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From publication to attention: mapping the dynamics of scholarly visibility in metaverse-commerce research

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Abstract

Citation counts capture only part of how research travels and the attention that metaverse-commerce scholarship attracts remains poorly understood. This study maps the scholarly visibility of 6,542 metaverse-commerce publications indexed in Dimensions between January 2020 and July 2026, drawing attention data from Altmetric.com and readership data from Mendeley. Following validated digital-object-identifier matching, the study examines how attention varies across six communication channels, research themes, disciplinary fields and access status. A two-part modelling strategy distinguishes the likelihood that a publication receives any attention from the intensity of attention among publications that receive it, while temporal indicators capture differences in the speed of attention accumulation across channels. Attention was widespread but uneven, concentrated on Twitter/X and Mendeley, while news, blogs, Wikipedia and policy reached far fewer works. Twitter/X attention accrued within days and Wikipedia and policy mentions only after months and Engineering was associated with receiving attention but not with its intensity. Open-access publications showed broader coverage on every channel and the most-attended theme was not the most-researched. The study argues that publication productivity and scholarly attention are distinct dimensions of a field and cautions against treating attention as a proxy for quality.

Keywords Altmetrics · Metaverse commerce · Scholarly attention · Research visibility · Attention dynamics · Research dissemination

Introduction

Metaverse-based commerce has moved within a few years from a speculative idea to an active field of enquiry spanning marketing, information systems, computer science, engineering and the social sciences. Immersive and spatial technologies such as virtual reality, augmented reality, mixed and extended reality and the platforms often grouped under the term metaverse are being examined as environments in which shopping, retailing and consumer exchange might be reorganized (Dwivedi et al. 2022; Mystakidis 2022; Weinberger 2022). Early conceptual work on retailing in three-dimensional virtual worlds (Bourlakis et al. 2009; Papagiannidis et al. 2008) has been joined by studies of augmented-reality marketing (Javornik 2016; Rauschnabel et al. 2022), virtual try-on and store experiences (Huang and Liao 2015) and consumer behaviour in metaverse settings (Shen et al. 2021). The result is a literature that is interdisciplinary by construction and that grows across several publication venues at once. Growth in publication counts is, however, only one signal of how a field develops. A count of articles measures productivity; it does not tell us how far those articles travel, who reads them or where they are discussed. Scholarly evaluation has traditionally leaned on citations but citations accrue slowly, are concentrated within academic communities and say little about attention in the wider information ecosystem (Bornmann 2014; Priem et al. 2011). Over the past decade, alternative or complementary indicators commonly termed altmetrics have been proposed to capture the traces that research leaves on social media, news, blogs or on reference managers such as Mendeley, in policy documents and on knowledge infrastructures such as Wikipedia (Adie and Roe 2013; Priem et al. 2011; Sugimoto et al. 2017). These indicators are best understood not as replacements for citations but as measures of different, related dimensions of visibility.

The distinction matters because the various channels record different acts. A Mendeley save reflects an intention to read or cite and is largely an academic signal (Mohammadi et al. 2015); a tweet records rapid, often informal dissemination (Haustein et al. 2014a; Thelwall et al. 2013); a news article or blog post reflects mediated public attention; a policy citation reflects uptake in governance and a Wikipedia link reflects incorporation into a widely used reference layer. Each is shaped by its own conventions and populations, so a publication that is prominent on one channel may be invisible on another. Treating these signals as interchangeable or collapsing them into a single number read as impact, obscures more than it reveals (Bornmann 2014; Costas et al. 2015). Metaverse-commerce is an unusually informative context in which to examine these dynamics. Because the field draws simultaneously on business and marketing, on computer science and engineering and on social-scientific accounts of technology and consumption, it lets us observe how attention is distributed across disciplines within a single and reasonably bounded research area. It also combines topics with strong public and industry salience (blockchain and non-fungible tokens, digital fashion and virtual try-on, privacy and platform governance) with more specialized technical work, so

the gap between what is heavily researched and what is heavily attended to can be studied directly.

Despite this, there is little domain-specific evidence on how online scholarly attention is actually distributed within metaverse-commerce research: across the major altmetric channels and over time, across research themes and disciplines, between open-access and subscription publications and between receiving any attention and accumulating more of it. General cross-disciplinary altmetric studies establish broad patterns (Costas et al. 2015; Zahedi et al. 2014) but cannot speak to the internal structure of an emerging, multidisciplinary commerce field. This gap is consequential for several audiences. Researchers need to know what altmetric signals mean before citing them in narratives of reach; publishers weigh dissemination and open-access strategy; universities and funders increasingly consult these indicators in evaluation and editors benefit from understanding how different disciplines and themes attract attention (Wilsdon et al. 2017). This study addresses that gap by mapping the online attention accumulated by a large corpus of metaverse-commerce publications. It is organized around four research questions:

RQ1: How has metaverse-commerce research evolved in publication volume and disciplinary composition during the study period?

RQ2: How does scholarly attention vary across communication channels, research themes and geographical contexts and how quickly does attention accumulate across these channels?

RQ3: Which publication, disciplinary and accessibility characteristics are associated with the likelihood that a publication receives scholarly attention?

RQ4: Which publication, disciplinary and accessibility characteristics are associated with the intensity of scholarly attention among publications that receive attention?

The contribution is threefold. Empirically, the study provides domain-specific evidence on the channel-specific distribution and timing of altmetric attention in metaverse-commerce research, based on 6,542 publications and validated DOI matching. Methodologically, it applies a transparent two-part model that separates whether a work attracts any attention from how much it attracts, treating the Altmetric Attention Score (AAS) as a weighted composite rather than an ordinary count. Conceptually, it argues that publication productivity, scholarly readership, social-media dissemination, public and policy visibility and research quality are related but non-identical dimensions of a field's development and that none should be read as a proxy for another.

Literature review and conceptual background

Altmetrics and scholarly attention

The case for looking beyond citations rests on a simple observation: citations are a lagging, academically internal indicator that captures a narrow slice of how research is used and discussed (Bornmann 2014). The altmetrics manifesto proposed that the digital traces research leaves elsewhere (shares, saves, mentions, links) could complement citation analysis by revealing attention that is faster and broader in origin (Priem et al. 2011). Subsequent work refined the claim considerably. Altmetric indicators correlate only weakly to moderately with citations and the strength of that relationship varies by field and by platform and which implies that they measure something related to but distinct from scholarly impact (Costas et al. 2015; Thelwall and Nevill 2018; Zahedi et al. 2014). Reviews of the area therefore frame altmetrics as indicators of attention and in some cases of societal reach rather than of quality (Bornmann 2014; Sugimoto et al. 2017). What altmetrics do not capture is equally important. Attention is not endorsement: a work may be shared because it is contested, topical or promotable rather than because it is sound (Bornmann 2014). Platform coverage is uneven across disciplines and time and the composition of altmetric activity shifts as online environments change (Haustein et al. 2014b). These cautions frame the present study: we describe and model attention as an observed phenomenon and avoid inferring quality or causal influence from it.

Attention channels and what they record

Altmetric channels differ in the populations that generate them and in the acts they record. Mendeley readership is generated largely by researchers and students and behaves as a reading-and-citing signal that accumulates relatively steadily. Analyses of Mendeley user categories show that saves are concentrated among academic users, which makes readership a more scholarly indicator than most social channels (Mohammadi et al. 2015). Social media and Twitter/X in particular, function as rapid dissemination infrastructure as mentions appear quickly after publication and are shaped by networks, topicality and promotion as much as by content (Eysenbach 2011; Haustein et al. 2014a; Thelwall et al. 2013). News, blogs, Wikipedia and policy channels represent yet other forms of visibility. News and blog coverage reflects mediated public attention and editorial selection. Wikipedia links reflect incorporation into a widely consulted reference layer and policy mentions reflect uptake in governance documents. These channels typically cover far fewer works than social media or readership and they operate on different timescales. The composite AAS produced by Altmetric.com weights these sources differently, which is why it is best treated as a weighted composite indicator rather than a simple count of mentions (Adie and Roe 2013).

Open access, discipline and the distribution of attention

Accessibility is one plausible correlate of attention. Work that can be read without a subscription is easier to share, cite in a blog or link from a reference page. A substantial literature debates whether open access is associated with greater citation impact and finds mixed but often positive associations (Bornmann 2014; Costas et al. 2015; Piwowar et al. 2018). For altmetric attention specifically, the accessibility argument is more direct, because most altmetric acts (tweeting, blogging, editing a reference page) presuppose access to the work itself. Prior cross-disciplinary work reports that open-access articles tend to show broader altmetric coverage, though the size of the advantage varies by channel (Zahedi et al. 2014). Disciplinary and thematic positioning add a further layer. Fields differ in their online cultures as some communities are heavy adopters of social media, others are not and humanities scholarship has been shown to attract attention through different channels than the sciences (Hammarfelt 2014). Within an interdisciplinary field such as metaverse-commerce, disciplinary provenance and thematic content may therefore correspond with different attention patterns, independent of scholarly quality. Foundational treatments of media attention and diffusion, namely agenda setting (McCombs and Shaw 1972), uses and gratifications (Katz et al. 1973), the elaboration likelihood model (Petty and Cacioppo 1986) and diffusion of innovations (Rogers 2003) offer vocabulary for describing why some topics travel faster than others but in an observational design they can inform interpretation without licensing causal claims.

Metaverse-commerce as a multidisciplinary domain and the research gap

Metaverse-commerce research inherits an early line of work on retailing and money-making in virtual worlds (Bourlakis et al. 2009; Papagiannidis et al. 2008), extended by service-quality perspectives on three-dimensional retail (Gadalla et al. 2013), typologies of virtual-world users (Hassouneh and Brengman 2014) and technology-acceptance accounts of augmented reality (Huang and Liao 2015; Javornik 2016). More recent contributions define and problematize the metaverse itself (Dwivedi et al. 2022; Mystakidis 2022; Weinberger 2022), examine advertising and marketing in immersive settings (Kim 2021; Rauschnabel et al. 2022), review consumer behaviour and virtual-commerce design (Shen et al. 2021) and analyse security and privacy in metaverse platforms (Wang et al. 2022; Yang et al. 2022). The field is thus genuinely multidisciplinary, combining business and marketing scholarship with computer science and engineering. Yet the existing altmetric literature is overwhelmingly cross-disciplinary in scope and does not describe how attention is structured inside a single emerging commerce domain. We do not know, for metaverse-commerce specifically, how scholarly attention is distributed across communication channels, whether publication productivity corresponds to attention across research themes, whether disciplinary fields differ

systematically in their likelihood and intensity of attention, or whether the timing of attention varies substantially between social, scholarly, media and institutional channels. These questions are important because receiving attention and accumulating substantial attention are not necessarily the same outcome. The present study therefore examines scholarly visibility as a multidimensional and channel-specific phenomenon rather than treating altmetric attention as a single aggregate outcome. The four research questions above are designed to close this gap through description and associational modelling rather than causal inference.

Research method

Data sources and corpus construction

The study combines three data infrastructures. Bibliographic records were drawn from Dimensions, which provides broad coverage of journal articles, conference papers and book chapters together with linked metadata (Hook et al. 2018). Attention data were obtained from Altmetric.com, which tracks mentions across social media, news, blogs, policy documents, Wikipedia and other sources and summarizes them in the weighted Altmetric Attention Score (AAS). Scholarly readership was measured using Mendeley reader counts. Mendeley readership is treated as a separate scholarly readership indicator and is not included in the calculation of the Altmetric Attention Score (AAS). Open-access status was determined using Unpaywall information as surfaced through Dimensions. Records were retrieved in July 2026 for publications dated January 2020 to July 2026. The full extraction and corpus-construction protocol is set out in Table 1.

Table 1 Data extraction and corpus-construction protocol

Component	Specification
Bibliographic database	Dimensions
Altmetric source	Altmetric.com (Altmetric Attention Score and platform indicators)
Scholarly readership source	Mendeley (reader counts)
Open-access information	Unpaywall (via Dimensions)
Search period	January 2020 – July 2026
Retrieval date	26th July, 2026
Search fields	Title, abstract, keywords
Immersive-technology terms	metaverse, virtual world, virtual/augmented/mixed/extended reality, spatial computing
Commerce terms	shopping, retail, commerce, e-commerce, consumer purchase, virtual store
Language	English
Document types	Journal articles, conference papers, book chapters
Initial records retrieved	9,247

Component	Specification
After duplicate removal	7,400
Final analytical corpus	6,542
DOI-bearing records	6,397 (97.8%); 6,384 unique DOIs after normalization
DOI-matching procedure	Normalisation and de-duplication; match to Altmetric.com; manual validation of 100 records (97% accuracy)
Theme classification	Non-exclusive assignment to seven themes by predefined rules
Statistical software	SPSS 28; R 4.2.1 (two-part, gamma, robustness models)

The DOI-bearing subset (N = 6,397) is the denominator for platform-coverage analyses; 6,384 unique normalized DOIs arise from 13 duplicate DOI occurrences across records. Source: compiled by authors

Search strategy, screening and eligibility

Searches were conducted in titles, abstracts and keywords, combining the immersive-technology and commerce concept sets listed in Table 1, restricted to English-language journal articles, conference papers and book chapters. Corpus construction followed a PRISMA-style workflow with four stages (identification, screening, eligibility and inclusion), in which every excluded record was assigned to a single, predefined exclusion category so that the pathway reconciles exactly to the final corpus (Page et al. 2021). The flow is depicted in Fig. 1. Identification returned 9,247 records from Dimensions, from which 1,847 duplicates were removed, leaving 7,400 records for screening. Title- and abstract-level screening excluded 610 records across six predefined categories: 197 not metaverse-related, 299 not commerce- or consumer-related, 49 technical metaverse work without consumer relevance, 25 editorials, letters or retracted items, 31 duplicate publications identified after initial de-duplication and nine with insufficient metadata. The 6,790 remaining records underwent full-text eligibility assessment and a further 248 were excluded for not meeting the eligibility criteria, yielding a final analytical corpus of 6,542 publications. The step-by-step counts are reported in Table 2 and the operational decision rules used to assign each exclusion category are set out in Table 3.

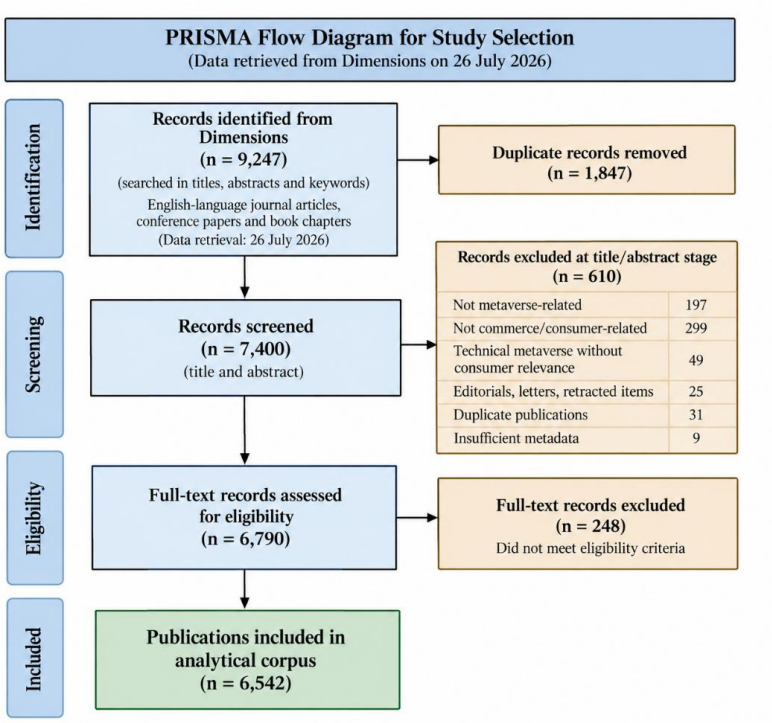


Fig. 1 PRISMA-style flow of identification, screening, eligibility and inclusion. Source: compiled by authors

Table 2 Identification and screening steps

Identification and screening step	n excluded	n remaining
Records retrieved from Dimensions	–	9,247
Duplicate records removed	1,847	7,400
Title/abstract screening: not metaverse-related	197	7,203
Not commerce/consumer-related	299	6,904
Technical metaverse without consumer relevance	49	6,855
Editorials, letters, retracted items	25	6,830
Duplicate publications	31	6,799
Insufficient metadata	9	6,790
Full-text eligibility exclusions	248	6,542
Final analytical corpus		**6,542**

Publications dated January 2020 to July 2026; retrieved July 2026. English-language journal articles, conference papers and book chapters. Steps reconcile exactly to the final corpus of 6,542. Source: compiled by authors

Table 3 Exclusion criteria and operational decision rules

Exclusion category	Operational decision rule
Not metaverse-related	Record does not address immersive or virtual environments per the immersive-technology term set.
Not commerce/consumer-related	No commerce, retail or consumer-behaviour or purchase focus per the commerce term set.
Technical without consumer relevance	Purely technical or engineering treatment (e.g. rendering, networking) with no consumer or commercial application.
Editorial/retracted	Editorials, letters, notes, errata or retracted items.
Duplicate	Same work identified after initial de-duplication (shared DOI, title or metadata).
Insufficient metadata	Missing fields required for analysis (e.g. year, document type or discipline).

Each excluded record was assigned to exactly one category, applied hierarchically in the order listed. Source: compiled by authors

DOI reconciliation and Altmetric matching

Because Altmetric.com links attention to works through digital object identifiers (DOIs), attention-level analyses use the DOI-bearing subset of the corpus. Of the 6,542 publications, 6,397 (97.8%) carried a DOI. DOIs were normalized and de-duplicated, which reduced the 6,397 DOI-bearing records to 6,384 unique normalized identifiers, reflecting 13 duplicate DOI occurrences across records. The two figures are complementary rather than contradictory: 6,397 is the count of DOI-bearing publication records and 6,384 is the count of distinct DOIs among them. Consistent with the data documentation, the publication-level denominator used for platform-coverage percentages is 6,397. Matching accuracy was assessed by manually validating a random sample of 100 DOI linkages, of which 97 were correct and three were mismatches, an accuracy of 97 per cent. DOI reconciliation is summarized in Table 4.

Table 4 DOI reconciliation and linkage validation

Dataset measure	N
Analytical corpus (all included publications)	6,542
DOI-bearing publication records (coverage denominator)	6,397
Unique normalized DOI identifiers	6,384
Duplicate DOI occurrences across records	13
Manually validated linkages	100
Correct linkages / mismatches	97 / 3
Validation accuracy	**97%**

Coverage percentages use the DOI-bearing denominator (N = 6,397). Unique normalized DOIs (6,384) differ from DOI-bearing records (6,397) because of 13 duplicate DOI occurrences. Source: compiled by authors

Theme classification, discipline and variables

Each DOI-linked publication was assigned to one or more of seven predefined themes (blockchain and NFT commerce, sustainability, virtual try-on, store design, privacy and security, social commerce and regulatory) using predefined classification rules applied to titles, abstracts and keywords (Table 5). Assignment was non-exclusive: a publication addressing, for example, both virtual try-on and privacy could be counted under both themes. Thematic counts therefore do not sum to the corpus total and must not be read as mutually exclusive shares. Publications not matching any theme rule were placed in an Unclassified residual category, which is a distinct grouping rather than an eighth substantive theme and is not directly comparable with the classified themes. The classification rules were applied consistently across titles, abstracts and author keywords, with a publication assigned to a theme when its metadata satisfied the corresponding predefined thematic criteria.

Table 5 Indicative concepts for thematic classification

Theme	Indicative concepts/terms used for classification
Blockchain & NFT commerce	Blockchain, NFT, non-fungible token, crypto-assets, digital assets, blockchain-based commerce
Sustainability	Sustainability, green commerce, environmental impact, circular economy
Virtual try-on	Virtual try-on, AR try-on, virtual fitting, digital fitting
Store design	Virtual store, immersive store, virtual retail environment, store design
Privacy & security	Privacy, cybersecurity, data security, identity/security risks
Social commerce	Social commerce, social shopping, social media commerce, influencer/community commerce
Regulatory	Regulation, governance, legal framework, compliance, policy

Source: compiled by authors

Disciplinary positioning was derived from Dimensions field metadata and grouped, on a one-discipline-per-publication basis, into Computer Science, Business & Management, Engineering, Social Sciences, Arts & Humanities and Other/Interdisciplinary, with Arts & Humanities used as the reference category in the regression models. Unlike the thematic scheme, the disciplinary grouping is mutually exclusive and its counts sum to the corpus of 6,542. Additional variables used in modelling were open-access status (open access vs. subscription), the natural logarithm of the Journal Impact Factor (JIF), an indicator of international collaboration and publication age. The dependent constructs were, first, whether a publication received any recorded attention and, second, the AAS among publications with a positive score. Mendeley reader counts were analysed as a separate readership channel.

Statistical analysis

Analyses were conducted in SPSS 28 and R 4.2.1. Descriptive coverage was computed as the percentage of DOI-linked publications with at least one mention on each channel, overall and by access status; the relative open-access advantage on each channel (the attention factor) is the ratio of open-access to subscription coverage (IBM Corp 2021; R Core Team 2022). Open-access and subscription AAS distributions were compared using the Mann–Whitney U test with a rank-biserial effect size, because AAS is strongly right-skewed. Each theme was compared with its complement (publications not assigned to that theme) on AAS ranks using Mann–Whitney tests, with Benjamini–Hochberg correction applied across the seven comparisons to control the false-discovery rate (Benjamini and Hochberg 1995).

The primary multivariable analysis used a two-part model, estimated on journal articles only (n = 3,847) because a comparable JIF is available for journal articles but not for conference papers or book chapters. The first stage is a logistic regression for the probability of receiving any attention; the second is a gamma regression with a log link for attention intensity among publications with a positive score (Cragg 1971). This specification is appropriate because AAS is a weighted composite with a large mass at zero and a right-skewed positive part, which an ordinary count model does not represent well. For the same reason, negative binomial and zero-inflated negative binomial models are reported only as sensitivity analyses, alongside ordinary least squares on raw and log-transformed AAS, robust M-estimation and a single-part gamma model. Variance-inflation factors were inspected to check for multicollinearity. Throughout, estimates are interpreted as associational; the observational design does not support causal claims.

Results

Evolution of publication output and disciplinary composition (RQ1)

Metaverse-commerce research expanded steadily across the study window. Annual output rose from 98 publications in 2020 to 319 in 2021, 765 in 2022, 1,273 in 2023, 1,454 in 2024 and 1,669 in 2025; the 2026 figure of 964 covers only January to July and is a partial-year value that is not comparable with the complete years and is excluded from any growth interpretation. The trajectory across the six complete years is one of sustained and accelerating growth, consistent with the emergence of a new field rather than a short-lived surge. Annual volume by discipline is shown in Fig. 2 and detailed in Table 6. Disciplinary composition was led by Computer Science (2,053 publications; 31.4% of the corpus) and Business & Management (1,757; 26.9%), followed by Engineering (1,108; 16.9%), Social Sciences (980; 15.0%), Arts & Humanities (474; 7.2%) and Other/Interdisciplinary work (170; 2.6%). This ordering held across the study period and every disciplinary

group grew over the complete years, confirming that metaverse-commerce is not the property of a single discipline but a genuinely shared research area.

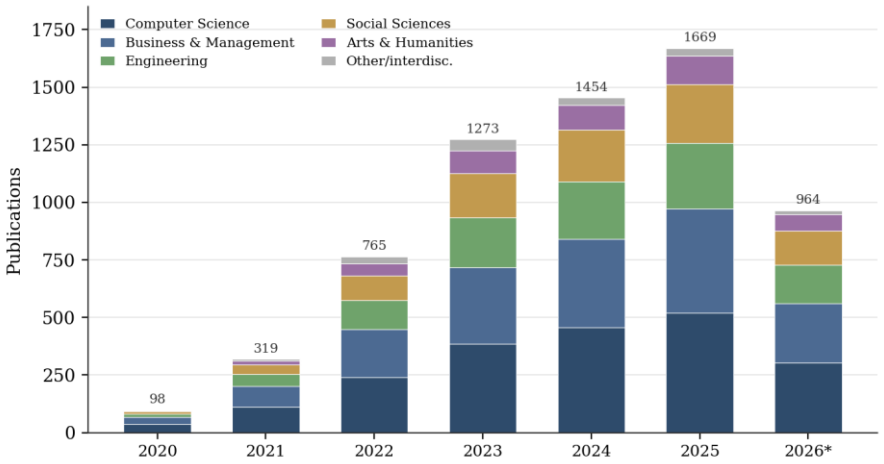


Fig. 2 Annual publication volume of metaverse-commerce research by discipline, 2020–July 2026 (N = 6,542). Source: compiled by authors

Table 6 Publication volume by discipline and year (N = 6,542)

Discipline	2020	2021	2022	2023	2024	2025	2026*	Total
Computer Science	37	110	241	386	456	521	302	2,053
Business & Management	29	91	208	332	386	451	260	1,757
Engineering	14	53	126	215	249	285	166	1,108
Social Sciences	11	40	107	192	224	257	149	980
Arts & Humanities	5	17	53	99	107	122	71	474
Other/interdisc.	2	8	30	49	32	33	16	170
Total	**98**	**319**	**765**	**1,273**	**1,454**	**1,669**	**964**	**6,542**

Disciplinary assignment is mutually exclusive (one discipline per publication); row and column totals sum to the analytical corpus of 6,542. 2026* is a partial year (January–July) and is excluded from growth interpretation. Source: compiled by authors

Distribution of attention across platforms (RQ2)

Attention was widespread but highly uneven across channels. Among the 6,397 DOI-linked publications, 71.2 per cent received at least one mention on some tracked source, so roughly three in ten works recorded no online attention at all. Coverage was concentrated on two channels: Twitter/X reached 62.4 per cent of publications and Mendeley 48.6 per cent. The remaining channels covered far smaller shares: blogs 15.8 per cent, news 11.3 per cent, Wikipedia 2.8 per cent and policy 2.6 per cent. In other words, the most common forms of recorded attention are rapid social sharing and scholarly readership, whereas mediated public attention (news, blogs) and institutional visibility (Wikipedia, policy) reach only a minority

of the literature. Coverage by channel and access status is reported in Table 7 and visualized in Fig. 3.

Table 7 Platform-specific altmetric coverage and open-access comparison (N = 6,397 DOI-linked publications)

Source	Any (%)	OA (%)	Subscription (%)	Factor
Any altmetric source	71.2	86.5	59.7	1.45
Twitter/X	62.4	83.2	46.7	1.78
Mendeley	48.6	59.2	40.6	1.46
Blogs	15.8	26.6	7.7	3.45
News	11.3	20.9	4.1	5.10
Wikipedia	2.8	4.5	1.5	3.00
Policy	2.6	3.9	1.6	2.44

Any altmetric source = at least one mention on a tracked source. Factor = OA coverage ÷ subscription coverage. OA = open access. Source: compiled by authors

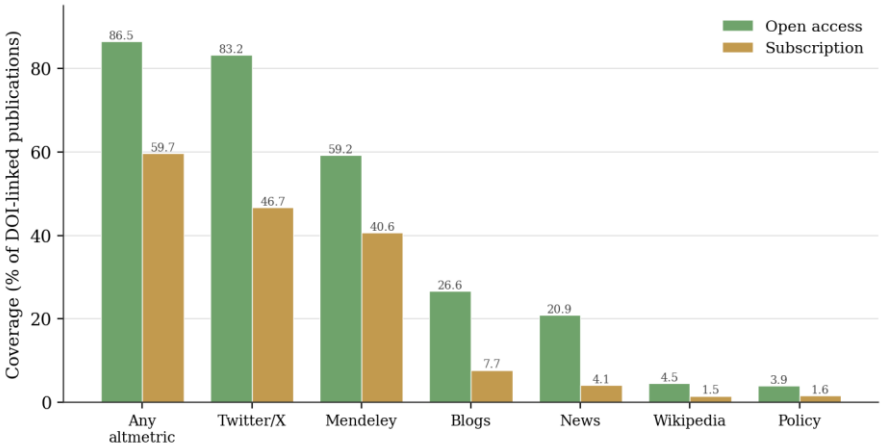


Fig. 3 Open-access and subscription altmetric coverage by attention channel. Values are the percentage of DOI-linked publications with at least one mention on each channel, shown separately for open-access and subscription publications. Data: Altmetric.com and Unpaywall via Dimensions (N = 6,397). Source: compiled by authors

Attention across research themes (RQ2)

Because thematic assignment is non-exclusive, theme counts overlap and do not sum to the corpus. The most heavily researched classified theme was virtual try-on (n = 1,539; 24.1% of DOI-linked publications), followed by store design (n = 1,319; 20.6%) and blockchain and NFT commerce (n = 1,221; 19.1%). Coverage told a different story: blockchain and NFT commerce recorded the highest coverage among classified themes at 87.4 per cent, ahead of sustainability (79.2%) and virtual try-on (76.8%), while regulatory research had the lowest classified-

theme coverage at 56.4 per cent. The theme attracting the broadest attention was therefore not the theme with the largest publication count, an early indication that productivity and attention are distinct. Theme statistics are reported in Table 8.

Table 8 Research-theme distribution and attention indicators (DOI-linked publications)

Theme	n (%)	Coverage (%)	Mean AAS	Mean cites	Median AAS
Blockchain & NFT commerce	1,221 (19.1)	87.4	14.2	21.4	8
Sustainability	675 (10.6)	79.2	12.6	10.8	6
Virtual try-on	1,539 (24.1)	76.8	10.8	16.2	5
Store design	1,319 (20.6)	72.6	9.6	13.2	5
Privacy & security	1,006 (15.7)	68.4	8.4	14.6	4
Social commerce	568 (8.9)	62.8	7.8	10.4	3
Regulatory	336 (5.3)	56.4	6.4	8.6	2
Unclassified (residual)	1,565 (24.5)	58.2	13.6	8.2	4

AAS = Altmetric Attention Score; cites = citations. Source: compiled by authors

Percentages use the DOI-linked denominator and the Unclassified category is a residual grouping, not a substantive theme; its high mean AAS (13.6) reflects a small number of very high-scoring works and a distinct, non-comparable composition and its median AAS (4) is unremarkable. It should not be compared with the classified themes as though classification were exhaustive and is excluded from thematic interpretation.

Ranked comparisons of each theme against its complement, with Benjamini–Hochberg correction, are reported in Table 9. Blockchain and NFT commerce (adjusted $p < .001$, $r = .12$), sustainability (adjusted $p = .002$, $r = .08$) and virtual try-on (adjusted $p = .042$, $r = .04$) showed significantly higher AAS ranks than their respective complements after adjustment; the effect sizes are small. Store design, privacy and security, social commerce and regulatory did not differ significantly from their complements. These tests concern AAS ranks and are not direct tests of the descriptive mean AAS values in Table 8 and they establish rank differences rather than causal effects.

Table 9 Theme-versus-complement comparisons of AAS ranks (Mann–Whitney U, Benjamini–Hochberg adjusted)

Theme	Mann-Whitney U	Z	Adj. Sig. (B–H)	r
Blockchain & NFT commerce	2,780,754	−6.53	< .001	.12
Sustainability	1,776,681	−3.40	.002	.08
Virtual try-on	3,588,702	−2.37	.042	.04
Store design	3,248,473	−1.68	.162	.03
Privacy & security	2,684,556	−0.50	.614	.01
Social commerce	1,688,545	.79	.503	−.02

Theme	Mann-Whitney U	Z	Adj. Sig. (B–H)	r
Regulatory	1,069,160	1.55	.171	−.05

Each theme compared with its complement (publications not assigned to that theme). r = rank-biserial effect size. Adjusted p controls the false-discovery rate across the seven comparisons. Source: compiled by authors

Open-access and subscription differences (RQ3)

Open-access publications showed broader coverage than subscription publications on every channel examined and higher attention scores overall. Of the DOI-linked works, 2,751 were open access and 3,646 subscription. Median AAS was 8 for open-access publications (IQR 3–22) against 4 for subscription publications (IQR 1–12), a median difference of 4. The Mann–Whitney comparison was statistically significant ($U = 3{,}911{,}757$, $z = -15.09$, $p < .001$), with a small-to-moderate rank-biserial effect size of .22 (95% CI [.19, .25]).

The relative open-access advantage was largest on precisely the channels that cover the fewest works. As Fig. 4 shows, the attention factor (open-access coverage divided by subscription coverage) was 5.10 for news and 3.45 for blogs, meaning open-access works were roughly five times and three-and-a-half times as likely to receive news and blog coverage, respectively. The factor was 3.00 for Wikipedia and 2.44 for policy and smaller for the high-coverage channels of Twitter/X (1.78) and Mendeley (1.46). The overall any-altmetric factor was 1.45.

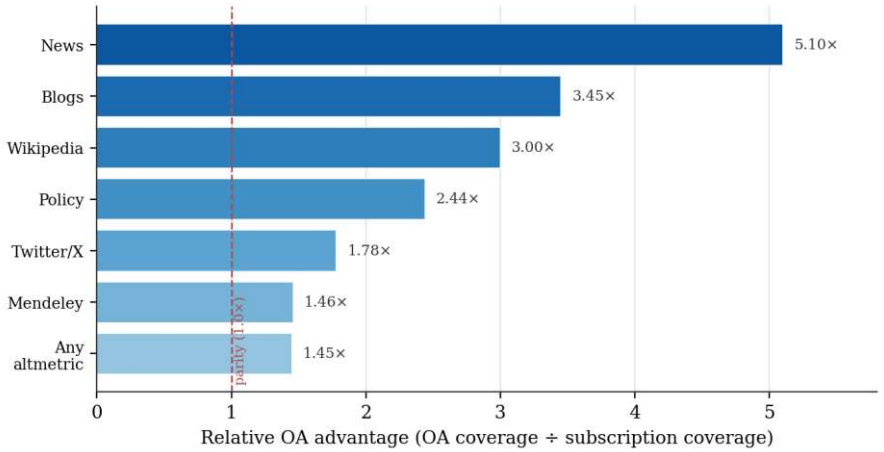


Fig. 4 Relative open-access advantage (attention factor) by attention channel. Attention factor = OA coverage ÷ subscription coverage; the dashed line marks parity (1.0×). Data: Altmetric.com and Unpaywall via Dimensions. Source: compiled by authors

Probability and intensity of scholarly attention (RQ3, RQ4)

The two-part model separates the probability that a publication receives any attention (Stage 1, RQ3) from the intensity of attention among publications that

receive it (Stage 2, RQ4). The model, estimated on journal articles (n = 3,847) with Arts & Humanities as the reference discipline, is reported in Table 10. In Stage 1 (probability of any attention), open access showed the strongest association (OR = 2.48, 95% CI [2.14, 2.87], p < .001), followed by Computer Science (OR = 2.01, [1.63, 2.48], p < .001), log JIF (OR = 1.78, [1.57, 2.02], p < .001), Business & Management (OR = 1.72, [1.42, 2.08], p < .001), international collaboration (OR = 1.58, [1.36, 1.83], p < .001), Engineering (OR = 1.35, [1.08, 1.69], p = .009) and publication age (OR = 1.21, [1.15, 1.27], p < .001). Social Sciences (OR = 1.21, [.95, 1.54], p = .122) and Other/Interdisciplinary (OR = .96, [.68, 1.35], p = .808) were not statistically significant.

In Stage 2 (intensity among positive-score publications, n = 2,846), the same predictors remained positive and significant: open access exp(b) = 1.39 ([1.28, 1.51], p < .001), log JIF exp(b) = 1.33 ([1.24, 1.42], p < .001), Computer Science exp(b) = 1.28 ([1.15, 1.42], p < .001), Business & Management exp(b) = 1.21 ([1.09, 1.34], p < .001), international collaboration exp(b) = 1.19 ([1.10, 1.29], p < .001) and publication age exp(b) = 1.16 ([1.11, 1.21], p < .001). Engineering was not significant in Stage 2 (exp(b) = 1.10, [.98, 1.23], p = .107), indicating that its association with whether a work attracts attention did not extend to how much attention it attracts. Social Sciences and Other/Interdisciplinary were again non-significant. The Stage 1 model was significant overall ($\chi^2(9) = 412.7$, p < .001; McFadden pseudo-R^2 = .094; AIC = 5,896); Stage 2 dispersion was .82 (AIC = 8,954); and all variance-inflation factors were below 2.4.

Table 10 Two-part model of scholarly attention for journal articles (n = 3,847)

Predictor	Stage 1: Logistic regression (any attention)				Stage 2: Gamma GLM, log link (AAS > 0)			
	Exp(B)	95% C.I. for Exp(B)		Sig.	Exp(B)	95% C.I. for Exp(B)		Sig.
		Lower	Upper			Lower	Upper	
Open access	2.48	2.14	2.87	< .001	1.39	1.28	1.51	< .001
Log JIF	1.78	1.57	2.02	< .001	1.33	1.24	1.42	< .001
International collaboration	1.58	1.36	1.83	< .001	1.19	1.10	1.29	< .001
Publication age	1.21	1.15	1.27	< .001	1.16	1.11	1.21	< .001
Computer Science	2.01	1.63	2.48	< .001	1.28	1.15	1.42	< .001
Business & Management	1.72	1.42	2.08	< .001	1.21	1.09	1.34	< .001
Engineering	1.35	1.08	1.69	.009	1.10	.98	1.23	.107
Social Sciences	1.21	.95	1.54	.122	1.06	.94	1.20	.348
Other/Interdisciplinary	.96	.68	1.35	.808	.94	.78	1.13	.506

Reference discipline: Arts & Humanities. Stage 1 = logistic regression for probability of any attention (n = 3,847; $\chi^2(9) = 412.7$, p < .001; McFadden pseudo-R^2 = .094; AIC = 5,896). Stage 2 = gamma regression with log link for attention intensity among positive-score publications (n = 2,846; dispersion = .82; AIC = 8,954). All VIF < 2.4. OR = odds ratio; JIF = Journal Impact Factor. Estimates are associational. Source: compiled by authors

Sensitivity analyses, reported in Table 11, confirmed the direction and significance of the two focal associations under alternative distributional and transformation choices. The open-access and log-JIF coefficients remained positive and significant across ordinary least squares on raw and log-transformed AAS, robust M-estimation, negative binomial, zero-inflated negative binomial and single-part gamma specifications.

Table 11 Sensitivity analyses for the open-access and journal-quality associations

Model	Statistic	OA			Log JIF			Role
		Estimate	95% CI		Estimate	95% CI		
			Lower	Upper		Lower	Upper	
OLS, raw AAS	B	8.42	5.67	11.17	4.31	2.98	5.64	Sens.
OLS, ln(AAS+1)	B	.41	.32	.50	.28	.21	.35	Sens.
Robust M-estimation	B	7.96	5.34	10.58	3.98	2.72	5.24	Sens.
Negative binomial	IRR	1.52	1.38	1.67	1.29	1.19	1.40	Sens.
Zero-inflated neg. binomial	IRR	1.48	1.34	1.63	1.27	1.17	1.38	Sens.
Gamma (single-part)	exp(b)	1.36	1.26	1.47	1.31	1.22	1.40	Sens.
Two-part, Stage 1	OR	2.48	2.14	2.87	1.78	1.57	2.02	Primary
Two-part, Stage 2	exp(b)	1.39	1.28	1.51	1.33	1.24	1.42	Primary

All coefficients $p < .001$. Sens. = sensitivity analysis. AAS is a weighted composite; negative binomial and zero-inflated negative binomial models are therefore sensitivity checks. AIC comparisons are meaningful only within comparable model families. IRR = incidence-rate ratio; OR = odds ratio. Source: compiled by authors

Channel-specific attention dynamics and geographic coverage (RQ2)

Channels differed markedly in the timing of first mentions among works with usable timestamps. Twitter/X mentions appeared soonest, with a median first mention at 5 days (IQR 2–12) and a median of 78 per cent of eventual mentions accrued by day 30, indicating rapid early accumulation. Blogs (median 10 days; 55% by day 30) and news (median 14 days; 45% by day 30) followed, while Mendeley readership accrued more gradually (median 18 days; 52% by day 30). Wikipedia (median 120 days) and policy (median 180 days) mentions appeared much later and had accrued only 12 per cent and 8 per cent of eventual mentions by day 30. The channels therefore operate on distinct temporal scales: days for Twitter/X, days to weeks for blogs, news and Mendeley and months for Wikipedia and policy. These figures describe channel-specific patterns of attention accumulation; the timing data do not establish causal diffusion mechanisms such as agenda setting or early-adopter behaviour. Diffusion indicators are reported in Table 12.

Table 12 Temporal diffusion indicators by attention channel

Platform	n	Median first mention (days)	IQR	Median share by day 30
Twitter/X	3,850	5	2–12	78%
Mendeley	2,940	18	8–45	52%
News	420	14	7–35	45%
Blogs	580	10	4–28	55%
Wikipedia	95	120	60–240	12%
Policy	85	180	90–365	8%

Based on Altmetric.com timestamp data for the subset with usable timestamps. Eventual mentions are those recorded through the July 2026 extraction. Percentages are medians across publications with at least one mention on the relevant platform. Source: compiled by authors

Geographic coverage, calculated within the DOI-linked publications associated with each region, was highest for North America (74.2%), followed by Europe (66.8%) and Asia (64.2%). The English-language scope of the corpus may contribute to these regional differences, so the geographic pattern is interpreted descriptively rather than as evidence of differential underlying attention.

Discussion

The findings can be read directly against the four research questions. On RQ1, the corpus documents a field in sustained expansion, growing across every complete year of the study and drawing contributions from computer science, business and management, engineering and the social sciences. As the later analyses show, this disciplinary breadth coincides with pronounced differences in attention, a point developed under RQ3 and RQ4.

On RQ2, attention was widespread but uneven and its distribution is highly channel-specific. That roughly seven in ten works received some attention while three in ten received none and that coverage was concentrated on Twitter/X and Mendeley, is consistent with the broader altmetric literature: social media provides rapid, wide dissemination and reference managers capture scholarly readership, whereas news, blogs, Wikipedia and policy record scarcer and more selective forms of visibility (Mohammadi et al. 2015; Sugimoto et al. 2017; Thelwall et al. 2013). The temporal indicators add a further dimension to this unevenness: channels differ not only in how many works they reach but in how quickly attention arrives. Twitter/X accrued most of its eventual mentions within a month, while Wikipedia and policy mentions appeared only after long lags. In the vocabulary of diffusion and attention research, social channels behave as fast, front-loaded environments and institutional channels as slow, cumulative ones (Rogers 2003), but the observational design means these are descriptions of timing, not demonstrations of a diffusion mechanism or of agenda setting (McCombs and Shaw 1972).

The thematic results speak to RQ2 and yield the study's clearest conceptual signal. The most-researched classified theme (virtual try-on, n = 1,539) was not the most-attended: blockchain and NFT commerce had the highest classified-theme coverage (87.4%) despite a smaller publication count. Rank comparisons confirmed that blockchain and NFT commerce, sustainability and virtual try-on attracted significantly higher AAS ranks than their complements, though with small effect sizes, while the other themes did not differ significantly. Productivity and attention are therefore related but non-identical: a field can accumulate many publications on a topic that attracts comparatively modest online attention and a topic with strong public and industry salience can attract disproportionate attention on a thinner publication base. The Unclassified residual, whose high mean AAS sits alongside an unremarkable median, is a reminder that composite attention scores are heavily skewed and that means can mislead when read without medians and without regard to how a category was defined.

On RQ3, access status was one of several characteristics associated with visibility: open-access publications showed broader coverage on every channel and higher AAS overall and the multivariable model placed open access among the strongest correlates of both the probability and the intensity of attention. Two features deserve emphasis. First, the relative open-access advantage was largest on the mediated public channels (news, 5.10×; blogs, 3.45×), where coverage is otherwise scarce, which fits the intuition that accessibility matters most where the act of attention presupposes reading the work and where coverage is not already near-universal. Second, this is an association, not a demonstration that open access causes attention; open-access works may differ systematically in topic, venue and promotion and the design cannot separate accessibility from these correlates (Bornmann 2014; Costas et al. 2015).

Also under RQ3 and RQ4, journal impact factor, international collaboration and publication age were positively associated with attention in both model stages and disciplinary positioning mattered: Computer Science and Business & Management were positively associated with both the probability and intensity of attention relative to Arts & Humanities, Engineering with the probability but not the intensity and Social Sciences and Other/Interdisciplinary with neither. The disciplinary differences are consistent with the observation that online attention cultures vary across fields (Hammarfelt 2014) and that altmetric coverage is unevenly distributed across disciplines (Haustein et al. 2014b).

Taken together, the four questions describe a single structure rather than four separate findings. A field that is expanding and disciplinarily broad (RQ1) does not attract attention evenly or at the same pace across channels and themes (RQ2); the unevenness follows access status, discipline and journal characteristics, which are associated with whether a work receives any attention (RQ3) and, not always in the same way, with how much attention it accumulates (RQ4). The same open-access and disciplinary gradients that appear in the descriptive coverage reappear, adjusted for correlates, in the two-part model. Two methodological features give these

convergences their weight and also mark their limits. The two-part specification treats visibility as two related but distinct processes: crossing the threshold of receiving any attention and accumulating attention beyond it. The Engineering result, significant in the first stage but not the second, shows that the characteristics associated with initial discoverability are not necessarily those associated with subsequent intensity, a distinction a single-equation model would blur. The battery of alternative specifications leaves the open-access and journal-quality associations directionally unchanged, so these are not artefacts of one distributional choice. What none of this establishes is a mechanism. The design is observational and the estimates associational; the study can show that access status, discipline and theme travel with attention, but not that they produce it and it deliberately stops short of the diffusion, agenda-setting or early-adopter claims that the timing patterns might otherwise invite.

Theoretical and practical implications

Theoretical contributions

The study's conceptual contribution is to render, with domain-specific evidence, the distinction between the several dimensions along which scholarly work becomes visible. Metaverse-commerce research travels through at least five partly independent attention ecosystems: scholarly readership, captured by Mendeley; social-media dissemination, captured by Twitter/X; mediated public visibility, captured by news and blogs; policy visibility; and knowledge-infrastructure visibility, captured by Wikipedia. The data show that a publication's standing in one ecosystem is a limited guide to its standing in another: coverage on the high-reach channels is common while coverage on the institutional channels is rare, the open-access advantage differs sharply by channel and the most-researched theme is not the most-attended. This supports a compact conceptual claim: research production, scholarly attention, societal visibility and research quality are related but non-identical and no single indicator can stand in for the others (Bornmann 2014; Priem et al. 2011; Sugimoto et al. 2017).

Read this way, altmetrics are best understood as measures of differentiated visibility rather than as a unitary alternative to citations. The finding that themes with strong public salience (blockchain and NFTs, sustainability) attract attention out of proportion to their publication base is consistent with the idea that topical resonance shapes what circulates (Katz et al. 1973; Petty and Cacioppo 1986) and the channel-specific timing patterns are consistent with diffusion accounts of how novelty spreads (Rogers 2003). The study does not propose a new theory; it uses these established perspectives to interpret an observed structure of attention and to argue that evaluative frameworks should treat visibility as multidimensional. In doing so it extends general altmetric findings (Costas et al. 2015; Zahedi et al. 2014) into the specific setting of an emerging multidisciplinary commerce field, suggesting that domain context shapes how the dimensions of visibility relate.

Practical implications

Because this is a study of how metaverse-commerce research travels rather than of consumer behaviour, its practical value lies in how different actors read and act on the evidence base, not in prescribing commercial tactics the data cannot support. Read in that spirit, the findings translate into specific, behaviour-level guidance for five groups. The recurring caution is that recorded attention indexes visibility, not quality or commercial merit, so each recommendation concerns how to use the evidence and none should be taken as a claim that attention causes outcomes.

Marketing researchers and academic authors should change three concrete habits. First, when reporting the reach of their own work, they should disaggregate rather than cite a single Altmetric Attention Score, separating scholarly readership (Mendeley) from social sharing (Twitter/X) and mediated public coverage (news, blogs), because these index different audiences and a high composite score is usually driven by the first two. Second, they should not infer topic importance from attention volume: the field's most-attended theme (blockchain and NFT commerce) is not its most-researched (virtual try-on), so authors mapping where a subfield stands should read productivity and attention as separate signals. Third, where licensing and funding permit, they should treat open-access deposit as a discoverability decision, since open-access status was associated with broader coverage on every channel and most strongly on the public-facing channels.

Managers and marketing practitioners in retail and consumer firms who scan the research literature for evidence on immersive commerce should adjust how they weight what they find. Attention-ranked reading lists will over-represent topics that circulate well on social media (blockchain, NFTs, sustainability) and under-represent quieter but heavily researched areas such as store design and privacy and security. Practitioners should therefore build evidence reviews around the volume and substance of research on a topic rather than its altmetric prominence and should not read a high attention score as a signal that a technology is commercially proven. The disciplinary spread of the corpus is a further prompt to draw on computer-science and engineering evidence, not only business and marketing sources, when scoping an immersive-commerce initiative.

Platform firms and publishers that host or disseminate this research can act on the accessibility pattern directly. Because the open-access advantage was largest on precisely the channels where coverage is otherwise scarce (news and blogs), making work openly available and investing in plain-language summaries, structured metadata and DOI hygiene are the levers most consistent with wider reach into public-facing channels; the 97.8 per cent DOI-bearing rate in this corpus shows that identifier completeness is a realistic operational target.

Policymakers and research funders should treat altmetric evidence as a supplement, not a shortcut. Policy and Wikipedia mentions reached under 3 per cent of this literature and accrued only after long lags, so absence of policy attention is a weak signal about a body of work's relevance and should not be used to deprioritize funding. Where funders report reach, they should follow

responsible-metrics practice and present a basket of indicators with explicit caveats rather than a single attention figure (Wilsdon et al. 2017). For universities and research evaluators the same discipline applies internally: because channels are unevenly available across disciplines (Social Sciences and interdisciplinary work showed no significant attention advantage, while Computer Science and Business & Management did), evaluating scholars against a common attention benchmark would penalise fields with quieter online cultures rather than lower-quality work. Editors, finally, should calibrate expectations about a submission's likely visibility to its discipline and theme rather than to a single journal-wide standard. Across every group, one principle holds: attention is not quality and the two must not be conflated.

Limitations

Several limitations bound the interpretation of these results. The design is observational, so all estimates are associational and none establishes causation. The corpus was built from Dimensions and restricted to English-language records, which constrains coverage and may shape the geographic pattern, so the higher North American coverage should not be read as evidence of differential underlying attention. Attention-level analyses depend on DOIs and on Altmetric.com coverage, both of which are incomplete: works without DOIs are excluded from coverage analysis and channels vary in how comprehensively Altmetric tracks them. The social-media ecosystem is itself changing and Twitter/X data in particular reflect a platform whose accessibility and conventions have shifted over the study window. Thematic classification is non-exclusive and rule-based, so themes overlap and the residual Unclassified category is not comparable with the classified themes. AAS is a weighted composite rather than a conventional count, which is why the two-part and gamma specifications are primary and the count models are only sensitivity checks; the composite's strong skew also means means must be read alongside medians. The 2026 observation is a partial year (January–July) and is excluded from growth interpretation. Online attention may reflect positive, neutral, critical or otherwise ambiguous engagement; the available altmetric data do not permit the direction or sentiment of attention to be determined consistently. Online attention is therefore not a measure of societal impact or research quality and the study makes no such claim.

Conclusion

Metaverse-commerce research has grown quickly, but this study set out to look past the sheer number of publications and ask a different question: once a field's work exists, how far does it actually travel and through which routes? The answer is that attention is real but unevenly spread. Most of a publication's early visibility comes from rapid sharing on social media and from being saved by other researchers, while coverage in the news, on blogs, in policy documents and on

reference infrastructures such as Wikipedia remains the exception rather than the rule. Attention also operates on different temporal scales across these channels: social sharing arrives within days, whereas policy and Wikipedia mentions arrive months later. The analysis further indicates that scholarly visibility has both an incidence dimension and an intensity dimension: the factors associated with attracting any attention are not necessarily identical in practical importance to those associated with accumulating greater attention. Open-access research tends to reach more of these audiences and the difference is felt most keenly on the public-facing channels where visibility is otherwise hardest to earn. The wider lesson is that a field grows along more than one axis at a time. Productivity, readership, public conversation, policy uptake and scholarly quality are related but separate stories and the topics that dominate the publication record are not always the ones that capture the most attention. Reading these signals together, rather than folding them into a single figure, gives a fuller picture of how an emerging area of scholarship makes its way into the world. To look beyond citations, then, is not to set them aside but to place them among the several traces that research leaves: each partial, each informative and none a substitute for careful judgement about the work itself.

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Data availability The bibliographic and altmetric data used in this study were obtained from Dimensions and Altmetric.com. Because these datasets are subject to database and platform access restrictions, the complete underlying dataset cannot be publicly redistributed. The search strategy, corpus-construction procedure, analytical definitions and statistical procedures are reported in sufficient detail to facilitate replication subject to access to the relevant databases.

Declarations

Ethics approval This study analysed secondary bibliographic records and scholarly-attention metadata obtained from research information platforms. It did not involve direct recruitment of human participants, human-subject interventions, or the collection of identifiable private information from participants. Formal ethics committee approval was therefore not sought. No institutional review board or ethics committee approval number is applicable. The applicability of institutional ethics-review requirements should be determined in accordance with the relevant institutional policies.

Consent to participate Not applicable. This study did not involve the recruitment or participation of human subjects. The analysis was conducted using secondary bibliographic and scholarly-attention metadata.

Consent for publication Not applicable. This study does not report identifiable individual participant information.

Research standards The study was conducted using secondary bibliographic and scholarly-attention data, with attention to transparent data handling, accurate reporting, and responsible research practices. The Declaration of Helsinki is not applicable because the study did not involve human participants.

Competing interests The authors declare no conflicts of interest.

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