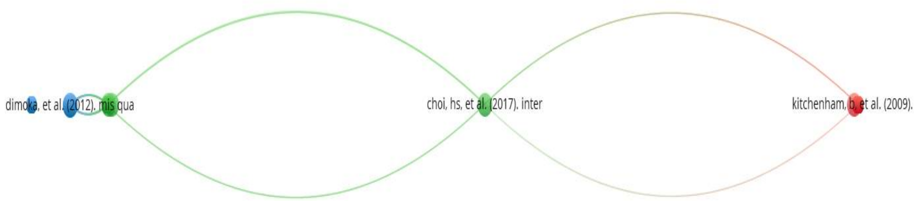

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Artificial neural networks and metaverse-related technologies can optimize customer engagement and retention by use of e-commerce tools, streamlining retail operations and optimizing product customization services.	Laviola et al., 2022; Skalidis et al., 2022; Xi et al., 2022
Digital marketing tools can leverage consumer retail data during purchase journeys, enhancing shopping experiences across virtual marketplaces and interoperable decentralized metaverse platforms.	Gibbert et al., 2022; Kraus et al., 2022; Zyda, 2022
Technology-powered live shopping and metaverse marketing strategies can optimize immersive retail experiences through customer monitoring systems across virtual worlds and extended reality environments.	Akyildiz et al., 2022; Gills and Hosseini, 2022; Gössling and Schweiggart, 2022
Customer personalization tools and metaverse marketing strategies can drive brand awareness during immersive virtual reality experiences by deploying synthetic data to determine historical purchasing trends.	Lukava et al., 2022; Turner, 2022; Xi et al., 2022
Smart retailing can harness data visualizations, consumer analytics, and spatial computing technology across interconnected virtual experiences to shape consumption behavior across interoperable decentralized metaverse platforms.	Guo and Gao, 2022; Liu et al., 2022; Solakis et al., 2022
Real-time predictive analytics and logistics intelligence can determine behavioral patterns across blockchain-based virtual worlds by integrating dynamic routing technology across interoperable decentralized metaverse platforms.	Gibbert et al., 2022; Kraus et al., 2022; Zhang et al., 2022
Real-time data analytics and metaverse-related technologies can leverage e-commerce capabilities to increase customer data and enhance business performance. Computer vision algorithms, customer engagement tools, and data mining techniques can attract and retain customers during digital shopper journeys in the virtual retail market.	Akyildiz et al., 2022; Turner, 2022; Xi et al., 2022
Analytical techniques can affect consumption patterns and shopping patterns by deploying data-driven decisions throughout customer journeys in a decentralized blockchain-based metaverse.	Chandra, 2022; Gibbert et al., 2022; Kraus et al., 2022
Interactive showrooms throughout immersive virtual shopping drive brand engagement and optimize consumer purchasing habits and value creation across interoperable decentralized metaverse platforms.	Gössling and Schweiggart, 2022; Liu et al., 2022; Zhang et al., 2022

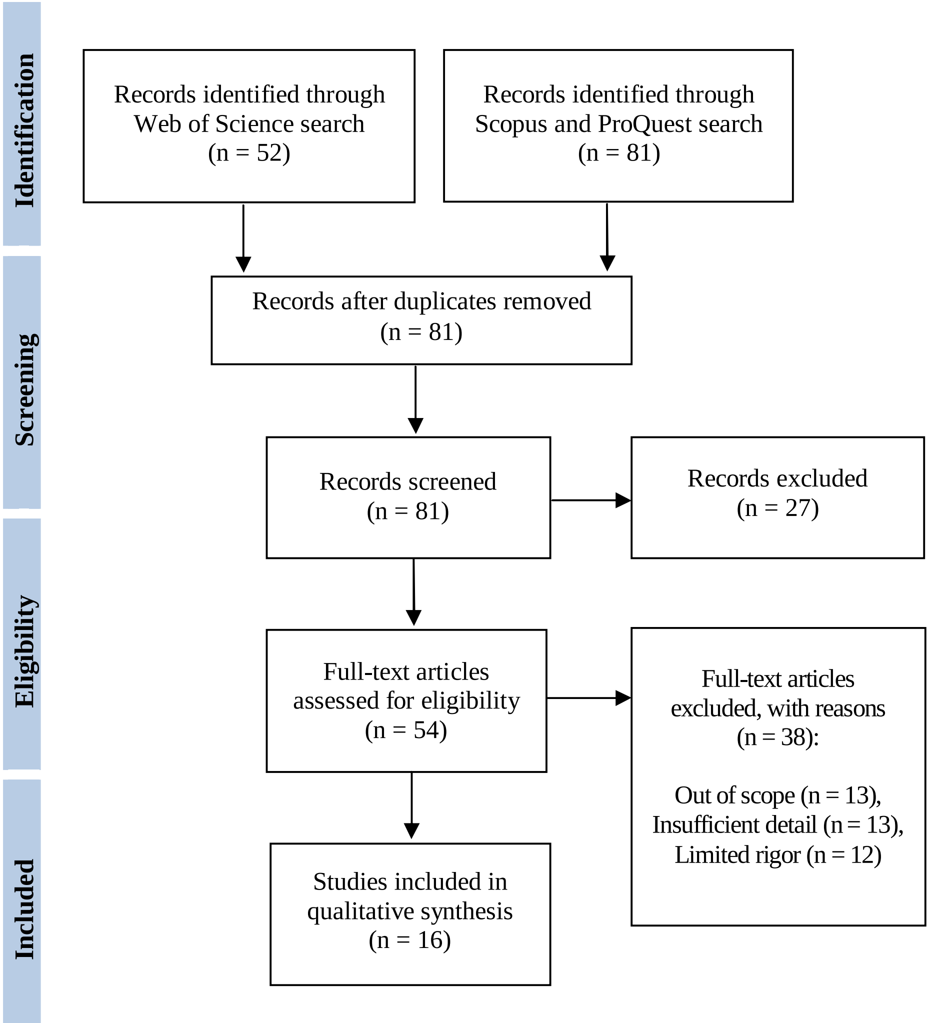

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

Distiller SR screened and extracted the collected data.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

ROBIS assessed the risk of bias in systematic reviews.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

Dedoose analyzed qualitative and mixed methods research.

Figure 6 Screening and quality assessment tools

4. Enhancing Shopping Experiences across Virtual Marketplaces and Interoperable Decentralized Metaverse Platforms

Artificial neural networks and metaverse-related technologies can optimize customer engagement and retention by use of e-commerce tools (Laviola et al., 2022; Skalidis et al., 2022; Xi et al., 2022), streamlining retail operations and optimizing product customization services. Augmented reality tools, data sharing interfaces, visual analytics, and artificial neural networks can influence consumer choices and purchasing decisions in experiential retail.

Digital marketing tools can leverage consumer retail data during purchase journeys (Gibbert et al., 2022; Kraus et al., 2022; Zyda, 2022), enhancing shopping experiences across virtual marketplaces and interoperable decentralized metaverse platforms. Machine vision algorithms, natural language processing tools, and speech analytics can determine purchase intent and behavior by integrating rich customer data during retail transactions. Immersive technologies can enhance operational performance across virtual stores by assessing purchasing decisions, customer confidence, engagement, and habits through data visualization in retail business and operations.

Technology-powered live shopping and metaverse marketing strategies can optimize immersive retail experiences through customer monitoring systems (Akyildiz et al., 2022; Gills and Hosseini, 2022; Gössling and Schweiggart, 2022) across virtual worlds and extended reality environments. Consumer intelligence, data-driven decisions, and computer vision algorithms can drive customer engagement as regards digital brand assets in experiential shopping. Robust predictive analytics can be pivotal in experiential retail and digital shopping as regards purchasing recommended items, consumer behaviors and expectations, and customer loyalty and trust across persistent virtual realms. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Artificial neural networks and metaverse-related technologies can optimize customer engagement and retention by use of e-commerce tools, streamlining retail operations and optimizing product customization services.	Laviola et al., 2022; Skalidis et al., 2022; Xi et al., 2022
Digital marketing tools can leverage consumer retail data during purchase journeys, enhancing shopping experiences across virtual marketplaces and interoperable decentralized metaverse platforms.	Gibbert et al., 2022; Kraus et al., 2022; Zyda, 2022
Technology-powered live shopping and metaverse marketing strategies can optimize immersive retail experiences through customer monitoring systems across virtual worlds and extended reality environments.	Akyildiz et al., 2022; Gills and Hosseini, 2022; Gössling and Schweiggart, 2022

5. Shaping Consumption Behavior across Interoperable Decentralized Metaverse Platforms

Customer personalization tools and metaverse marketing strategies can drive brand awareness during immersive virtual reality experiences (Lukava et al., 2022; Turner, 2022; Xi et al., 2022) by deploying synthetic data to determine historical purchasing trends. Voice biometrics technology, search engine algorithms, sensor data, and decision support tools can shape customer behavior and deliver business value across immersive 3D worlds. Computer vision algorithms, digital machines, voice biometrics, and customer behavior analytics can determine customer engagement behaviors and provide personalized customer service support throughout immersive 3D worlds.

Smart retailing can harness data visualizations, consumer analytics, and spatial computing technology across interconnected virtual experiences to shape consumption behavior (Guo and Gao, 2022; Liu et al., 2022; Solakis et al., 2022) across interoperable decentralized metaverse platforms. Immersive 3D technologies can integrate virtual connectivity throughout consumer journeys as regards digital assets, leading to customized digital experiences by interaction and movement tracking.

Real-time predictive analytics and logistics intelligence can determine behavioral patterns across blockchain-based virtual worlds (Gibbert et al., 2022; Kraus et al., 2022; Zhang et al., 2022) by integrating dynamic routing technology across interoperable decentralized metaverse platforms. Data sharing technologies, retail analytics, and natural language processing models can optimize purchase decisions and data infrastructure with regard to customer engagement, brand loyalty, and preferences throughout persistent virtual worlds. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Customer personalization tools and metaverse marketing strategies can drive brand awareness during immersive virtual reality experiences by deploying synthetic data to determine historical purchasing trends.	Lukava et al., 2022; Turner, 2022; Xi et al., 2022
Smart retailing can harness data visualizations, consumer analytics, and spatial computing technology across interconnected virtual experiences to shape consumption behavior across interoperable decentralized metaverse platforms.	Guo and Gao, 2022; Liu et al., 2022; Solakis et al., 2022
Real-time predictive analytics and logistics intelligence can determine behavioral patterns across blockchain-based virtual worlds by integrating dynamic routing technology across interoperable decentralized metaverse platforms.	Gibbert et al., 2022; Kraus et al., 2022; Zhang et al., 2022

6. Deploying Data-driven Decisions throughout Customer Journeys in a Decentralized Blockchain-based Metaverse

Real-time data analytics and metaverse-related technologies can leverage e-commerce capabilities (Akyildiz et al., 2022; Turner, 2022; Xi et al., 2022) to increase customer data and enhance business performance. Conversational artificial intelligence can assess immersive virtual experiences during retail livestreaming by leveraging augmented reality shopping tools. Retail business analytics can increase digital engagement across virtual spaces while raising brand awareness. Computer vision algorithms, customer engagement tools, and data mining techniques can attract and retain customers during digital shopper journeys in the virtual retail market.

Analytical techniques can affect consumption patterns and shopping patterns by deploying data-driven decisions throughout customer journeys (Chandra, 2022; Gibbert et al., 2022; Kraus et al., 2022) in a decentralized blockchain-based metaverse. Artificial intelligence customer service chatbots can harness advanced analytics and decision-making tools to enhance customer satisfaction in virtual commerce. Automated speech recognition, real-time sensor data, and computer vision algorithms can optimize connected shopping experiences in virtual economy.

Interactive showrooms throughout immersive virtual shopping drive brand engagement and optimize consumer purchasing habits and value creation (Gössling and Schweiggart, 2022; Liu et al., 2022; Zhang et al., 2022) across interoperable decentralized metaverse platforms. Retail brands can leverage sentiment analytics, location-based decisions, and 3D environment immersions to determine consumer behavior and engagement as regards virtual assets. Data visualization tools can articulate customer interaction experiences by data storage and processing, predicting user behaviors across immersive digital environments. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Real-time data analytics and metaverse-related technologies can leverage e-commerce capabilities to increase customer data and enhance business performance.	Akyildiz et al., 2022; Turner, 2022; Xi et al., 2022
Analytical techniques can affect consumption patterns and shopping patterns by deploying data-driven decisions throughout customer journeys in a decentralized blockchain-based metaverse.	Chandra, 2022; Gibbert et al., 2022; Kraus et al., 2022
Interactive showrooms throughout immersive virtual shopping drive brand engagement and optimize consumer purchasing habits and value creation across interoperable decentralized metaverse platforms.	Gössling and Schweiggart, 2022; Liu et al., 2022; Zhang et al., 2022

7. Discussion

I integrate my systematic review throughout research indicating how augmented reality tools, data sharing interfaces, visual analytics, and artificial neural networks can influence consumer choices and purchasing decisions in experiential retail. My research complements recent analyses clarifying how data sharing technologies, retail analytics, and natural language processing models can optimize purchase decisions and data infrastructure with regard to customer engagement, brand loyalty, and preferences throughout persistent virtual worlds. I elucidate, by cumulative evidence, previous research demonstrating how robust predictive analytics can be pivotal in experiential retail and digital shopping as regards purchasing recommended items, consumer behaviors and expectations, and customer loyalty and trust across persistent virtual realms.

8. Synopsis of the Main Research Outcomes

Immersive 3D technologies can integrate virtual connectivity throughout consumer journeys as regards digital assets, leading to customized digital experiences by interaction and movement tracking. Conversational artificial intelligence can assess immersive virtual experiences during retail livestreaming by leveraging augmented reality shopping tools. Consumer intelligence, data-driven decisions, and computer vision algorithms can drive customer engagement as regards digital brand assets in experiential shopping.

9. Conclusions

Relevant research has investigated whether automated speech recognition, real-time sensor data, and computer vision algorithms can optimize connected shopping experiences in virtual economy. This systematic literature review presents the published peer-reviewed sources covering how computer vision algorithms, digital machines, voice biometrics, and customer behavior analytics can determine customer engagement behaviors and provide personalized customer service support throughout immersive 3D worlds. The research outcomes drawn from the above analyses indicate that retail business analytics can increase digital engagement across virtual spaces while raising brand awareness.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published in 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on virtual commerce in a decentralized blockchain-based metaverse may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of technology-powered live shopping and metaverse marketing strategies.

Subsequent analyses should develop on customer personalization tools and metaverse marketing strategies. Future research should thus investigate real-time data analytics and metaverse-related technologies. In the future, attention should be directed to interactive showrooms throughout immersive virtual shopping.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the author.

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Author contributions

The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Metaverse Applications, Technologies, and Infrastructure: Predictive Algorithms, Real-Time Customer Data Analytics, and Virtual Navigation Tools

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ABSTRACT. The aim of this systematic review is to synthesize and analyze metaverse applications, technologies, and infrastructure in relation to predictive algorithms, real-time customer data analytics, and virtual navigation tools. With increasing evidence of metaverse live-video shopping events, there is an essential demand for comprehending whether consumer digital engagement as regards virtual assets improves immersive shopping journeys and experiences. In this research, prior findings were cumulated indicating that consumer journey analytics and data-driven decision making can determine purchase intentions across immersive 3D worlds and in virtual stores. We carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout March 2022, with search terms including "metaverse" + "predictive algorithms," "real-time customer data analytics," and "virtual navigation tools." As we analyzed research published between 2021 and 2022, only 86 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, we decided on 20, chiefly empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Distiller SR, ROBIS, and SRDR.

Keywords: metaverse; customer; virtual; predictive algorithm; data analytics

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1. Introduction

Retail analytics can shape consumer habits and behavior (Andrei et al., 2016a, b; Kral et al., 2022; Nica et al., 2022) as regards virtual items during immersive virtual shopping and experiences. The purpose of our systematic review is to examine the recently published literature on metaverse applications, technologies, and infrastructure and integrate the insights it configures on predictive algorithms, real-time customer data analytics, and virtual navigation tools. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that customer identification technology, transaction analytics, and data-driven measurements (Andronie et al., 2021a, b; Lăzăroiu et al., 2017; Obadă and Dabija, 2022) can increase customer satisfaction as regards virtual assets. The actuality and novelty of this study are articulated by addressing self-service technology deployment in a decentralized blockchain-based metaverse, that is an emerging topic involving much interest. Our research problem is whether consumer digital engagement as regards virtual assets (Bacalu, 2021; Lăzăroiu et al., 2020; Olssen, 2021) improves immersive shopping journeys and experiences.

In this review, prior findings have been cumulated indicating that consumer journey analytics and data-driven decision making can determine purchase intentions (Blazek et al., 2022; Nemțeanu et al., 2022; Popescu, 2014) across immersive 3D worlds and in virtual stores. The identified gaps advance data visualization capabilities, real-time performance monitoring, metaverse-related technologies, and analytic decision models. Our main objective is to indicate that biometric analytics and computer vision algorithms (Kral et al., 2020; Nica, 2018; Vinerean et al., 2022) can shape consumer behavior and habits (Gordon, 2021; Nica, 2017; Popescu, 2017) in virtual spaces, configuring immersive retail experiences as regards digitized retail products. This systematic review contributes to the literature on metaverse live-video shopping events by clarifying that retail analytics can be pivotal in building brand awareness across shared virtual environments and immersive digital worlds (Hackman and Reindl, 2022; Nica et al., 2018; Popescu, 2018) by use of mobility data, customizing user experience.

2. Theoretical Overview of the Main Concepts

Assessing digital shopping journeys and consumption habits across immersive virtual worlds and extended reality environments requires smart connected devices. Leveraging text analytics, digital shelf data, location-based decision-making, and machine vision can result in heightened consumer expectations and optimized immersive virtual experiences during customer journey by articulating dynamic personalized offers. Smart technologies integrating artificial intelligence-enabled digital products across virtual retail stores require data visualizations, behavioral analytics, and sentiment analysis algorithms to configure customer profiles and determine customer engagement, sentiment, and behavior. Consumer analytics can be pivotal in personalized services as regards digital shopping in virtual economy. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), leveraging location data in relation to metaverse assets and services (section 4), retail business analytics and metaverse capabilities (section 5), building brand image and customer relationships with reference to metaverse assets and services (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

We carried out a quantitative literature review of ProQuest, Scopus, and the Web of Science throughout March 2022, with search terms including "metaverse" + "predictive algorithms," "real-time customer data analytics," and "virtual navigation tools." The search terms were determined as being the most employed words or phrases across the analyzed literature. As we analyzed research published between 2021 and 2022, only 86 papers met the eligibility criteria. By removing controversial or unclear findings (scanty/unimportant data), results unsupported by replication, undetailed content, or papers having quite similar titles, we decided on 20, chiefly empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Distiller SR, ROBIS, and SRDR (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + predictive algorithms	27	6
metaverse + real-time customer data analytics	29	7
metaverse + virtual navigation tools	30	7
Type of paper		
Original research	65	19
Review	3	1
Conference proceedings	11	0
Book	3	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

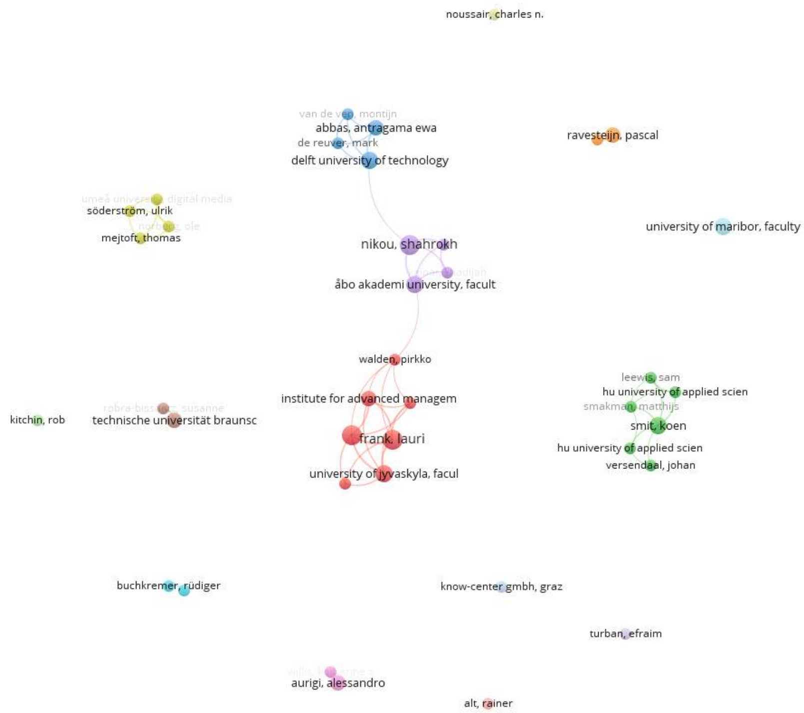

Figure 1 Co-authorship

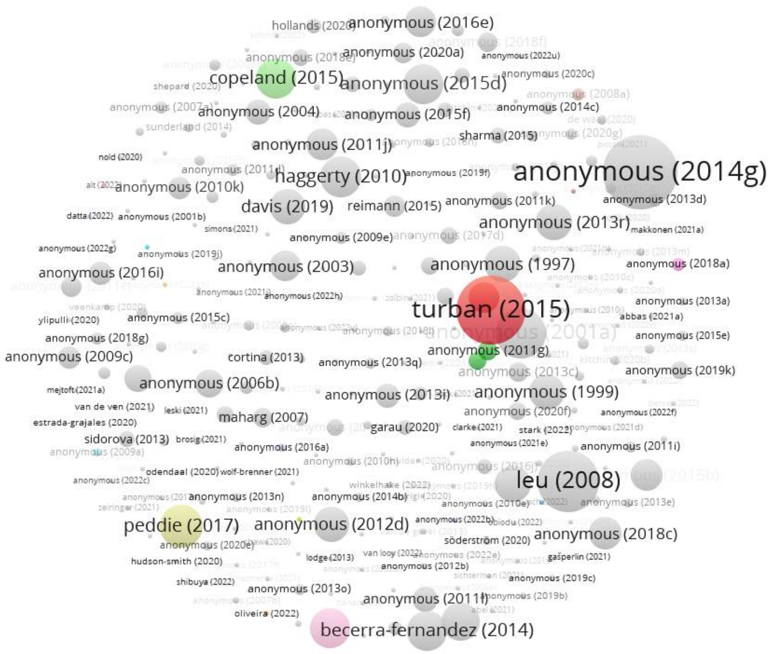

Figure 2 Citation

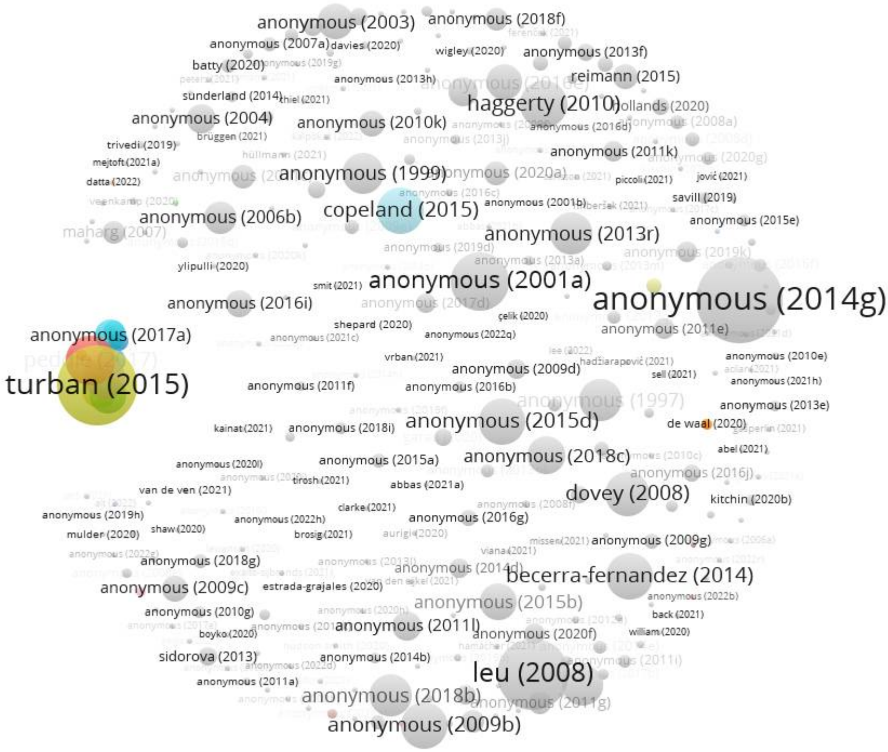

Figure 3 Bibliographic coupling

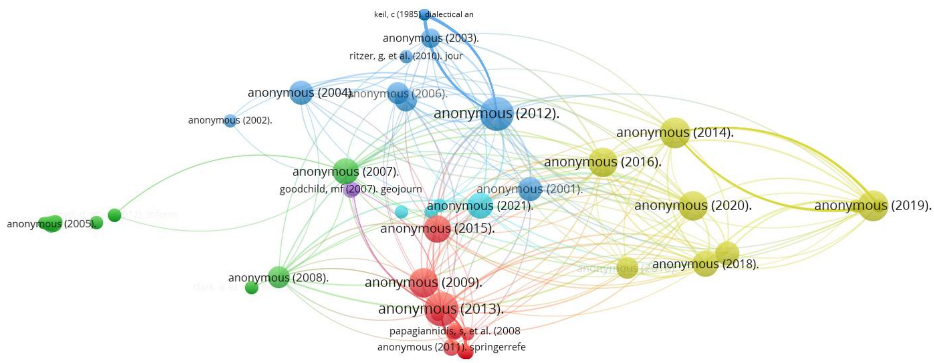

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Customer behavior analytics and metaverse capabilities can optimize purchase journeys by leveraging location data, driving customer engagement across online and virtual marketplaces and configuring interactive brand experiences.	Almarzouqi et al. 2022; Laviola et al., 2022; Zhang et al., 2022a
Deploying predictive analytics and metaverse capabilities can be instrumental in attracting and retaining customers by integrating biometric data to articulate seamless purchasing experiences. Biometric analytics and computer vision algorithms can shape consumer behavior and habits in virtual spaces, configuring immersive retail experiences as regards digitized retail products.	Dozio et al., 2022; Lv et al., 2022; Yeh et al., 2022
Real-time customer data analytics and vision technology can attract and retain customers while optimizing brand loyalty by leveraging location data in relation to metaverse assets and services.	Gills and Hosseini, 2022; Han et al., 2022; Siyaev and Jo, 2021
Data visualization capabilities, real-time performance monitoring, metaverse-related technologies, and analytic decision models can shape purchase paths and consumption habits, driving shopper engagement in virtual stores.	Lin et al., 2022; Reis and Ashmore, 2022; Zyda, 2022
Retail business analytics and metaverse capabilities can assess consumer purchasing habits and digital retail experiences in shared virtual spaces by use of immersive technologies.	Kozinets, 2022; Laviola et al., 2022; Turner, 2022
Retail and consumer brands can configure immersive experiences across interconnected digital worlds during customer journey through self-service technology deployment in a decentralized blockchain-based metaverse.	Almarzouqi et al., 2022; Skalidis et al., 2022; Solakis et al., 2022
Business intelligence tools, text analytics, and immersive 3D technologies can configure personalized offers and customized user experiences through data-driven decisions, articulating metaverse live-video shopping events.	Akyildiz et al., 2022; Dozio et al., 2022; Han et al., 2022
Data visualization tools, metaverse technologies, and spatial analytics can articulate immersive retail experiences across virtual stores, determining customer engagement behaviors.	Lv et al., 2022; Reis and Ashmore, 2022; Zhang et al., 2022a
Deploying consumer behavior data across immersive digital environments can build brand image and customer relationships with reference to metaverse assets and services.	Beniiche et al., 2022; Gursoy et al., 2022; Zhang et al., 2022b

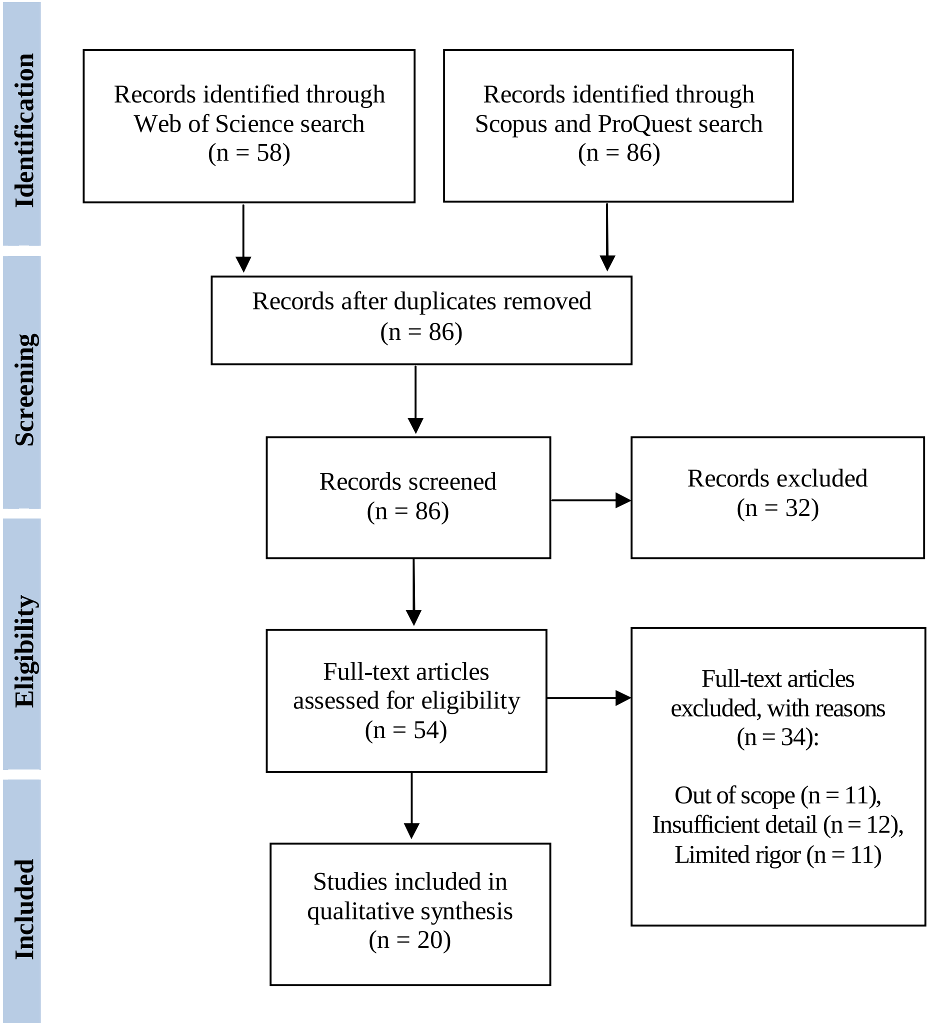

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2021–2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

Distiller SR screened and extracted the collected data.

AMSTAR evaluated the methodological quality of systematic reviews.

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

ROBIS assessed the risk of bias in systematic reviews.

AXIS evaluated the quality of cross-sectional studies.

Dedoose analyzed qualitative and mixed methods research.

Figure 6 Screening and quality assessment tools

4. Leveraging Location Data in Relation to Metaverse Assets and Services

Customer behavior analytics and metaverse capabilities can optimize purchase journeys (Almarzouqi et al., 2022; Laviola et al., 2022; Zhang et al., 2022a) by leveraging location data, driving customer engagement across online and virtual marketplaces and configuring interactive brand experiences. Improving operational efficiency through synthetic data can optimize customer interaction experiences in virtual spaces. Consumer analytics can be pivotal in personalized services as regards digital shopping in virtual economy.

Deploying predictive analytics and metaverse capabilities can be instrumental in attracting and retaining customers (Dozio et al., 2022; Lv et al., 2022; Yeh et al., 2022) by integrating biometric data to articulate seamless purchasing experiences. Virtual connectivity can assist data-driven decisions in experiential shopping and retail livestreaming by integrating analytical artificial intelligence, computer vision algorithms, and augmented reality technology, thus shaping consumer behavior. Biometric analytics and computer vision algorithms can shape consumer behavior and habits in virtual spaces, configuring immersive retail experiences as regards digitized retail products.

Real-time customer data analytics and vision technology can attract and retain customers while optimizing brand loyalty (Gills and Hosseini, 2022; Han et al., 2022; Siyaev and Jo, 2021) by leveraging location data in relation to metaverse assets and services. Customer identification technology, transaction analytics, and data-driven measurements can increase customer satisfaction as regards virtual assets. Laser remote-sensing technology, spatial analytics, and business intelligence tools and software can meet customer demand during immersive 3D experiences across interconnected virtual worlds. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Customer behavior analytics and metaverse capabilities can optimize purchase journeys by leveraging location data, driving customer engagement across online and virtual marketplaces and configuring interactive brand experiences.	Almarzouqi et al. 2022; Laviola et al., 2022; Zhang et al., 2022a
Deploying predictive analytics and metaverse capabilities can be instrumental in attracting and retaining customers by integrating biometric data to articulate seamless purchasing experiences.	Dozio et al., 2022; Lv et al., 2022; Yeh et al., 2022
Real-time customer data analytics and vision technology can attract and retain customers while optimizing brand loyalty by leveraging location data in relation to metaverse assets and services.	Gills and Hosseini, 2022; Han et al., 2022; Siyaev and Jo, 2021

5. Retail Business Analytics and Metaverse Capabilities

Data visualization capabilities, real-time performance monitoring, metaverse-related technologies, and analytic decision models (Lin et al., 2022; Reis and Ashmore, 2022; Zyda, 2022) can shape purchase paths and consumption habits, driving shopper engagement in virtual stores. Computer vision tools, predictive algorithms, and immersive technologies can develop operational processes as regards personalized shopping experiences in virtual commerce. Smart technologies integrating artificial intelligence-enabled digital products across virtual retail stores require data visualizations, behavioral analytics, and sentiment analysis algorithms to configure customer profiles and determine customer engagement, sentiment, and behavior.

Retail business analytics and metaverse capabilities can assess consumer purchasing habits and digital retail experiences in shared virtual spaces (Kozinets, 2022; Laviola et al., 2022; Turner, 2022) by use of immersive technologies. Computer vision algorithms and predictive analytics can deploy rich customer data to determine consumer purchasing decisions as regards virtual items during digital shopping journeys. Retail analytics can shape consumer habits and behavior as regards virtual items during immersive virtual shopping and experiences.

Retail and consumer brands can configure immersive experiences across interconnected digital worlds (Almarzouqi et al., 2022; Skalidis et al., 2022; Solakis et al., 2022) during customer journey through self-service technology deployment in a decentralized blockchain-based metaverse. Data visualization tools, computer vision algorithms, and text analytics can determine consumer purchasing habits in immersive virtual shopping. Assessing digital shopping journeys and consumption habits across immersive virtual worlds and extended reality environments requires smart connected devices. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Data visualization capabilities, real-time performance monitoring, metaverse-related technologies, and analytic decision models can shape purchase paths and consumption habits, driving shopper engagement in virtual stores.	Lin et al., 2022; Reis and Ashmore, 2022; Zyda, 2022
Retail business analytics and metaverse capabilities can assess consumer purchasing habits and digital retail experiences in shared virtual spaces by use of immersive technologies.	Kozinets, 2022; Laviola et al., 2022; Turner, 2022
Retail and consumer brands can configure immersive experiences across interconnected digital worlds during customer journey through self-service technology deployment in a decentralized blockchain-based metaverse.	Almarzouqi et al., 2022; Skalidis et al., 2022; Solakis et al., 2022

6. Building Brand Image and Customer Relationships with Reference to Metaverse Assets and Services

Business intelligence tools, text analytics, and immersive 3D technologies can configure personalized offers and customized user experiences through data-driven decisions (Akyildiz et al., 2022; Dozio et al., 2022; Han et al., 2022), articulating metaverse live-video shopping events. Computer vision algorithms, data visualizations, and simulation modeling, by harnessing user data during personalized shopping experiences across virtual environments, can shape retail customer behavior in relation to digital assets. Advanced analytics and data visualizations can shape customer expectations and articulate seamless retail shopping experiences throughout 3D immersive environments.

Data visualization tools, metaverse technologies, and spatial analytics can articulate immersive retail experiences across virtual stores (Lv et al., 2022; Reis and Ashmore, 2022; Zhang et al., 2022a), determining customer engagement behaviors. Retail analytics can be pivotal in building brand awareness across shared virtual environments and immersive digital worlds by use of mobility data, customizing user experience. Consumer digital engagement as regards virtual assets improves immersive shopping journeys and experiences.

Deploying consumer behavior data across immersive digital environments can build brand image and customer relationships (Beniiche et al., 2022; Gursoy et al., 2022; Zhang et al., 2022b) with reference to metaverse assets and services. Leveraging text analytics, digital shelf data, location-based decision-making, and machine vision can result in heightened consumer expectations and optimized immersive virtual experiences during customer journey by articulating dynamic personalized offers. Consumer journey analytics and data-driven decision making can determine purchase intentions across immersive 3D worlds and in virtual stores. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Business intelligence tools, text analytics, and immersive 3D technologies can configure personalized offers and customized user experiences through data-driven decisions, articulating metaverse live-video shopping events.	Akyildiz et al., 2022; Dozio et al., 2022; Han et al., 2022
Data visualization tools, metaverse technologies, and spatial analytics can articulate immersive retail experiences across virtual stores, determining customer engagement behaviors.	Lv et al., 2022; Reis and Ashmore, 2022; Zhang et al., 2022a
Deploying consumer behavior data across immersive digital environments can build brand image and customer relationships with reference to metaverse assets and services.	Beniiche et al., 2022; Gursoy et al., 2022; Zhang et al., 2022b

7. Discussion

We integrate our systematic review throughout research indicating how data visualization tools, computer vision algorithms, and text analytics can determine consumer purchasing habits in immersive virtual shopping. Our research complements recent analyses clarifying how virtual connectivity can assist data-driven decisions in experiential shopping and retail livestreaming by integrating analytical artificial intelligence, computer vision algorithms, and augmented reality technology, thus shaping consumer behavior. We elucidate, by cumulative evidence, previous research demonstrating how computer vision algorithms, data visualizations, and simulation modeling, by harnessing user data during personalized shopping experiences across virtual environments, can shape retail customer behavior in relation to digital assets.

8. Synopsis of the Main Research Outcomes

Laser remote-sensing technology, spatial analytics, and business intelligence tools and software can meet customer demand during immersive 3D experiences across interconnected virtual worlds. Computer vision algorithms and predictive analytics can deploy rich customer data to determine consumer purchasing decisions as regards virtual items during digital shopping journeys. Consumer digital engagement as regards virtual assets improves immersive shopping journeys and experiences.

9. Conclusions

Relevant research has investigated whether improving operational efficiency through synthetic data can optimize customer interaction experiences in virtual spaces. This systematic literature review presents the published peer-reviewed sources covering how advanced analytics and data visualizations can shape customer expectations and articulate seamless retail shopping experiences throughout 3D immersive environments. The research outcomes drawn from the above analyses indicate that computer vision tools, predictive algorithms, and immersive technologies can develop operational processes as regards personalized shopping experiences in virtual commerce.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on metaverse applications, technologies, and infrastructure in relation to predictive algorithms, real-time customer data analytics, and virtual navigation tools may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of customer behavior analytics and metaverse capabilities.

Subsequent analyses should develop on immersive experiences across interconnected digital worlds. Future research should thus investigate immersive retail experiences across virtual stores. In the future, attention should be directed to customer engagement across online and virtual marketplaces.

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The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Virtual Immersive Shopping Experiences in Metaverse Environments: Predictive Customer Analytics, Data Visualization Algorithms, and Smart Retailing Technologies

John Hudson*

ABSTRACT. In this article, I cumulate previous research findings indicating that smart connected devices can assist data-driven decisions in retail livestreaming by articulating personalized shopping experiences as regards digital ownership across extended reality environments. I contribute to the literature on virtual immersive shopping experiences in metaverse environments by showing that contextual awareness and real-time performance data can typify immersive retail experiences, improving brand recognition. Throughout February 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "virtual immersive shopping experiences," "predictive customer analytics," "data visualization algorithms," and "smart retailing technologies." As I inspected research published between 2021 and 2022, only 83 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 16, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, MMAT, and ROBIS.

Keywords: virtual; immersive; shopping; metaverse; customer analytics; visualization

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1. Introduction

Augmented analytics capabilities can shape consumer behavior patterns (Andronie et al., 2021a, b; Lăzăroiu et al., 2017; Olssen, 2021) by enhancing content and product data. The purpose of my systematic review is to examine the recently published literature on virtual immersive shopping experiences in metaverse environments and integrate the insights it configures on predictive customer analytics, data visualization algorithms, and smart retailing technologies. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, my paper has attempted to prove that advanced analytics, artificial intelligence-enabled natural language recognition, and computer vision algorithms can build consumer relationships (Barbu et al., 2021; Lăzăroiu et al., 2022; Popescu, 2017; Valle, 2021), while optimizing consumption habits and purchasing behavior shifts (Blake and Frajtova Michalikova, 2021; Mitchell, 2021; Popescu et al., 2017) throughout interconnected virtual experiences. The actuality and novelty of this study are articulated by addressing purchase intentions throughout metaverse environments, that is an emerging topic involving much interest. My research problem is whether contextual awareness and real-time performance data can typify immersive retail experiences, improving brand recognition.

In this review, prior findings have been cumulated indicating that text and speech analytics can be leveraged during immersive virtual shopping, engaging and retaining consumers. The identified gaps advance how computer vision algorithms, metaverse technologies, and retail business analytics (Bratu and Sabău, 2022; Musova et al., 2021; Popescu, 2018) can drive brand engagement and optimize consumer purchasing habits. My main objective is to indicate that consumer brand companies can leverage sentiment analysis data to articulate personalized customer experiences (Glogovețan et al., 2022; Nica et al., 2021; Popescu et al., 2021), improving shopping behaviors across retail environments. This systematic review contributes to the literature on shaping customer behavior and building brand awareness (Jenkins, 2022; Nica, 2021; Svabova et al., 2020) across a decentralized metaverse world by clarifying that smart connected devices can assist data-driven decisions in retail livestreaming by articulating personalized shopping experiences (Kliestik et al., 2020; Obadă and Dabija, 2022; Watson, 2022) as regards digital ownership across extended reality environments.

2. Theoretical Overview of the Main Concepts

Contextual augmented reality, voice recognition software, virtual navigation tools, and data mining techniques can shape consumption behavior by configuring historical purchasing trends and customer journey mapping typifying virtual store experiences. Digital shopping journeys across immersive virtual environments can build customer engagement by leveraging synthetic data and visual capabilities. Live shopping events across immersive digital environments can build customer engagement and optimize virtual retail experiences. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), retail analytics and metaverse technologies (section 4), shaping customer behavior and building brand awareness across a decentralized metaverse world (section 5), configuring purchase behavior and preferences as regards virtual assets across a decentralized metaverse world (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout February 2022, I performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including “metaverse” + “virtual immersive shopping experiences,” “predictive customer analytics,” “data visualization algorithms,” and “smart retailing technologies.” As I inspected research published between 2021 and 2022, only 83 articles satisfied the eligibility criteria. The search terms were determined as being the most employed words or phrases across the analyzed literature. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, I decided upon 16, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AMSTAR, Distiller SR, MMAT, and ROBIS (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + virtual immersive shopping experiences	21	4
metaverse + predictive customer analytics	21	4
metaverse + data visualization algorithms	20	4
metaverse + smart retailing technologies	21	4
Type of paper		
Original research	61	16
Review	3	0
Conference proceedings	12	0
Book	4	0
Editorial	3	0

Source: Processed by the author. Some topics overlap.

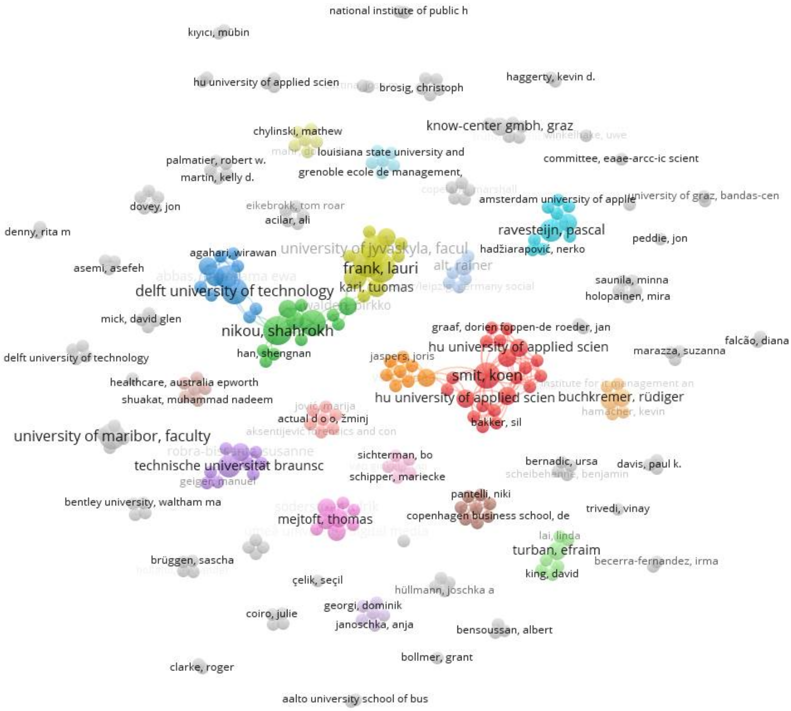

Figure 1 Co-authorship

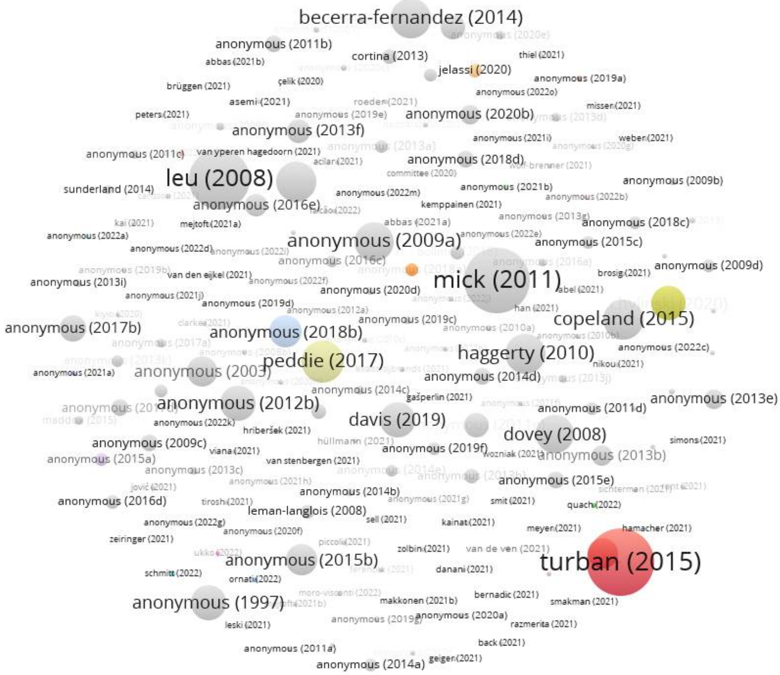

Figure 2 Citation

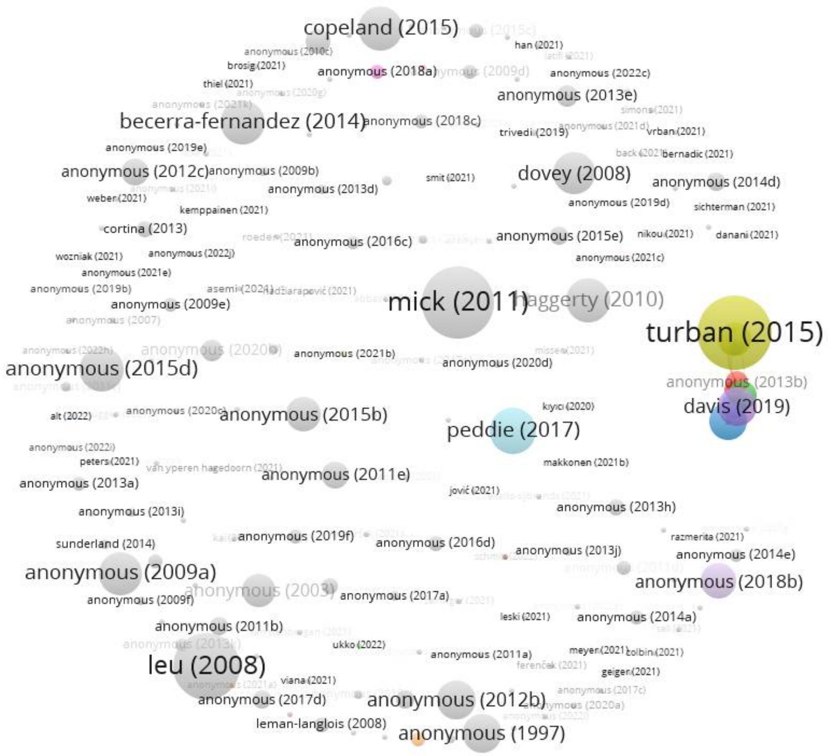

Figure 3 Bibliographic coupling

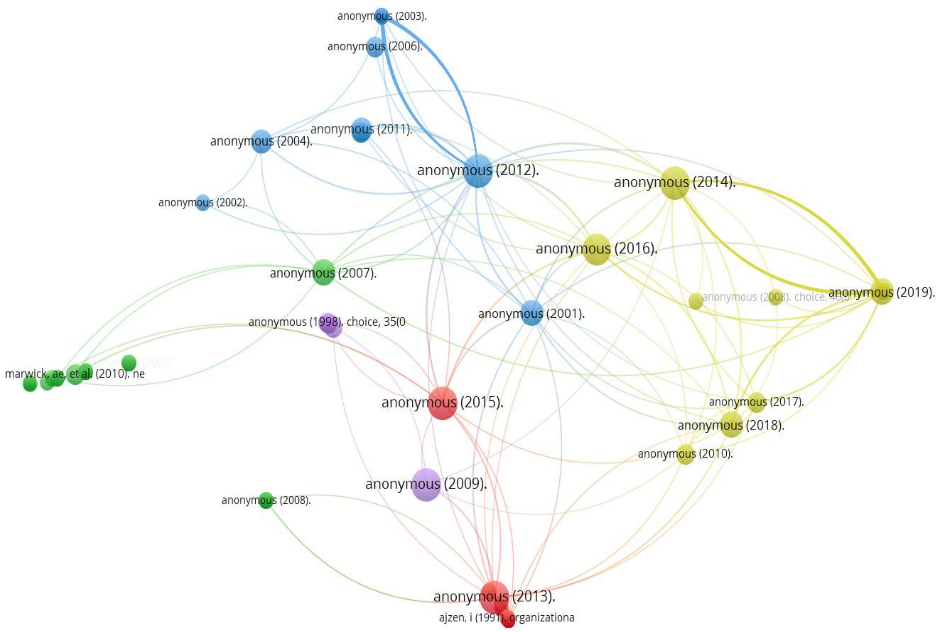

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Computer vision algorithms, metaverse technologies, and retail business analytics can drive brand engagement and optimize consumer purchasing habits throughout immersive 3D worlds.	Beniiche et al., 2022; Gössling and Schweiggart, 2022; Zhang et al., 2022a
Retail analytics and metaverse technologies can articulate seamless personalized experiences, shaping customer retention, shopping habits, and buying patterns, while improving engagement rates.	Kraus et al., 2022; Liu et al., 2022; Zyda, 2022
Customer personalization tools and metaverse technologies can enhance digital shopping experiences across immersive interconnected virtual worlds. Digital shopping journeys across immersive virtual environments can build customer engagement by leveraging synthetic data and visual capabilities.	Chandra, 2022; Lin et al., 2022; Zhao et al., 2022
Retail brands can deploy data visualizations, computer vision algorithms, and virtual connectivity to articulate lifetime customer value by assessing purchase intentions throughout metaverse environments.	Akyildiz et al., 2022; Gössling and Schweiggart, 2022; Siyaev and Jo, 2021
Customer engagement tools and real-time predictive analytics can leverage synthetic data to articulate customized digital experiences, shaping customer behavior and building brand awareness across a decentralized metaverse world.	Beniiche et al., 2022; Hwang and Chien, 2022; Kshetri, 2022
Data visualization tools and metaverse technologies can improve consumer shopping experiences and optimize business results across real-time 3D social entertainment.	Kraus et al., 2022; Liu et al., 2022; Park et al., 2022
Data-driven artificial intelligence, natural language processing tools, and behavioral analytics can harness customer data to configure purchase behavior and preferences as regards virtual assets across a decentralized metaverse world. Contextual awareness and real-time performance data can typify immersive retail experiences.	Akyildiz et al., 2022; Lin et al., 2022; Zhang et al., 2022a
Real-time performance data, immersive visualization systems, and business analytics can optimize personalized shopping experiences during customer journey across technological and network infrastructures, and metaverse environments.	Almarzouqi et al. 2022; Siyaev and Jo, 2021; Zyda, 2022
Digital machines, voice biometrics technology, and customer engagement tools can deploy real-time sensor data to optimize user journeys, driving brand awareness across metaverse environments.	Chandra, 2022; Park et al., 2022; Zhang et al., 2022b

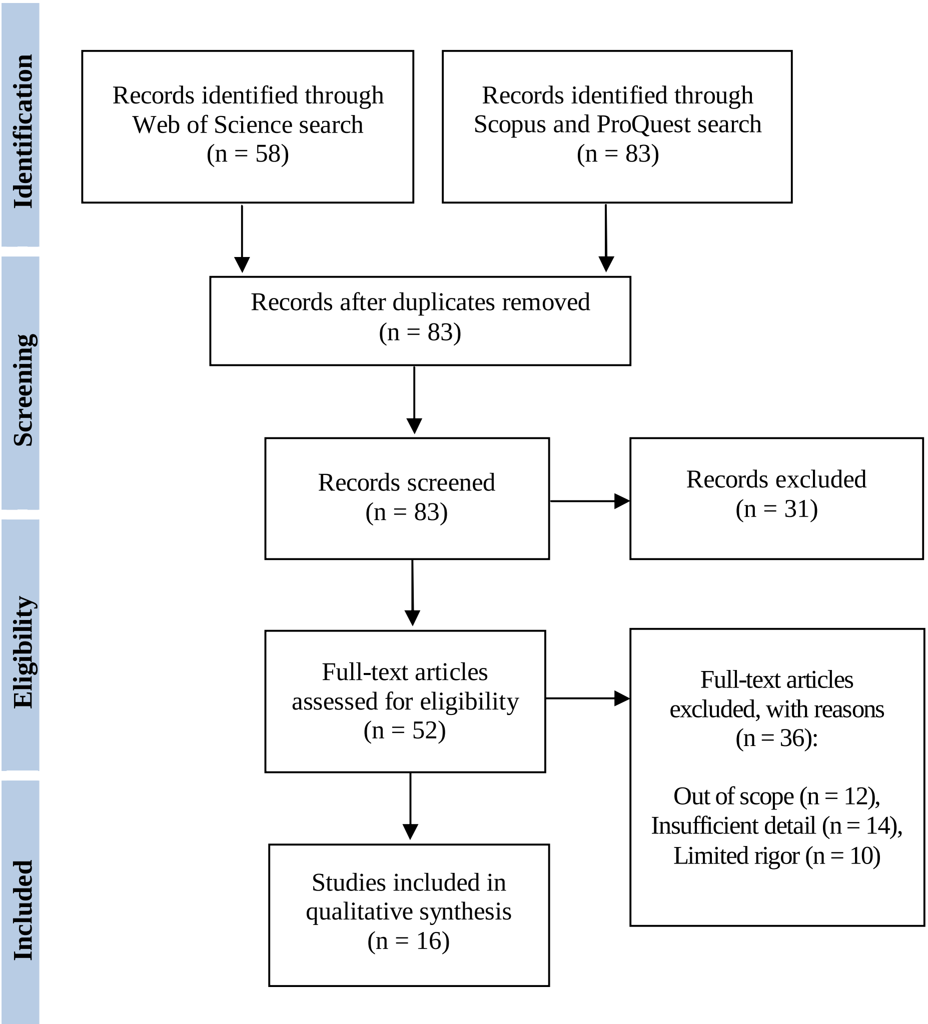

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.
To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

To ensure first-rate standard of evidence, a systematic search of relevant databases including peer-reviewed published journal articles was conducted using predefined search terms, covering a range of research methods and data sources. Reference lists of all relevant sources were manually reviewed for additional relevant citations.

↓

Titles of papers and abstracts were screened for suitability and selected full texts were retrieved to establish whether they satisfied the inclusion criteria. All records from each database were evaluated by using data extraction forms. Data covering research aims, participants, study design, and method of each paper were extracted.

↓

The inclusion criteria were: (i) articles included in the Web of Science, Scopus, and ProQuest databases, (ii) publication date (2021–2022), (iii) written in English, (iv) being an original empirical research or review article, and (v) particular search terms covered; (i) conference proceedings, (ii) books, and (iii) editorial materials were eliminated from the analysis.

↓

Distiller SR screened and extracted the collected data.

↓

SRDR gathered, handled, and analyzed the data for the systematic review, being configured as an archive and tool harnessed in data extraction through transparent, efficient, and reliable quantitative techniques. Elaborate extraction forms can be set up, meeting the needs of research questions and study designs.

↓

AMSTAR evaluated the methodological quality of systematic reviews.

↓

AXIS evaluated the quality of cross-sectional studies.

↓

The quality of academic articles was determined and risk of bias was measured by MMAT, that tested content validity and usability of selected studies in terms of screening questions, type of design, corresponding quality criteria, and overall quality score.

↓

ROBIS assessed the risk of bias in systematic reviews.

↓

Dedoose analyzed qualitative and mixed methods research.

Figure 6 Screening and quality assessment tools

4. Retail Analytics and Metaverse Technologies

Computer vision algorithms, metaverse technologies, and retail business analytics can drive brand engagement and optimize consumer purchasing habits (Beniiche et al., 2022; Gössling and Schweiggart, 2022; Zhang et al., 2022a) throughout immersive 3D worlds. By deploying voice biometrics, immersive technologies, and predictive customer analytics, smart retailing technologies can optimize consumer purchasing habits, while leading to hyper-personalization. Smart connected devices can assist data-driven decisions in retail livestreaming by articulating personalized shopping experiences as regards digital ownership across extended reality environments.

Retail analytics and metaverse technologies can articulate seamless personalized experiences, shaping customer retention, shopping habits, and buying patterns (Kraus et al., 2022; Liu et al., 2022; Zyda, 2022), while improving engagement rates. Leveraging consumer data in experiential retail and live shopping events is pivotal in increasing loyalty and engagement while driving customer retention. Predictive customer analytics, augmented and virtual reality technologies, and data visualization algorithms can leverage data-driven decisions, driving consumer behavior and optimizing purchasing habits and personalized product recommendations across virtual marketplaces.

Customer personalization tools and metaverse technologies can enhance digital shopping experiences (Chandra, 2022; Lin et al., 2022; Zhao et al., 2022) across immersive interconnected virtual worlds. Computer vision algorithms, biometric analytics, and decision-making tools are decisive in smart retailing by integrating immersive technologies across virtual environments. Text and speech analytics can be leveraged during immersive virtual shopping, engaging and retaining consumers. Digital shopping journeys across immersive virtual environments can build customer engagement by leveraging synthetic data and visual capabilities. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Computer vision algorithms, metaverse technologies, and retail business analytics can drive brand engagement and optimize consumer purchasing habits throughout immersive 3D worlds.	Beniiche et al., 2022; Gössling and Schweiggart, 2022; Zhang et al., 2022a
Retail analytics and metaverse technologies can articulate seamless personalized experiences, shaping customer retention, shopping habits, and buying patterns, while improving engagement rates.	Kraus et al., 2022; Liu et al., 2022; Zyda, 2022
Customer personalization tools and metaverse technologies can enhance digital shopping experiences across immersive interconnected virtual worlds.	Chandra, 2022; Lin et al., 2022; Zhao et al., 2022

5. Shaping Customer Behavior and Building Brand Awareness across a Decentralized Metaverse World

Retail brands can deploy data visualizations, computer vision algorithms, and virtual connectivity to articulate lifetime customer value (Akyildiz et al., 2022; Gössling and Schweiggart, 2022; Siyaev and Jo, 2021) by assessing purchase intentions throughout metaverse environments. Advanced analytics, artificial intelligence-enabled natural language recognition, and computer vision algorithms can build consumer relationships, while optimizing consumption habits and purchasing behavior shifts throughout interconnected virtual experiences. Simulation modeling, visual capabilities, and sentiment analytics can improve immersive retail experiences in virtual spaces by leveraging location data.

Customer engagement tools and real-time predictive analytics can leverage synthetic data to articulate customized digital experiences (Beniiche et al., 2022; Hwang and Chien, 2022; Kshetri, 2022), shaping customer behavior and building brand awareness across a decentralized metaverse world. Predictive maintenance and spatial analytics can improve customer engagement behaviors through interaction and movement tracking in experiential shopping in online and virtual marketplaces. Contextual augmented reality, voice recognition software, virtual navigation tools, and data mining techniques can shape consumption behavior by configuring historical purchasing trends and customer journey mapping typifying virtual store experiences.

Data visualization tools and metaverse technologies (Kraus et al., 2022; Liu et al., 2022; Park et al., 2022) can improve consumer shopping experiences and optimize business results across real-time 3D social entertainment. Augmented analytics capabilities can shape consumer behavior patterns by enhancing content and product data. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Retail brands can deploy data visualizations, computer vision algorithms, and virtual connectivity to articulate lifetime customer value by assessing purchase intentions throughout metaverse environments.	Akyildiz et al., 2022; Gössling and Schweiggart, 2022; Siyaev and Jo, 2021
Customer engagement tools and real-time predictive analytics can leverage synthetic data to articulate customized digital experiences, shaping customer behavior and building brand awareness across a decentralized metaverse world.	Beniiche et al., 2022; Hwang and Chien, 2022; Kshetri, 2022
Data visualization tools and metaverse technologies can improve consumer shopping experiences and optimize business results across real-time 3D social entertainment.	Kraus et al., 2022; Liu et al., 2022; Park et al., 2022

6. Configuring Purchase Behavior and Preferences as Regards Virtual Assets across a Decentralized Metaverse World

Data-driven artificial intelligence, natural language processing tools, and behavioral analytics can harness customer data to configure purchase behavior and preferences (Akyildiz et al., 2022; Lin et al., 2022; Zhang et al., 2022a) as regards virtual assets across a decentralized metaverse world. Data visualization capabilities, synthetic data tools, and advanced analytics are instrumental in optimizing customer service and engagement during digital shopping journeys by leveraging location data. Contextual awareness and real-time performance data can typify immersive retail experiences, improving brand recognition.

Real-time performance data, immersive visualization systems, and business analytics can optimize personalized shopping experiences during customer journey (Almarzouqi et al. 2022; Siyaev and Jo, 2021; Zyda, 2022) across technological and network infrastructures, and metaverse environments. Accurate product data can assist customer relationship management in enabling frictionless user experiences across immersive virtual worlds. Smart retailing can optimize customer engagement and loyalty throughout immersive virtual worlds by integrating spatial data in customer decision journeys.

Digital machines, voice biometrics technology, and customer engagement tools can deploy real-time sensor data to optimize user journeys (Chandra, 2022; Park et al., 2022; Zhang et al., 2022b), driving brand awareness across metaverse environments. Consumer brand companies can leverage sentiment analysis data to articulate personalized customer experiences, improving shopping behaviors across retail environments. Live shopping events across immersive digital environments can build customer engagement and optimize virtual retail experiences. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Data-driven artificial intelligence, natural language processing tools, and behavioral analytics can harness customer data to configure purchase behavior and preferences as regards virtual assets across a decentralized metaverse world.	Akyildiz et al., 2022; Lin et al., 2022; Zhang et al., 2022a
Real-time performance data, immersive visualization systems, and business analytics can optimize personalized shopping experiences during customer journey across technological and network infrastructures, and metaverse environments.	Almarzouqi et al. 2022; Siyaev and Jo, 2021; Zyda, 2022
Digital machines, voice biometrics technology, and customer engagement tools can deploy real-time sensor data to optimize user journeys, driving brand awareness across metaverse environments.	Chandra, 2022; Park et al., 2022; Zhang et al., 2022b

7. Discussion

I integrate my systematic review throughout research indicating how leveraging consumer data in experiential retail and live shopping events is pivotal in increasing loyalty and engagement while driving customer retention. My research complements recent analyses clarifying how by deploying voice biometrics, immersive technologies, and predictive customer analytics, smart retailing technologies can optimize consumer purchasing habits, while leading to hyper-personalization. I elucidate, by cumulative evidence, previous research demonstrating how simulation modeling, visual capabilities, and sentiment analytics can improve immersive retail experiences in virtual spaces by leveraging location data.

8. Synopsis of the Main Research Outcomes

Predictive customer analytics, augmented and virtual reality technologies, and data visualization algorithms can leverage data-driven decisions, driving consumer behavior and optimizing purchasing habits and personalized product recommendations across virtual marketplaces. Smart retailing can optimize customer engagement and loyalty throughout immersive virtual worlds by integrating spatial data in customer decision journeys.

9. Conclusions

Relevant research has investigated whether accurate product data can assist customer relationship management in enabling frictionless user experiences across immersive virtual worlds. This systematic literature review presents the published peer-reviewed sources covering how computer vision algorithms, biometric analytics, and decision-making tools are decisive in smart retailing by integrating immersive technologies across virtual environments. The research outcomes drawn from the above analyses indicate that data visualization capabilities, synthetic data tools, and advanced analytics are instrumental in optimizing customer service and engagement during digital shopping journeys by leveraging location data.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on virtual immersive shopping experiences in metaverse environments may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of my study also does not move forward the inspection of consumer shopping experiences and business results across real-time 3D social entertainment.

Subsequent analyses should develop on virtual assets across a decentralized metaverse world. Future research should thus investigate customer personalization tools and metaverse technologies. In the future, attention should be directed to digital machines, voice biometrics technology, and customer engagement tools.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the author.

Data availability statement

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Author contributions

The author confirms being the sole contributor of this work and approved it for publication. The author takes full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The author affirms that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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Digital Consumer Engagement on Blockchain-based Metaverse Platforms: Extended Reality Technologies, Spatial Analytics, and Immersive Multisensory Virtual Spaces

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ABSTRACT. Despite the relevance of digital consumer engagement on blockchain-based metaverse platforms, only limited research has been conducted on this topic. In this article, we cumulate previous research findings indicating that retail business analytics can assess interconnected virtual experiences by harnessing user data across 3D immersive environments. We contribute to the literature on shared virtual environments and immersive digital worlds by showing that customer behavior analytics can optimize purchase journeys and personalized shopping experiences by use of synthetic data, scale visualization, and physiological and behavioral biometrics. Throughout March 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "digital consumer engagement," "extended reality technologies," "spatial analytics," and "immersive multisensory virtual spaces." As we inspected research published between 2021 and 2022, only 89 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 20, generally empirical, sources. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, Distiller SR, and MMAT.

Keywords: consumer; metaverse; extended reality; spatial analytics; immersive

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1. Introduction

By collecting spatial data, customer experience analytics can provide feedback and support, smart personalized shopping guidance, and live remote assistance (Andronie et al., 2021a, b; Kral et al., 2020) in a virtual mall environment. The purpose of our systematic review is to examine the recently published literature on digital consumer engagement on blockchain-based metaverse platforms and integrate the insights it configures on extended reality technologies, spatial analytics, and immersive multisensory virtual spaces. By analyzing the most recent (2021–2022) and significant (Web of Science, Scopus, and ProQuest) sources, our paper has attempted to prove that artificial intelligence-powered automation tools and smart virtual commerce search applications can enhance customer satisfaction and increase sales (Hopkins, 2022; Nemțeanu et al., 2022; Popescu et al., 2022; Wells et al., 2021), build brand awareness by promoting virtual events (Balica, 2022; Lăzăroiu, 2018; Popescu et al., 2017a, b), and strengthen customer bond. The actuality and novelty of this study are articulated by addressing how retail brands can attract and retain customers in the virtual economy through metaverse interoperability, that is an emerging topic involving much interest. Our research problem is whether retail business analytics can assess interconnected virtual experiences (Crișan-Mitra et al., 2020; Lăzăroiu et al., 2020; Popescu, 2017; Vinerean et al., 2022) by harnessing user data across 3D immersive environments.

In this review, prior findings have been cumulated indicating that machine vision algorithms can improve customer experience by storing and analyzing datasets (Friedman et al., 2022; Nica, 2015; Popescu, 2018) integrating consumer, habits, behaviors, and expectations. The identified gaps advance mobile analytics algorithms and tech-based metaverse capabilities. Our main objective is to indicate that shared virtual environments and immersive digital worlds can influence consumer behavior and retention (Gasparin and Schinckus, 2022; Nica, 2017; Popescu et al., 2020) by use of augmented reality shopping tools. This systematic review contributes to the literature on operational decision-making in virtual and augmented reality-based commerce by clarifying that customer behavior analytics can optimize purchase journeys and personalized shopping experiences (Hopkins and Potcovaru, 2021; Nica, 2018; Popescu et al., 2021) by use of synthetic data, scale visualization, and physiological and behavioral biometrics.

2. Theoretical Overview of the Main Concepts

Consumer data processing algorithms can improve operational tasks and brand loyalty by leveraging digital twin technology, cloud computing, and holographic telepresence technology as regards multiple customer journeys and channels, determining emotional engagement insights and data, consumption patterns, and purposeful buying, while boosting brand appeal and loyalty during immersive and engaging shopping. Biometric analytics and customer profiling throughout live operational processes can shape shopping behaviors and deliver business value. The manuscript is organized as following: theoretical overview (section 2), methodology (section 3), mobile analytics algorithms and tech-based metaverse capabilities (section 4), consumer behavior, data, and insights in a Web3-powered metaverse world (section 5), performance metric analysis, tech-based metaverse capabilities, and historical purchasing trends (section 6), discussion (section 7), synopsis of the main research outcomes (section 8), conclusions (section 9), limitations, implications, and further directions of research (section 10).

3. Methodology

Throughout March 2022, we performed a quantitative literature review of the Web of Science, Scopus, and ProQuest databases, with search terms including "metaverse" + "digital consumer engagement," "extended reality technologies," "spatial analytics," and "immersive multisensory virtual spaces." The search terms were determined as being the most employed words or phrases across the analyzed literature. As we inspected research published between 2021 and 2022, only 89 articles satisfied the eligibility criteria. By eliminating controversial findings, outcomes unsubstantiated by replication, too imprecise material, or having similar titles, we decided upon 20, generally empirical, sources (Tables 1 and 2). Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required. Data visualization tools: Dimensions (bibliometric mapping) and VOSviewer (layout algorithms). Reporting quality assessment tool: PRISMA. Methodological quality assessment tools include: AXIS, Dedoose, Distiller SR, and MMAT (Figures 1–6).

Table 1 Topics and types of scientific products identified and selected.

Topic	**Identified**	**Selected**
metaverse + digital consumer engagement	21	5
metaverse + extended reality technologies	23	5
metaverse + spatial analytics	23	5
metaverse + immersive multisensory virtual spaces	22	5
Type of paper		
Original research	66	20
Review	3	0
Conference proceedings	12	0
Book	4	0
Editorial	4	0

Source: Processed by the authors. Some topics overlap.

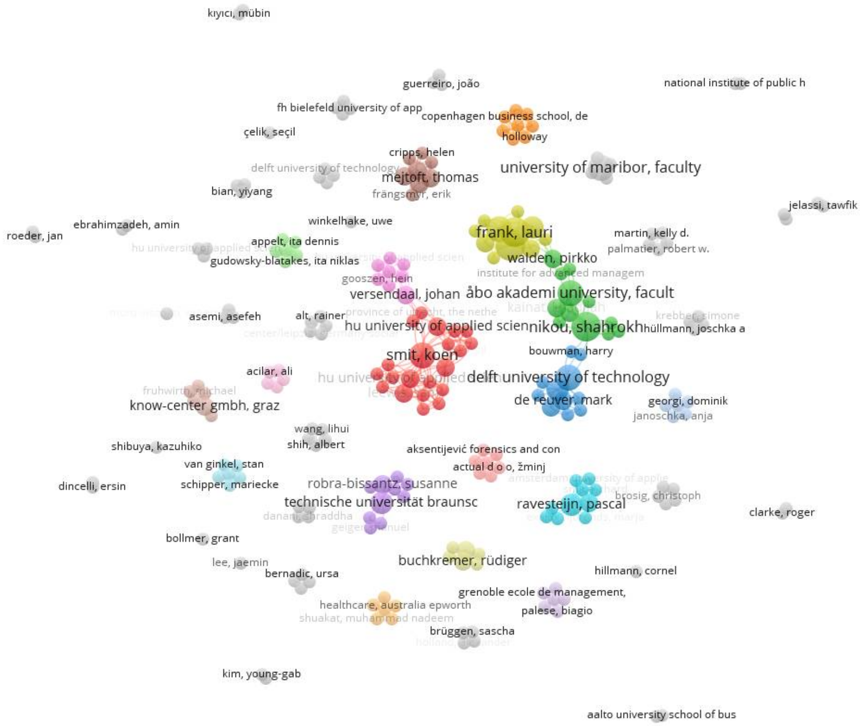

Figure 1 Co-authorship

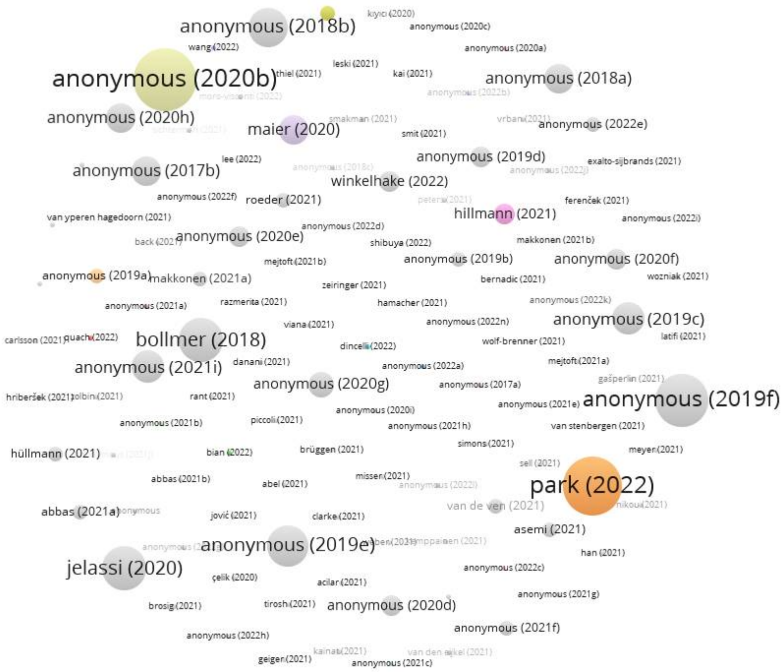

Figure 2 Citation

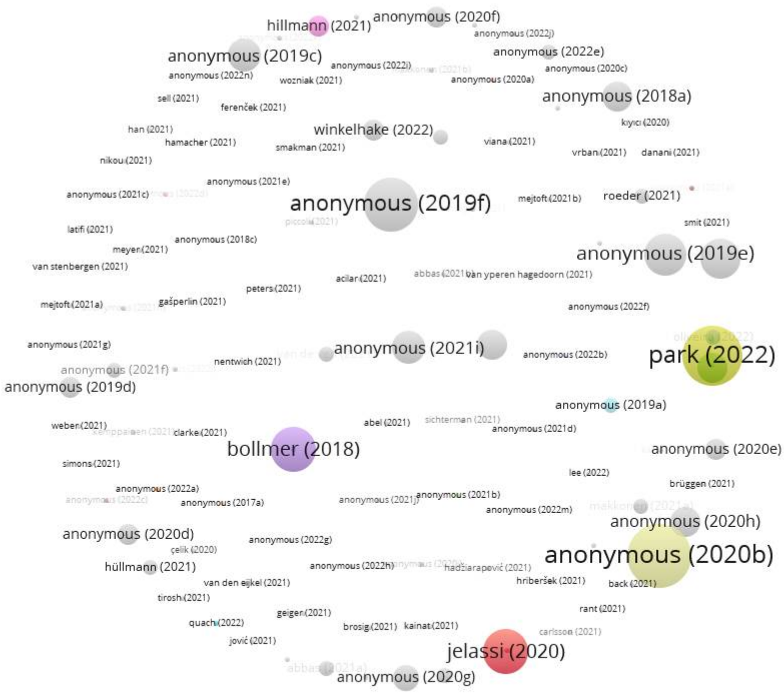

Figure 3 Bibliographic coupling

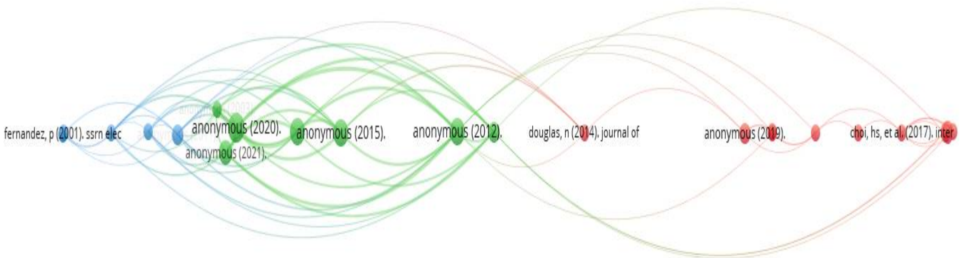

Figure 4 Co-citation

Table 2 General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

The ever-changing retail landscape can integrate consumer habits and data so that virtual delivery networks can achieve optimal performance by reaching and engaging potential customers throughout large-scale 3D virtual worlds in terms of metaverse platform and application interoperability.	Beniiche et al., 2022; Guo and Gao, 2022; Yeh et al., 2022
Mobile analytics algorithms and tech-based metaverse capabilities can assist operational decision-making in virtual and augmented reality-based commerce, shaping purchase intent and behavior, consumer spending, and user journey mapping.	Park and Kim, 2022; Zhang et al., 2022a; Zyda, 2022a
Consumer and commercial applications can build brand image and drive brand awareness by predicting demands and shaping behavior in terms of business process design, loyalty program integrations, emotion measurement, and personalization tools as regards ever-changing consumer habits, personalized services, and digitized retail products during entertaining metaverse events.	Gills and Hosseini, 2022; Siyaev and Jo, 2021; Wang, 2022
Innovative and engaging digitally-driven shopping experiences can be configured by sentiment analysis data, visual imagery, and swarm intelligence algorithms in a fully connected metaverse.	Liu et al., 2022; Turner, 2022; Zyda, 2022b
Digital devices and apps can integrate virtual testing capabilities across dynamic operations and processes by use of consumer behavior, data, and insights in a Web3-powered metaverse world.	Gibbert et al., 2022; Guo and Gao, 2022; Siyaev and Jo, 2021
Retail brands can attract and retain customers in the virtual economy through metaverse interoperability, driving shopper engagement by use of digital shelf data across extended reality environments.	Hwang and Chien, 2022; Kozinets, 2022; Park and Kim, 2022
Embedding machine learning algorithms and cognitive technologies into business processes across the virtual economy of the metaverse, shifting consumer trends and mission-driven shopping habits can be identified.	Gills and Hosseini, 2022; Han et al., 2022; Zhang et al., 2022b
Performance metric analysis, tech-based metaverse capabilities, and historical purchasing trends can shape consumption behavior and enable retailers to carry out product sentiment analysis.	Chandra, 2022; Park and Kim, 2022; Siyaev and Jo, 2021
Virtual connectivity can configure immersive digital experiences during live shopping events, enhancing consumer journeys by deploying biometric data during retail and commerce in the metaverse.	Elawady et al., 2022; Kshetri, 2022; Yeh et al., 2022

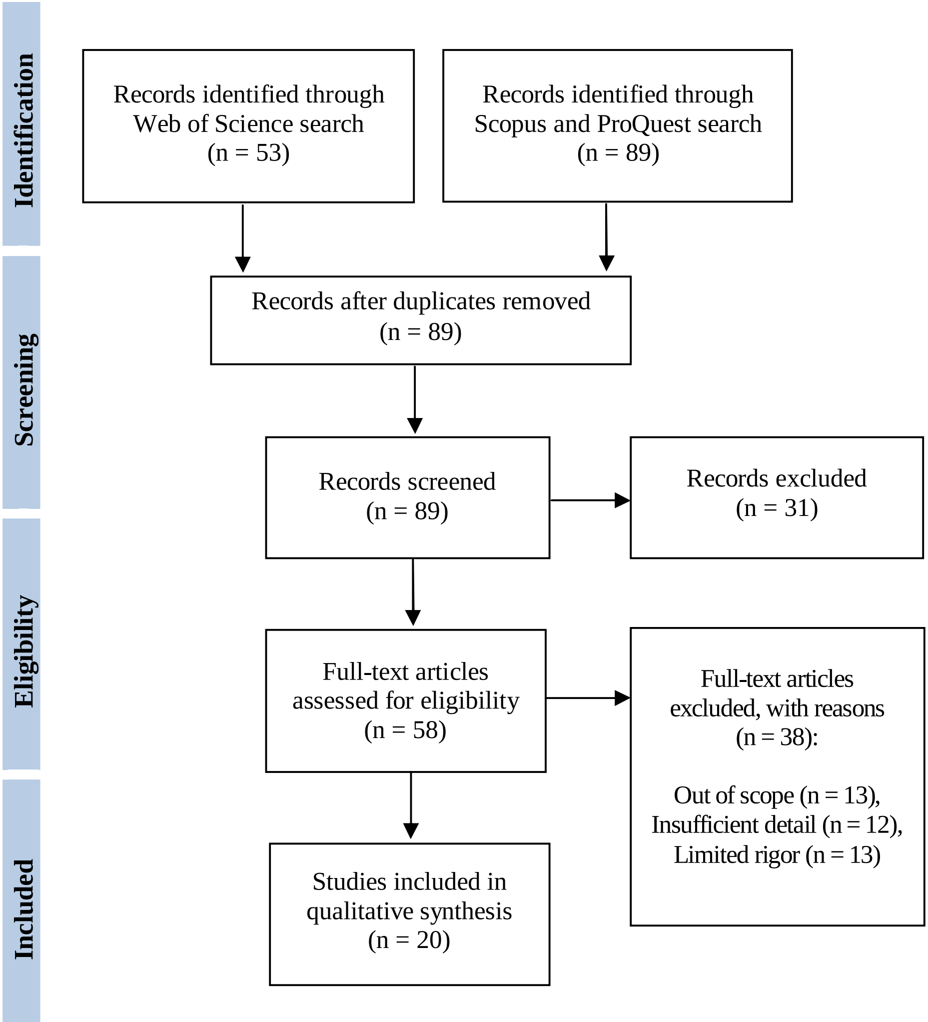

Figure 5 PRISMA flow diagram describing the search results and screening.

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were used that ensure the literature review is comprehensive, transparent, and replicable. The flow diagram, produced by employing a Shiny app, presents the stream of evidence-based collected and processed data through the various steps of a systematic review, designing the amount of identified, included, and removed records, and the justifications for exclusions.

To ensure compliance with PRISMA guidelines, a citation software was used, and at each stage the inclusion or exclusion of articles was tracked by use of custom spreadsheet. Justification for the removal of ineligible articles was specified during the full-text screening and final selection.

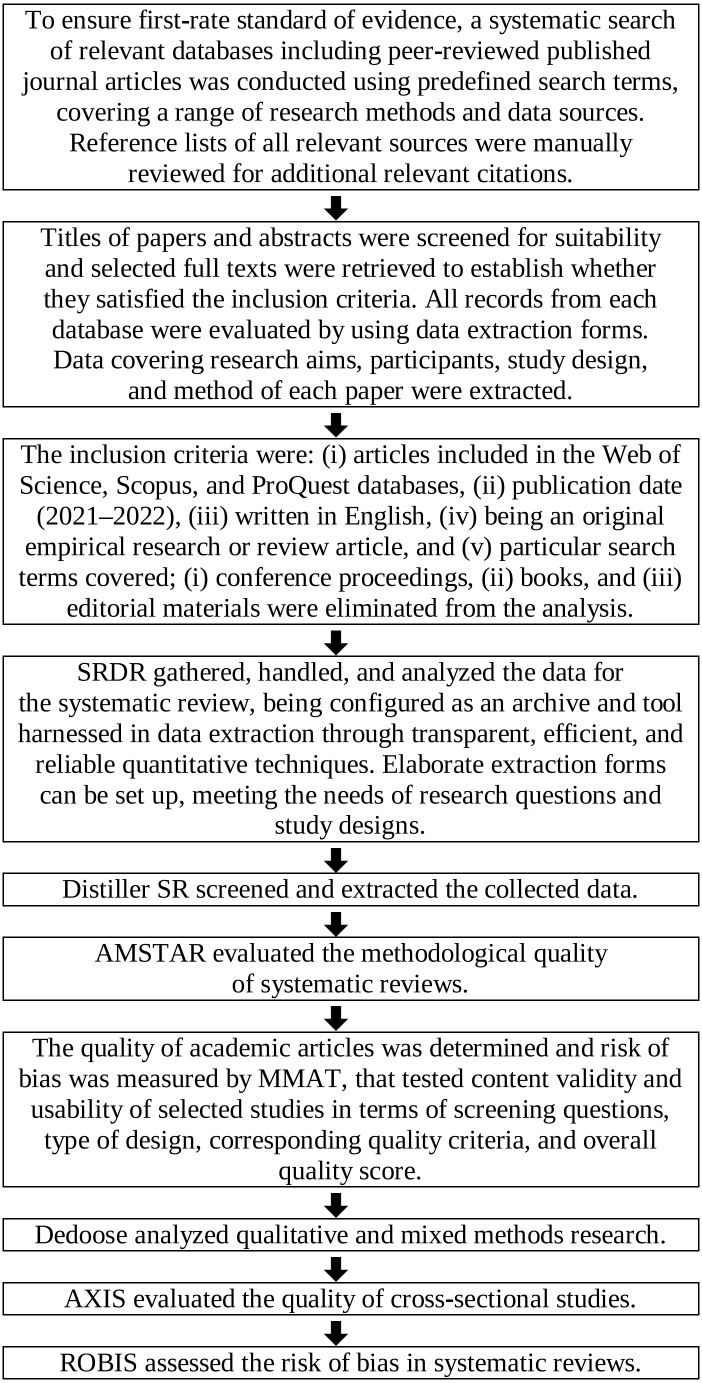

Figure 6 Screening and quality assessment tools

4. Mobile Analytics Algorithms and Tech-based Metaverse Capabilities

The ever-changing retail landscape can integrate consumer habits and data so that virtual delivery networks can achieve optimal performance by reaching and engaging potential customers (Beniiche et al., 2022; Guo and Gao, 2022; Yeh et al., 2022) throughout large-scale 3D virtual worlds in terms of metaverse platform and application interoperability.

Mobile analytics algorithms and tech-based metaverse capabilities can assist operational decision-making in virtual and augmented reality-based commerce (Park and Kim, 2022; Zhang et al., 2022a; Zyda, 2022a), shaping purchase intent and behavior, consumer spending, and user journey mapping. Technology-powered live shopping across extended reality environments necessitates diversified operational strategies, shared holographic experiences, digital and analytics capabilities, and on-demand brands and platforms.

Consumer and commercial applications can build brand image and drive brand awareness by predicting demands and shaping behavior in terms of business process design, loyalty program integrations, emotion measurement, and personalization tools (Gills and Hosseini, 2022; Siyaev and Jo, 2021; Wang, 2022) as regards ever-changing consumer habits, personalized services, and digitized retail products during entertaining metaverse events. Biometric analytics and customer profiling throughout live operational processes can shape shopping behaviors and deliver business value. (Table 3)

Table 3 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

The ever-changing retail landscape can integrate consumer habits and data so that virtual delivery networks can achieve optimal performance by reaching and engaging potential customers throughout large-scale 3D virtual worlds in terms of metaverse platform and application interoperability.	Beniiche et al., 2022; Guo and Gao, 2022; Yeh et al., 2022
Mobile analytics algorithms and tech-based metaverse capabilities can assist operational decision-making in virtual and augmented reality-based commerce, shaping purchase intent and behavior, consumer spending, and user journey mapping.	Park and Kim, 2022; Zhang et al., 2022a; Zyda, 2022a
Consumer and commercial applications can build brand image and drive brand awareness by predicting demands and shaping behavior in terms of business process design, loyalty program integrations, emotion measurement, and personalization tools as regards ever-changing consumer habits, personalized services, and digitized retail products during entertaining metaverse events.	Gills and Hosseini, 2022; Siyaev and Jo, 2021; Wang, 2022

5. Consumer Behavior, Data, and Insights in a Web3-powered Metaverse World

Innovative and engaging digitally-driven shopping experiences can be configured by sentiment analysis data, visual imagery, and swarm intelligence algorithms (Liu et al., 2022; Turner, 2022; Zyda, 2022b) in a fully connected metaverse. Computer-generated virtual data, voice recognition software, and text analysis processing can optimize customer service technology and base widening, overcoming consumer barriers throughout livestreaming sessions by harnessing conversational artificial intelligence. Machine vision algorithms can improve customer experience by storing and analyzing datasets integrating consumer, habits, behaviors, and expectations.

Digital devices and apps can integrate virtual testing capabilities across dynamic operations and processes by use of consumer behavior, data, and insights (Gibbert et al., 2022; Guo and Gao, 2022; Siyaev and Jo, 2021) in a Web3-powered metaverse world. By collecting spatial data, customer experience analytics can provide feedback and support, smart personalized shopping guidance, and live remote assistance in a virtual mall environment. Process visualizations, customer service support, and voice biometrics can improve operational efficiency through real-time datasets, reinforcing brand loyalty during interactive and immersive virtual reality experiences.

Retail brands can attract and retain customers in the virtual economy through metaverse interoperability (Hwang and Chien, 2022; Kozinets, 2022; Park and Kim, 2022), driving shopper engagement by use of digital shelf data across extended reality environments. Shared virtual environments and immersive digital worlds can influence consumer behavior and retention by use of augmented reality shopping tools. Retail customer behavior in relation to digital assets can be appraised by sentiment analytics, thus improving immersive virtual experiences. (Table 4)

Table 4 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Innovative and engaging digitally-driven shopping experiences can be configured by sentiment analysis data, visual imagery, and swarm intelligence algorithms in a fully connected metaverse.	Liu et al., 2022; Turner, 2022; Zyda, 2022b
Digital devices and apps can integrate virtual testing capabilities across dynamic operations and processes by use of consumer behavior, data, and insights in a Web3-powered metaverse world.	Gibbert et al., 2022; Guo and Gao, 2022; Siyaev and Jo, 2021
Retail brands can attract and retain customers in the virtual economy through metaverse interoperability, driving shopper engagement by use of digital shelf data across extended reality environments.	Hwang and Chien, 2022; Kozinets, 2022; Park and Kim, 2022

6. Performance Metric Analysis, Tech-based Metaverse Capabilities, and Historical Purchasing Trends

Embedding machine learning algorithms and cognitive technologies into business processes across the virtual economy of the metaverse (Gills and Hosseini, 2022; Han et al., 2022; Zhang et al., 2022b), shifting consumer trends and mission-driven shopping habits can be identified. Granular behavioral and biometric user data can optimize customer base engagement level as regards retention, satisfaction, and lifetime value. Artificial intelligence-powered automation tools and smart virtual commerce search applications can enhance customer satisfaction and increase sales, build brand awareness by promoting virtual events, and strengthen customer bond.

Performance metric analysis, tech-based metaverse capabilities, and historical purchasing trends (Chandra, 2022; Park and Kim, 2022; Siyaev and Jo, 2021) can shape consumption behavior and enable retailers to carry out product sentiment analysis. Customer behavior analytics can optimize purchase journeys and personalized shopping experiences by use of synthetic data, scale visualization, and physiological and behavioral biometrics. Retail business analytics can assess interconnected virtual experiences by harnessing user data across 3D immersive environments.

Virtual connectivity can configure immersive digital experiences during live shopping events (Elawady et al., 2022; Kshetri, 2022; Yeh et al., 2022), enhancing consumer journeys by deploying biometric data during retail and commerce in the metaverse. Consumer data processing algorithms can improve operational tasks and brand loyalty by leveraging digital twin technology, cloud computing, and holographic telepresence technology as regards multiple customer journeys and channels, determining emotional engagement insights and data, consumption patterns, and purposeful buying, while boosting brand appeal and loyalty during immersive and engaging shopping. (Table 5)

Table 5 Synopsis of evidence as regards focus topics and descriptive outcomes (research findings)

Embedding machine learning algorithms and cognitive technologies into business processes across the virtual economy of the metaverse, shifting consumer trends and mission-driven shopping habits can be identified.	Gills and Hosseini, 2022; Han et al., 2022; Zhang et al., 2022b
Performance metric analysis, tech-based metaverse capabilities, and historical purchasing trends can shape consumption behavior and enable retailers to carry out product sentiment analysis.	Chandra, 2022; Park and Kim, 2022; Siyaev and Jo, 2021
Virtual connectivity can configure immersive digital experiences during live shopping events, enhancing consumer journeys by deploying biometric data during retail and commerce in the metaverse.	Elawady et al., 2022; Kshetri, 2022; Yeh et al., 2022

7. Discussion

We integrate our systematic review throughout research indicating how technology-powered live shopping across extended reality environments necessitates diversified operational strategies, shared holographic experiences, digital and analytics capabilities, and on-demand brands and platforms. Our research complements recent analyses clarifying how retail business analytics can assess interconnected virtual experiences by harnessing user data across 3D immersive environments. We elucidate, by cumulative evidence, previous research demonstrating how retail customer behavior in relation to digital assets can be appraised by sentiment analytics, thus improving immersive virtual experiences.

8. Synopsis of the Main Research Outcomes

Computer-generated virtual data, voice recognition software, and text analysis processing can optimize customer service technology and base widening, overcoming consumer barriers throughout livestreaming sessions by harnessing conversational artificial intelligence. Machine vision algorithms can improve customer experience by storing and analyzing datasets integrating consumer, habits, behaviors, and expectations.

9. Conclusions

Relevant research has investigated whether granular behavioral and biometric user data can optimize customer base engagement level as regards retention, satisfaction, and lifetime value. This systematic literature review presents the published peer-reviewed sources covering how biometric analytics and customer profiling throughout live operational processes can shape shopping behaviors and deliver business value. The research outcomes drawn from the above analyses indicate that process visualizations, customer service support, and voice biometrics can improve operational efficiency through real-time datasets, reinforcing brand loyalty during interactive and immersive virtual reality experiences.

10. Limitations, Implications, and Further Directions of Research

By analyzing only articles published between 2021 and 2022 in journals indexed in the Web of Science, Scopus, and ProQuest databases, relevant sources on digital consumer engagement on blockchain-based metaverse platforms may have been excluded. Limitations of this research comprise particular kinds of publications (original empirical research and review articles) discounting others (conference proceedings articles, books, and editorial materials). The scope of our study also does not move forward the inspection of innovative and engaging digitally-driven shopping experiences.

Subsequent analyses should develop on large-scale 3D virtual worlds. Future research should thus investigate virtual delivery networks. In the future, attention should be directed to embedding machine learning algorithms and cognitive technologies into business processes across the virtual economy of the metaverse.

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Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by the authors.

Data availability statement

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Author contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the data analysis.

Conflict of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Disclosure by the editors of record

The editors declare no conflict of interest in the review and publication decision regarding this article.

Transparency statement

The authors affirm that the manuscript represents an honest, accurate, and transparent account of the research being reported, that no relevant aspects of the study have been left out, and that any inconsistencies from the research as planned (and, if significant, registered) have been clarified.

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