

Team Size Moderates the Citation Association of High-Output- Country Participation: A Large-Scale Informetric Analysis

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Research Article

Keywords: Team size, High-output-country participation, Research collaboration, Citation impact, Informetrics, Research evaluation

Posted Date: October 29th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11280109/v1>

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Additional Declarations: No competing interests reported.

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Compliance with Ethical Standards

Ethical Approval

This study does not involve human participants, clinical experimentation, or the collection of primary data from individuals. The research is based exclusively on secondary data obtained from the CMIE ProwessIQ database and the National Stock Exchange of India(NSE). Accordingly, ethical approval relating to human participants was not required for this study.

Informed Consent

Not applicable. This study does not involve human participants, surveys, interviews, or the collection of personal or identifiable information from individuals.

Conflict of Interest

The authors declare no conflicts of interest that could have influenced the conduct, analysis, interpretation, or reporting of this research.

Funding

This research received no funding.

Author Contributions

The first author contributed to the conceptualization and design of the study, data collection, data analysis, interpretation of results, and manuscript preparation. The second author contributed to the literature review, research design, validation of the analysis, and critical revision of the manuscript. Both authors reviewed and approved the final manuscript.

Consent for Publication

Not applicable. This study does not contain any individual-level information or material requiring consent for publication.

Data Availability Statement

Subject to the applicable database licensing and access conditions, further information regarding the data and variables used in the study may be obtained from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Abstract

Team size and country composition are central to interpreting differences in collaboration-related citations, yet their joint association remains poorly understood. This study examines whether team size moderates the citation association of high-output-country (HOC) participation while distinguishing country-output status from country and affiliation diversity. Resource complementarity and signal dilution offer competing expectations about how this association varies with team size. The analysis covers 60,403 co-authored articles with two to five authors, published in 49 Scopus-indexed Business, Management, and Accounting journals between January 1966 and April 2025. Negative binomial models account for citation overdispersion and include journal and five-year publication-block fixed effects, as well as article-level controls. Across binary and weighted HOC measures, the interaction between team size and HOC participation is negative and statistically significant. Model predictions indicate that the citation advantage associated with HOC participation in smaller teams declines and can reverse as team size increases. This pattern persists across specifications incorporating different diversity and institutional terms, although the interaction is not statistically significant for annualized citations. The study identifies team size as a boundary condition on the HOC–citation association and highlights the importance of distinguishing team scale, geographical diversity, and country-output status in bibliometric research evaluation.

Keywords: Team size; High-output-country participation; Research collaboration; Citation impact; Informetrics; Research evaluation

JEL classifications: I23; C25; O30

1. Introduction

Interpreting collaboration-related citation differences requires distinguishing between the size of a research team, its geographical composition, and the research-output status of the countries represented. Evidence that team authorship and international collaboration are associated with citations does not establish whether these characteristics reinforce one another (Wuchty, Jones, & Uzzi, 2007; Larivière, Gingras, Sugimoto, & Tsou, 2015; Rousseau & Ding, 2016). This raises an informetric question relevant to research evaluation: does team size (TS) strengthen or weaken the citation association of high-output-country (HOC) participation? This study examines the relationship within Business, Management, and Accounting (BMA) research while considering diversity in countries and affiliations. HOC participation refers to authors' country affiliations classified by research output; it does not establish the reputation or quality of individual collaborators.

Research on collaboration and citation performance provides the foundation for this question (Aman, 2016; Payumo et al., 2017; Abramo, D'Angelo, & Di Costa, 2019; Ronda-Pupo & Katz, 2016; Larivière, Haustein, & Börner, 2015). Work on authorship scaling, collaboration processes, and citation networks further motivates the examination of how citation associations vary with team composition and scale (Ronda-Pupo, 2017; Hartley, 2016; Gazni & Thelwall, 2014; Jonsen et al., 2013; Nerur, Rasheed, & Pandey, 2016). Studies of national research participation, rankings, and collaborator composition provide reasons to distinguish geographical diversity from country-output status (Glänzel, 2001; Black et al., 2017; Cummings & Hoebink, 2017; Bajwa & König, 2019; Freeman & Huang, 2015). These characteristics capture different features of collaboration: teams with similar country diversity can differ in HOC participation, and a domestic team can include HOC authors, whereas an international team may include none. The unresolved issue is whether the citation association associated with HOC participation varies with TS, and how that pattern relates to general collaboration diversity.

BMA provides an empirical setting in which to examine this distinction. Existing studies document institutional output and journal internationalization (Chan, Fung, & Leung, 2006; Ellis & Zhan, 2011; Koseoglu, 2016; Aïssaoui & Geringer, 2018), accounting co-authorship and citation patterns (Endenich & Trapp, 2016; Tucker, Parker, & Merchant, 2016; Uyar, Kılıç, & Köseoğlu, 2020; Gaunt, 2014), and national publication contexts and journal representation (Hussain, Liu, Wang, & Zuo, 2015; Annisette, Cooper, & Gendron, 2018). Research addressing language, internationalization, and developing-country scholarship further contextualizes differences in participation and visibility (Horn, 2017; Cooke, Wood, Wang, & Veen, 2019; Andrikopoulos, Bekiaris, Vadasi, & Zounta, 2016; Moses & Hopper, 2022; Negash, Lemma, & Samkin, 2019). This literature establishes the relevance of collaboration and geographical participation, but leaves the interaction between TS and HOC participation insufficiently specified. Examining that interaction addresses the broader problem of interpreting collaboration indicators in citation analysis, while the empirical conclusions remain bounded by the disciplinary setting and team sizes studied.

Resource-access and quality-signaling arguments offer competing expectations about this interaction. Participation from established research environments may be associated with access to scholarly networks, greater exposure, and perceived credibility (Aïssaoui, Geringer, & Livanis, 2020; Ryazanova, McNamara, & Aguinis, 2017). Resource complementarity suggests that additional collaborators could help realize these benefits. Alternatively, overlapping resources and reduced signal salience may make HOC participation less distinctive as teams expand. These arguments motivate testing moderation; the bibliometric measures do not directly observe the proposed mechanisms.

The study analyzes 60,403 co-authored articles published in 49 Scopus-indexed BMA journals between January 1966 and April 2025, with teams ranging from two to five authors. HOC status requires a country to have an annual output of at least three articles and an output rank at or above the 90th percentile. Participation is measured through both the presence of authors affiliated with qualifying countries and their proportion of the author team. Negative binomial models accommodate citation overdispersion and include TS, HOC participation, and their interaction, together with journal and five-year publication-block fixed effects and article-level controls. Alternative specifications examine country and affiliation diversity, high-output-institution (HOI) participation, and citation outcomes. Additional checks assess the sensitivity of baseline relationships.

The principal finding is a negative interaction between TS and HOC participation across four related count-model specifications. Model predictions indicate an HOC citation advantage in smaller teams that declines and can reverse as TS increases. This pattern persists across specifications with different diversity and institutional terms, although those comparisons do not conclusively isolate HOC specificity. The interaction remains negative under alternative citation outcomes, but statistical support weakens for annualized citations (AC). The study contributes to informetric research by examining country-output status alongside collaboration diversity and identifying TS as a boundary condition on its citation association. The finding concerns the estimated difference associated with HOC participation and does not imply that larger teams necessarily receive fewer citations overall. For research evaluation, it supports interpreting team scale, geographical diversity, and country-output status jointly when assessing collaboration-related citation differences.

Section 2 develops theoretical arguments and hypotheses. Section 3 describes the data, measures, and models. Section 4 reports the findings and robustness analyses. Section 5 discusses implications, limitations, and directions for future research.

2. Theoretical Background, Literature Review, and Hypothesis Development

2.1 Collaboration Research in BMA and the Unresolved Interaction

Research on collaboration in BMA research examines institutional productivity, publication patterns, internationalization, and co-authorship networks. Studies of institutional output and journal participation document differences across countries and universities (Chan, Fung, &

Leung, 2006; Ellis & Zhan, 2011; Koseoglu, 2016; Aïssaoui & Geringer, 2018). Accounting research examines co-authorship arrangements, institutional networks, and authorship and citation trends (Endenich & Trapp, 2016; Tucker, Parker, & Merchant, 2016; Uyar, Kılıç, & Köseoğlu, 2020; Gaunt, 2014). Other contributions address national publication contexts and representation in leading journals (Hussain, Liu, Wang, & Zuo, 2015; Annisette, Cooper, & Gendron, 2018).

These studies establish the relevance of collaboration structure and geographical participation, but leave a more specific question unresolved: Does TS alter the citation association of HOC participation? Evidence that TS and international collaboration are separately associated with citations does not establish whether their combination produces additional benefits. The present study examines this interaction while distinguishing country-output status from country and affiliation diversity. Its theoretical focus is whether the resources associated with HOC participation retain their value as the team expands.

2.2 HOC Collaboration and Citation Performance

HOC participation may be associated with citation performance because research resources and opportunities for scholarly visibility are unevenly distributed across countries. Resource-dependency reasoning suggests that collaboration can provide access to infrastructure and established scholarly networks beyond those available to an author independently (Aïssaoui, Geringer, & Livanis, 2020). Authors based in high-output countries may be better positioned to access these resources, although country-output status does not establish the resources or reputation of any individual collaborator.

Access to established scholarly networks may increase a paper's opportunities to reach relevant readers and enter subsequent research conversations. This pathway concerns exposure and dissemination; it does not imply that country affiliation independently determines research quality or guarantees additional citations.

A related signaling argument concerns perceived credibility. Ryazanova, McNamara, and Aguinis (2017) examine research performance as a quality signal in academic labor markets. Extending this reasoning, association with an established research environment may contribute to a paper's perceived credibility. This extension is a theoretical proposition, distinct from the resource-access argument and not a direct measure of author reputation.

Research on collaboration and citation performance provides relevant empirical context (Aman, 2016; Payumo et al., 2017; Abramo, D'Angelo, & Di Costa, 2019; Ronda-Pupo & Katz, 2016; Larivière, Haustein, & Börner, 2015). Studies of national co-authorship patterns, journal rankings, and scholarly representation further contextualize differences between research environments (Glänzel, 2001; Black et al., 2017; Cummings & Hoebink, 2017). These arguments motivate a positive HOC association; Section 2.4 considers whether it varies with TS.

H1: HOC collaboration is positively associated with citation performance.

2.3 HOC Status Beyond General Collaboration Diversity

Country diversity and country-output status describe different aspects of collaboration. Diversity concerns the distribution of authors across countries; HOC status concerns whether represented countries meet an output-based classification. Teams with comparable diversity can therefore differ in HOC participation. Conversely, a domestic team can include HOC authors (e.g., all authors are from the HOC country only), while an international team need not include any. The resource-access argument consequently predicts that HOC status carries information not fully captured by diversity alone.

For example, two equally balanced, two-country teams have the same diversity profile even if only one includes a qualifying country with high output. Their opportunities for scholarly exposure may nevertheless differ.

Research on the geographical concentration of academic production motivates this distinction (Bajwa & König, 2019). Freeman and Huang (2015), examining ethnic co-authorship, show why collaborator composition warrants attention beyond aggregate measures of collaboration. Their findings provide indirect evidence rather than a direct test of country-output status.

Studies addressing non-English nativeness (Horn, 2017), international human resource management (Cooke, Wood, Wang, & Veen, 2019), and international collaboration in auditing (Andrikopoulos, Bekiaris, Vadasi, & Zounta, 2016) concern distinct dimensions of academic and organizational internationalization. Research on developing-country scholarship provides further context for uneven participation and visibility in research (Moses & Hopper, 2022; Negash, Lemma, & Samkin, 2019). Together, these perspectives motivate the separation of composition from output status. Comparisons across specifications with different diversity

controls provide evidence relevant to this distinction, but do not conclusively identify its underlying mechanism.

H2: The association between HOC collaboration and citation performance is not fully accounted for by country and affiliation diversity.

2.4 TS as a Boundary Condition on the HOC–Citation Relationship

TS may alter the value associated with HOC participation. The study by Wuchty, Jones, and Uzzi (2007) documents the citation advantage of team-authored research. Combined with the resource-access argument, this suggests a potential complementarity: additional collaborators could help a team use the networks and infrastructure associated with HOC participation more effectively. However, separate positive associations do not establish that TS strengthens the HOC association.

An alternative argument predicts attenuation. As additional collaborators contribute networks and expertise, access associated with HOC participation may become less distinctive. Where these resources overlap, expanding the team need not proportionately increase the incremental benefit of HOC participation. Similarly, if country affiliation acts as a credibility signal, that signal may become less salient within a longer byline. These are proposed explanations of moderation, not mechanisms directly observed in the bibliometric measures.

Several studies motivate the examination of such conditional benefits. Larivière, Gingras, Sugimoto, and Tsou (2015) describe historical changes in collaboration returns: increasingly large and diverse teams are required to obtain citation advantages. This temporal finding does not directly establish within-team HOC moderation. Rousseau and Ding (2016) examine whether international collaboration provides a citation advantage in highly visible interdisciplinary journals, offering a related context for questioning uniform benefits. Work on authorship scaling, collaboration, and citations, as well as international research processes, provides additional context (Ronda-Pupo, 2017; Hartley, 2016; Gazni & Thelwall, 2014; Jonsen et al., 2013).

Dilution here refers to the distinctiveness of HOC-associated resources or signals, not to an inevitable decline in the proportion of HOC authors. That proportion need not fall as teams expand. This distinction also separates the hypothesis from a claim that larger teams receive fewer citations overall: TS can remain positively associated with citations while the additional HOC association declines. The proposed attenuation can therefore be examined by considering

both the presence and the intensity of HOC participation. Together, resources overlap and reduced signal salience motivate the following prediction.

H3: TS negatively moderates the association between HOC collaboration and citation performance.

H1 states the positive-association expectation, H2 addresses its specificity, and H3 examines its dependence on TS. Alongside citation-based research on the movement of ideas across scholarly communities (Nerur, Rasheed, & Pandey, 2016), this framework focuses on how the composition of collaborations relates to research visibility. The empirical analysis tests whether HOC participation contributes information beyond diversity and whether its citation association weakens as teams expand.

3. Methodology

3.1 Data and Research Design

This study uses bibliometric data relating to articles published in Business, Management, and Accounting (BMA) group journals as per Scopus classification from the year Jan 1966 to April 2025. The Study selected the top 50 BMA journals based on their Citescore. Due to the non-availability of data, one journal has been withdrawn from the sample. The final sample contains 49 data journals. Citation counts (CIT) are modeled with negative binomial (NB2) regression rather than ordinary least squares or standard Poisson regression, a choice justified by the extreme overdispersion of the citation outcome (variance-to-mean ratio = 189.9). The entire bibliometric data, covering qualitative and quantitative variables such as authors' names, affiliations, citations, journal names, and publication years, were consolidated into a single master file, resulting in 60,576 observations.

3.2. Variable Measurement

3.2.1. High-Output-Country Status (HOC)

Let $N_{c,t}$ denote the number of articles published by the country c in year t , and let $R_{c,t}$ denote its percentile rank among all countries active in that year. For article i , published in the year t_i , let A_i denote its set of authors, C_i the set of countries represented among those authors, and $c(a)$ the country associated with the author a . High-output-country status is defined using both an absolute publication threshold and a relative output threshold. The binary indicator (HOCB) is shown in equation (1):

$$\text{HOCB}_i = \mathbf{1}\{\exists c \in C_i: N_{c,t_i} \geq 3 \text{ and } R_{c,t_i} \geq 90\text{th percentile}\} \dots \dots \dots (1)$$

Thus, $\text{HOCB}_i = 1$ when at least one country is represented in the article i satisfies both the minimum-output requirement of three articles in a year t_i and the 90th-percentile country-output criterion, and zero otherwise.

To capture the intensity of high-output-country representation rather than its mere presence, the weighted measure (HOCW) is defined as the proportion of authors whose country satisfies the same criteria as shown in equation (2)

$$\text{HOCW}_i = \frac{\sum_{a \in A_i} \mathbf{1}\{N_{c(a),t_i} \geq 3 \text{ and } R_{c(a),t_i} \geq 90\text{th percentile}\}}{|A_i|} \dots \dots \dots (2)$$

Here, $|A_i|$ denotes the number of authors on the article i . Accordingly, HOCW_i ranges from 0 to 1 and captures the share of the article's byline attributable to authors associated with qualifying high-output countries. It therefore distinguishes articles containing a single qualifying HOC co-author from those in which a greater proportion of the author team is associated with high-output countries.

The corresponding high-output-institution measures, HOIB_i and HOIW_i , are constructed analogously at the institutional level. The minimum annual publication threshold is set at two articles (≥ 2), rather than three (≥ 3) as used for countries, reflecting the smaller publication base of individual institutions relative to countries.

3.2.2. Collaboration Diversity (CDI and ADI)

For article i , let S_i denote the number of distinct countries represented among its co-authors, and let p_{ik} denote the proportion of authors associated with the country k . Country-level collaboration diversity is measured using both the complement of the Herfindahl–Hirschman Index and normalized Shannon entropy. The HHI-based country-diversity measure (CDH) is shown in equation (3):

$$\text{CDH}_i = 1 - \sum_{k=1}^{S_i} p_{ik}^2 \dots \dots \dots (3)$$

Higher values of CDH_i indicate a more evenly distributed author composition across countries, whereas a value of zero indicates that all authors are associated with a single country.

The normalized country-diversity entropy measure (CDE) is presented in equation (4)

$$\text{CDE}_i = \frac{-\sum_{k=1}^{S_i} p_{ik} \log_2(p_{ik})}{\log_2(S_i)}, \quad S_i > 1 \dots \dots \dots (4)$$

For articles represented by only one country ($S_i = 1$), CDE_i is defined as zero. Normalization by $\log_2(S_i)$ places the measure on a common 0 to 1 scale, with higher values indicating a more even distribution of authors across the countries represented in the article. The corresponding affiliation-diversity measures, ADH_i and ADE_i , are constructed identically using affiliation shares in place of country shares. Where only one affiliation is represented, ADE_i is likewise defined as zero.

3.2.3. Cross-Border and Cross-Affiliation Indicators

Two binary indicators capture whether collaboration extends across national or institutional boundaries. The cross-country collaboration indicator (CCD) is shown in equation (5):

$$CCD_i = 1\{S_i > 1\} \dots \dots \dots (5)$$

Accordingly, $CCD_i = 1$ when article i includes authors from more than one country and zero otherwise. Similarly, letting F_i denote the number of distinct institutional affiliations represented in the article i . The cross-affiliation indicator (CAD) is presented in equation (6).

$$CAD_i = 1\{F_i > 1\} \dots \dots \dots (6)$$

Thus, $CAD_i = 1$ when more than one institutional affiliation is represented in the article and zero otherwise.

3.2.4. Article Age and Citation-Rate Alternatives

Because older articles have had more time to accumulate citations, article age is calculated relative to 2026, with a minimum exposure period of 1 year. The adjusted age measure (AGE) is given by equation (7).

$$AGE_i = \begin{cases} 2026 - YEAR_i, & \text{if } YEAR_i < 2026, \\ 1, & \text{otherwise.} \end{cases} \dots \dots \dots (7)$$

Annualized citations (AC) are then calculated as total citations divided by adjusted article age, as shown in equation (8)

$$AC_i = \frac{CIT_i}{AGE_i} \dots \dots \dots (8)$$

As an alternative means of accounting for publication-year differences in citation accumulation, a year-standardized citation measure (ZCIT) is constructed as presented in equation (9)

$$ZCIT_i = \frac{CIT_i - \overline{CIT}_{t_i}}{SD(CIT)_{t_i}} \dots \dots \dots (9)$$

Here, $\overline{CIT}_{t_i}$ and $SD(CIT)_{t_i}$ denote, respectively, the mean and standard deviation of citations among articles published in the same year as the article i . Positive values, therefore, indicate citation performance above the publication-year mean, whereas negative values indicate performance below the corresponding year mean.

3.3 Empirical Model Specification

3.3.1 Baseline and Alternative Collaboration-Diversity Specifications

The baseline analysis evaluates whether TS and collaboration diversity are associated with citation performance. The primary specification uses HHI-based measures of country and affiliation diversity as presented in equation (10).

$$\ln[E(CIT_i)] = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 CDH_i + \beta_4 ADH_i + X_i' \gamma + \lambda_j + \delta_b \dots\dots\dots(10)$$

The second specification replaces the HHI measures with binary indicators of cross-country and cross-affiliation collaboration as shown in equation (11).

$$\ln[E(CIT_i)] = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 CCD_i + \beta_4 CAD_i + X_i' \gamma + \lambda_j + \delta_b \dots\dots\dots(11)$$

The third specification uses entropy-based diversity measures as shown in equation (12).

$$\ln[E(CIT_i)] = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 CDE_i + \beta_4 ADE_i + X_i' \gamma + \lambda_j + \delta_b \dots\dots\dots(12)$$

The fourth specification replaces the HHI-based diversity measures with the count-percent measures of country diversity (CDP) and affiliation diversity (ADP), as presented in Equation (13).

$$\ln[E(CIT_i)] = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 CDP_i + \beta_4 ADP_i + X_i' \gamma + \lambda_j + \delta_b \dots\dots\dots(13)$$

In equation (13), CDP and ADP denote the count-percent measures of country and affiliation diversity, respectively. The HHI specification in Equation (10) serves as the primary baseline model, while Equations (11)-(13) provide alternative operationalizations of collaboration diversity. These alternative measures are treated as different representations of the underlying construct of diversity. Across all baseline specifications, the control vector γ includes Adjusted Age (AGE), page count (PAGES), funding dummy (FUND), and open-access dummy (OA), capturing differences in citation exposure, article length, funding status, and open-access availability, respectively. The models also include journal fixed effects and five-year publication-block fixed effects to control for unobserved journal-specific heterogeneity and temporal variation in citation patterns. The measurement and definition of all the variables are presented in Table 1.

[Insert Table 1 about here]

3.3.2 HOC and HOC/HOI Moderation Models

The HOC moderation model evaluates whether collaboration with HOC researchers is associated with citation performance and whether this association varies with TS. The specification retains the baseline HHI-based diversity measures and introduces both the HOC main effect and the $TS \times HOC$ interaction as shown in equation (14)

$$\ln[E(CIT_i)] = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 CDH_i + \beta_4 ADH_i + \beta_5 HOC_i + \beta_6 (TS_i \times HOC_i) + X_i' \gamma + \lambda_j + \delta_b \dots \dots \dots (14)$$

H1 is assessed through the sign and significance of the HOC coefficient, whereas H3 is tested through the interaction term. A negative and significant $TS \times HOC$ coefficient indicates that the citation advantage associated with HOC collaboration weakens as TS increases.

To test whether the HOC association is distinct from general collaboration diversity, the second specification removes CDH and ADH and jointly includes HOC, HOI, and their respective TS interactions as presented in equation (15)

$$\ln[E(CIT_i)] = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 HOC_i + \beta_4 HOI_i + \beta_5 (TS_i \times HOC_i) + \beta_6 (TS_i \times HOI_i) + X_i' \gamma + \lambda_j + \delta_b \dots \dots \dots (15)$$

Each equation is estimated separately using binary and weighted operationalizations of HOC and of HOI, where applicable. H2 is evaluated by comparing the HOC coefficient across the two specifications; stability in sign, significance, and approximate magnitude after removing the diversity measures supports the interpretation that the HOC effect is not merely a proxy for collaboration diversity.

3.3.3 Alternative Outcomes and Robustness Specifications

The robustness analysis first assesses whether the baseline findings depend on the choice of CIT as the outcome variable. Then re-estimates the regression model by replacing CIT with three alternative dependent variables, i.e., $Y_i^{(m)} \in \{\ln(CIT_i + 1), AC_i, ZCIT_i\}$. Equation (16) presented alternative regression specifications.

$$Y_i^{(m)} = \beta_0 + \beta_1 TS_i + \beta_2 TS_i^2 + \beta_3 CDH_i + \beta_4 ADH_i + X_i' \gamma + \lambda_j + \delta_b + \varepsilon_i \dots \dots \dots (16)$$

In equation (16), the first measure, $LCIT = \ln(CIT_i + 1)$, reduces the influence of highly cited observations while accommodating zero-citation articles. The AC_i measures annualized

citations and therefore adjusts for differences in citation exposure across article ages. The $ZCIT_i$ standardizes citation performance compared to other articles published in the same year.

4. Discussion of Results

4.1 Descriptive Statistics and Correlation Analysis

The sample comprises 60,403 co-authored articles published in 49 Scopus-indexed BMA journals between January 1966 and April 2025 (Table 2). Citation counts are strongly right-skewed (mean = 57.0; median = 21; skewness = 4.16) and substantially overdispersed (variance-to-mean ratio = 189.9), supporting negative binomial regression as the primary count-data specification. The mean of HOCB is 0.727, indicating that 72.7% of sampled articles include at least one author based in a high-output country. The moderation analysis, therefore, concerns a common characteristic of collaboration in this sample.

[Insert Table 2 about here]

Table 3 reports a strong correlation between CDH and CCD ($r = 0.970$), indicating substantial overlap; these measures are consequently entered in separate specifications. HOCB has modest pairwise correlations with citations ($r = 0.087$) and TS ($r = 0.077$). These unconditional associations do not establish whether the HOC–citation relationship varies with TS, which is examined in Sections 4.3 and 4.4.

[Insert Table 3 about here]

Table 4 reports multicollinearity diagnostics: mean-centering TS reduces the VIFs for its linear and squared terms from 48.0 and 47.0 to 1.90 and 1.56, respectively; VIFs for the remaining regressors range from 1.03 to 1.43.

[Insert Table 4 about here]

4.2 Baseline Associations with Citation Performance

[Insert Table 5 about here]

Table 5 presents the baseline relationships among team structure, collaboration diversity, and citation performance prior to the introduction of HOC status. Across the four negative binomial specifications, the linear TS coefficient is positive and statistically significant at the 10% to 1% level. Coefficients range from 0.121 to 0.190. Because the models also include TS^2 , the association with an additional author depends on both terms and the initial TS.

The squared term is statistically insignificant throughout, indicating insufficient evidence of quadratic curvature. The positive linear coefficients broadly accord with research linking team authorship to citation performance (Wuchty, Jones, & Uzzi, 2007). However, this restricted range does not establish how returns evolve in larger teams (Larivière, Gingras, Sugimoto, & Tsou, 2015). Figure 1 illustrates the baseline model's increasing predicted citation counts across teams of two to five authors, with 95% confidence intervals.

Country-diversity coefficients are positive across all operationalizations. CDH is marginally significant, while CDP provides stronger statistical evidence. This directional consistency reduces concerns that the association depends entirely on a single measure, although the specifications are not independent replications. The pattern accords with research on international collaboration and scholarly visibility (Abramo, D'Angelo, & Di Costa, 2019; Payumo et al., 2017) and geographically uneven access to research resources (Aïssaoui, Geringer, & Livanis, 2020; Bajwa & König, 2019).

None of the affiliation-diversity measures (ADH, CAD, ADE, or ADP) is statistically significant. The models, therefore, provide clearer evidence of country diversity without establishing that affiliation diversity is not associated with citations. This distinction is relevant to research on country-specific visibility constraints (Moses & Hopper, 2022). AGE, PAGES, FUND, and OA are positive and highly significant throughout.

4.3 HOC Collaboration and TS Moderation

[Insert Table 6 about here]

Table 6 introduces HOC status and its interaction with TS. The HOC coefficients are positive and statistically significant in both the binary ($\beta = 0.181^{**}$) and weighted ($\beta = 0.219^{***}$) specifications. For the binary specification, the conditional HOC effect on the log of the expected citation scale is $0.181 - 0.063 \times \text{TS}$. For the weighted specification, the corresponding conditional effect is $0.219 - 0.068 \times \text{TS}$. The estimates imply a positive association at smaller TS values that declines and can become negative as teams expand. HOCB and HOCW represent different contrasts, so their coefficient magnitudes are not directly comparable.

The $\text{TS} \times \text{HOC}$ coefficients are negative and statistically significant in both models (-0.063 and -0.068), supporting H3 on the model's log-mean scale. Their consistency suggests that the negative interaction is not confined to one HOC measure. Figure 2 illustrates this interaction: predicted citations are higher for HOC teams at two authors, but the ordering reverses near three authors, with the gap widening thereafter.

The smaller-team advantage is compatible with resource-access arguments (Aïssaoui, Geringer, & Livanis, 2020), quality-signaling reasoning (Ryazanova, McNamara, & Aguinis, 2017), and research on country-level scholarly inequalities (Bajwa & König, 2019; Abramo, D'Angelo, & Di Costa, 2019). The negative interaction is consistent with literature on changing collaboration returns (Larivière, Gingras, Sugimoto, & Tsou, 2015), context-dependent international collaboration benefits (Rousseau & Ding, 2016), and authorship scaling (Ronda-Pupo, 2017).

4.4 HOC Specificity Beyond General Collaboration Diversity

[Insert Table 7 about here]

Table 7 examines an alternative specification that excludes CDH and ADH and jointly includes HOC, HOI, and their TS interactions. The HOC coefficients remain positive and statistically significant, changing from 0.181 to 0.195 in the binary specification and from 0.219 to 0.226 in the weighted specification. These coefficients must again be interpreted jointly with their interactions. This stability is consistent with H2, but the comparison does not isolate HOC specificity. Diversity controls are removed while institutional terms are added, so multiple specification changes occur simultaneously. Tables 6 and 7 suggest that the estimated HOC pattern persists across these modeling choices; they do not establish that general diversity cannot contribute to the relationship. This interpretation is compatible with research emphasizing collaborator identity (Freeman & Huang, 2015), concentrated national research output (Bajwa & König, 2019), the multidimensional nature of internationalization (Cooke et al., 2019), and country-specific visibility constraints (Moses & Hopper, 2022).

The TS $\times$ HOC interaction remains negative and statistically significant (-0.067 for HOCB and -0.085 for HOCW), providing additional support for H3. Neither TS $\times$ HOI interaction is statistically significant. Figure 3 presents predicted citations for the four HOC–HOI combinations, illustrating the declining HOC advantage within each HOI category; the plotted differences do not, by themselves, establish statistical significance.

4.5 Robustness to Alternative Citation Outcomes

[Insert Table 8 about here]

[Insert Table 9 about here]

Tables 8 and 9 show sensitivity to alternative citation outcomes. In Table 8, the country-diversity association remains positive across LCIT, AC, and ZCIT, whereas affiliation diversity is not statistically significant. The linear TS coefficient is significant only for LCIT, although TS² is significant for ZCIT. Thus, the estimated TS relationship depends, in part, on the outcome measure and should be interpreted in terms of both measures. In Table 9, HOC coefficients remain positive across all four specifications: 0.141 and 0.695 for HOCB, and 0.209 and 0.861 for HOCW. Their magnitudes are not directly comparable across outcome scales. The TS × HOC coefficient is negative in all four models but statistically significant only for the LCIT outcomes. Accordingly, the direction of moderation is consistent, while statistical support for H3 does not extend uniformly to AC. The evidence supports a qualified conclusion rather than outcome-independent confirmation (Cummings & Hoebink, 2017; Moses & Hopper, 2022).

4.6 Estimator Sensitivity of the Baseline Results

[Insert Table 10 about here]

Table 10 compares the baseline findings under NB2, Poisson, and OLS specifications. The Poisson deviance-to-degrees-of-freedom ratio is 62.78, and the estimated NB2 dispersion parameter is 1.291, indicating substantial departure from Poisson equidispersion. These diagnostics support NB2 for modeling raw citation counts. The NB2 estimates reproduce the baseline pattern: TS is positive and marginally significant ($\beta = 0.126$), CDH is positive and marginally significant ($\beta = 0.175$), and ADH is statistically insignificant. Under the Poisson model, TS and CDH remain positive but are not statistically significant. This difference indicates specification-sensitive inference; overdispersion alone does not explain the change in significance, particularly because the reported standard errors are cluster-robust by journal.

OLS using LCIT yields positive coefficients for TS ($\beta = 0.197$) and CDH ($\beta = 0.103$). Because this specification changes both the estimator and outcome scale, the larger TS coefficient cannot be interpreted as a stronger effect than its NB2 counterpart. TS² and ADH remain statistically insignificant, while article-level controls remain positive and significant. Overall, coefficient directions are broadly consistent, but statistical support varies. These comparisons concern baseline associations rather than directly testing HOC moderation.

4.7 Temporal Stability of the Baseline Relationships

[Insert Table 11 about here]

Table 11 evaluates sensitivity to temporal controls and historical subsamples. The five-year publication-block specification reproduces the positive associations between TS and CDH. Neither remains statistically significant under individual publication-year fixed effects, which also require excluding AGE because it is determined by publication year. Statistical support for these baseline relationships is therefore sensitive to finer temporal adjustment. The pre-1996 subsample produces imprecise estimates. Its smaller sample size may contribute to this uncertainty, although sample size alone cannot establish the reason. In the 1996-onward subsample, TS remains positive and statistically significant ($\beta = 0.144$), as does CDH ($\beta = 0.180$), while ADH remains statistically insignificant.

These results provide clearer evidence for the baseline associations in the more recent period. However, significance in one subsample and insignificance in another do not, by themselves, establish that the coefficients differ across periods; that conclusion requires a direct comparison. The evidence indicates sensitivity in statistical precision and temporal specification, rather than demonstrating either complete historical stability or a definitive change in the underlying relationships.

4.8 Functional-Form and Sample-Trimming Robustness

[Insert Table 12 about here]

Table 12 assesses whether the baseline findings depend on the functional form of TS or the inclusion of highly cited articles. Replacing TS and TS² with $\ln(TS)$ yields a positive, highly significant coefficient of 0.342. Under this specification, the coefficient is an elasticity: a 1% increase in TS corresponds to approximately a 0.34% increase in expected citations, holding other covariates constant. Because TS is discrete and ranges from 2 to 5 authors, comparisons among feasible TS values provide a more concrete substantive interpretation. CDH remains positive and statistically significant ($\beta = 0.176$), whereas ADH remains statistically insignificant. The positive TS association, therefore, persists under a logarithmic specification.

Excluding articles with more than 500 citations produces a similar baseline pattern. The linear TS coefficient changes from 0.126 to 0.130, with greater precision (compared to the baseline model), while CDH remains positive at 0.170. TS² and ADH remain statistically insignificant. Because the quadratic term is retained, the linear TS coefficient should again be interpreted

jointly with that term. Together, these checks suggest that the baseline pattern is not solely attributable to the selected TS functional form or articles above the citation threshold. Their scope is limited to baseline relationships and should be distinguished from the direct moderation evidence in Tables 5, 6, and 8.

5. Conclusion and Implications

This study shows that the citation benefits of collaboration in BMA research depend not only on TS or international diversity but also on who is represented on the team and on the team's size. HOC collaboration is positively associated with citation performance under both HOCB and HOCW specifications, supporting H1. Its coefficient remains stable after general country- and affiliation-diversity controls are removed, supporting H2 and indicating that HOC status captures a visibility advantage beyond diversity alone. Most importantly, the $TS \times HOC$ interaction is consistently negative, supporting H3: the citation advantage associated with HOC collaboration diminishes as TS increases.

The findings have several implications. For researchers and research leaders, expanding TS should not be assumed to amplify the visibility benefit associated with an HOC collaborator. The evidence instead suggests that this benefit is concentrated in smaller teams, consistent with a dilution interpretation. For research institutions and funding bodies, the results caution against evaluating collaboration using simple counts of international co-authors or team members; country-level collaboration characteristics appear more informative than affiliation diversity alone. Bibliometric evaluation systems should therefore distinguish team scale, country composition, and high output country participation rather than treating collaboration as a uniformly beneficial attribute. The main conclusions remain broadly stable across alternative HOC measures, citation outcomes, estimators, functional forms, and tighter citation trimming, although the $TS \times HOC$ effect becomes statistically weaker under AC outcomes. Future research could incorporate author-level reputation and network measures and examine whether the same boundary condition persists in larger teams and other disciplinary settings.

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Tables and Figures

Table 1: Variable Definition and Measurement

Variable name	Abbreviation	Definition and measurement
Total citation count	CIT	Total citations received by an article, recorded in Scopus as a nonnegative count. Used as the primary dependent variable in Equations (10)– (15)
Log-transformed citations	LCIT	Natural logarithm of citations plus one: $\ln(CIT + 1)$. Adding one accommodates uncited articles; the transformation compresses higher citation counts.
Annualized citations	AC	Total citations divided by adjusted article age: CIT/AGE (Equation (8)). Measures average citations per exposure year, using the age convention in Equation (7).
Publication-year-standardized citations	ZCIT	Article CIT minus the mean citation count for its publication year, divided by that year's citation standard deviation (Equation (9)). Measures citation performance relative to articles published in the same year.
Team size	TS	Number of authors of an article.
High-output-country participation	HOCB/ HOCW	Presence of a qualifying high output country (HOCB; Equation (1)); proportion of authors from qualifying high output countries (HOCW; Equation (2)). Qualification requires ≥ 3 publications and an output rank ≥ 90 th percentile in the article's publication year.
High-output-institution participation	HOIB/ HOIW	Presence of a qualifying high output institution (HOIB); proportion of authors associated with qualifying high output institutions (HOIW). Constructed analogously to Equations (1)– (2), using ≥ 2 annual publications and the corresponding 90th-percentile output criterion.
Country diversity	CDH/ CDE/ CDP	HHI measure of country author shares (CDH) as per Equation (3); normalized Shannon entropy, zero for single-country articles (CDE; Equation (4)); count-percent diversity (CDP; Equation (13)). Count-percent measure of country diversity, calculated from the number of distinct countries represented in an article relative to the relevant author-team base.
Affiliation diversity	ADH/ ADE/ ADP	HHI measure of affiliation shares (ADH); normalized Shannon entropy, zero for single-affiliation articles (ADE), constructed analogously to Equations (3)– (4); count-percent diversity (ADP; Equation (13)). Count-percent measure of affiliation diversity, calculated from the number of distinct affiliations represented in an article relative to the relevant author-team base.
Cross-country and cross-affiliation collaboration	CCD/ CAD	Indicators equal to one when an article represents multiple countries (CCD; Equation (5)) or multiple institutional affiliations (CAD; Equation (6)), and zero otherwise. Neither indicator weights the distribution of author shares.
Adjusted article age	AGE	Years of citation exposure: 2026 minus publication year for articles published before 2026, and one otherwise (Equation (7)).

Article length in pages	PAGES	Article page count, measured in page units and included in the control vector.
Funding and open-access indicators	FUND/OA	Binary indicators of article funding status (FUND) and open-access availability (OA).

Table 2: Descriptive Statistics

Variable	Mean	Median	Std. Dev.	Min	Max	Skew	N
CIT	57.015	21	104.046	0	1,001	4.159	60,403
TS	2.765	3	0.821	2	5	0.823	60,403
CDH	0.199	0.000	0.251	0.000	0.833	0.583	60,403
ADH	0.468	0.500	0.234	0.000	0.833	-1.066	60,403
CCD	0.402	0	0.490	0	1	0.400	60,403
CAD	0.831	1	0.375	0	1	-1.762	60,403
AGE	12.556	10	10.461	1	60	1.308	60,403
PAGES	19.521	17	9.814	5	50	0.942	60,403
FUND	0.380	0	0.485	0	1	0.494	60,403
OA	0.316	0	0.465	0	1	0.793	60,403
HOCB	0.727	1	0.445	0	1	-1.021	60,403

Source: Authors' Calculation.

Table 3: Pairwise Correlation Matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) CIT	1.000							
(2) TS	-0.055	1.000						
(3) CDH	-0.032	0.221	1.000					
(4) ADH	-0.008	0.399	0.439	1.000				
(5) CCD	-0.032	0.229	0.970	0.428	1.000			
(6) AGE	0.264	-0.310	-0.184	-0.223	-0.186	1.000		
(7) PAGES	0.212	-0.028	0.026	0.065	0.029	0.068	1.000	
(8) HOCB	0.087	0.077	0.048	0.155	0.046	0.117	0.117	1.000

Source: Authors' Calculation.

Table 4 Variance Inflation Factors (Multicollinearity Diagnostics)		
Regressor	VIF (TS entered raw)	VIF (TS mean-centered)
TS / TS ²	48.0 / 47.0	1.90 / 1.56
CDH	1.28	1.28
ADH	1.43	1.43
AGE	1.19	1.19
PAGES	1.03	1.03
FUND	1.06	1.06
OA	1.06	1.06

Source: Authors' Calculation.

Table 5: Main Negative-Binomial Model and Alternative Diversity Specifications				
Table 5 reports four negative-binomial regression specifications with CIT as the dependent variable and a log link. All specifications are estimated using NB2. Column (2) presents the primary HHI-based specifications using CDH and ADH. Column (3) replaces these with the binary collaboration indicators CCD and CAD. Column (4) uses the entropy measures CDE and ADE, while Column (5) uses the count-percent measures CDP and ADP. Each specification includes TS, TS ² , AGE, PAGES, FUND, OA, journal fixed effects, and five-year block fixed effects. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * p < 0.10, ** p < 0.05, and *** p < 0.01.				
(1)	(2)	(3)	(4)	(5)
TS	0.126* (0.069)	0.121* (0.067)	0.123* (0.066)	0.190*** (0.063)
TS ²	-0.001 (0.010)	-0.001 (0.010)	0.000 (0.010)	-0.007 (0.010)
CDH	0.175* (0.089)			
ADH	-0.015 (0.048)			
CCD		0.070* (0.039)		
CAD		0.011 (0.028)		
CDE			0.076* (0.042)	
ADE			0.007 (0.029)	
CDP				0.205** (0.099)
ADP				-0.030 (0.044)
AGE	0.282*** (0.036)	0.283*** (0.036)	0.283*** (0.036)	0.283*** (0.036)
PAGES	0.018*** (0.002)	0.018*** (0.002)	0.018*** (0.002)	0.018*** (0.002)

FUND	0.105***	0.106***	0.105***	0.106***
	(0.032)	(0.032)	(0.032)	(0.032)
OA	0.276***	0.279***	0.279***	0.276***
	(0.041)	(0.042)	(0.042)	(0.041)
N	60,403	60,403	60,403	60,403
LR χ^2 (df = 8)	7,894.5	7,872.1	7,873.6	7,903.2
McFadden's pseudo-R ²	0.0140	0.0140	0.0140	0.0140
AIC	554,866.7	554,889.0	554,887.6	554,857.9
BIC	555,488.3	555,510.6	555,509.2	555,479.5

Source: Authors' Calculation.

Table 6: High-Output-Country (HOC) Moderation Effect

Table 6 presents two NB2 regression specifications with CIT as the dependent variable and a log link. Column (2) uses HOCB as the focal HOC measure, while Column (3) uses HOCW. Both specifications include TS, TS², CDH, ADH, the relevant HOC main effect, and the TS $\times$ HOC interaction. Journal fixed effects and five-year block fixed effects are included. The two HOC measures are estimated separately and are not entered jointly. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

(1)	(2)	(3)
TS	0.157**	0.169**
	(0.067)	(0.068)
TS ²	0.001	-0.002
	(0.011)	(0.010)
CDH	0.172*	0.182***
	(0.088)	(0.065)
ADH	-0.018	-0.024
	(0.047)	(0.046)
HOC	0.181**	0.219***
	(0.082)	(0.083)
TS $\times$ HOC	-0.063**	-0.068**
	(0.031)	(0.030)
AGE	0.282***	0.283***
	(0.036)	(0.036)
PAGES	0.018***	0.018***
	(0.002)	(0.002)
FUND	0.107***	0.107***
	(0.032)	(0.032)
OA	0.276***	0.275***
	(0.040)	(0.040)
N	60,403	60,403
LR χ^2 (df = 10)	7,916.7	7,925.8
McFadden's pseudo-R ²	0.0141	0.0141

AIC	554,848.5	554,839.3
BIC	555,488.1	555,478.9

Source: Authors' Calculation.

Table 7: HOC/HOI Moderation without General Diversity Controls

Table 7 presents two NB2 regression specifications with CIT as the dependent variable and a log link. Column (2) uses the binary participation measures HOCB and HOIB, whereas Column (3) uses the weighted measures HOCW and HOIW. Both specifications include TS, TS², the HOC and HOI main effects, and their respective interactions with TS along with journal fixed effects and five-year block fixed effects. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	(1)	(2)	(3)
TS		0.170***	0.189***
		(0.062)	(0.063)
TS ²		0.001	-0.002
		(0.010)	(0.010)
HOC		0.195**	0.226***
		(0.084)	(0.084)
HOI		0.427**	0.379
		(0.202)	(0.387)
TS × HOC		-0.067**	-0.085**
		(0.033)	(0.034)
TS × HOI		-0.061	-0.008
		(0.077)	(0.148)
AGE		0.281***	0.281***
		(0.036)	(0.036)
PAGES		0.018***	0.018***
		(0.002)	(0.002)
FUND		0.105***	0.107***
		(0.032)	(0.032)
OA		0.286***	0.284***
		(0.045)	(0.043)
N		60,403	60,403
LR χ^2 (df = 10)		7,919.5	7,913.9
McFadden's pseudo-R ²	0.0141		0.0141
AIC		554,845.6	554,851.2
BIC		555,485.2	555,490.8

Source: Authors' Calculation.

Table 8: Alternative-Outcome Robustness of the Baseline Collaboration Model

Table 8 presents three cluster-robust OLS specifications that retain the same explanatory variables as the baseline collaboration model while changing the dependent variable. Column (2) uses LCIT, Column (3) uses AC, and Column (4) uses ZCIT together with journal fixed effects and five-year block fixed effects. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	LCIT	AC	ZCIT
(1)	(2)	(3)	(4)
TS	0.197*** (0.055)	0.387 (0.318)	-0.009 (0.040)
TS ²	-0.013 (0.008)	0.032 (0.049)	0.013** (0.006)
CDH	0.103* (0.061)	0.586* (0.346)	0.058* (0.035)
ADH	0.015 (0.047)	-0.036 (0.191)	0.005 (0.021)
AGE	0.253*** (0.025)	0.502*** (0.076)	-0.003 (0.005)
PAGES	0.021*** (0.003)	0.086*** (0.017)	0.010*** (0.002)
FUND	0.110*** (0.025)	0.337** (0.136)	0.039** (0.016)
OA	0.236*** (0.023)	1.070*** (0.163)	0.091*** (0.015)
N	60,403	60,403	60,403
R ²	0.4811	0.1249	0.0757
Adjusted R ²	0.4805	0.1239	0.0747
F-statistic	834.83	128.51	73.73
F df	(67, 60335)	(67, 60335)	(67, 60335)

Source: Authors' Calculation.

Table 9: Alternative-Outcome Robustness of the HOC/HOI Moderation Model

Table 9 presents four cluster-robust OLS specifications combining two alternative citation outcomes with binary and weighted HOC/HOI measures. Column (2) uses LCIT with HOCB and HOIB, while Column (3) uses AC with the same binary measures. Column (4) uses LCIT with HOCW and HOIW, and Column (5) uses AC with the weighted measures along with journal fixed effects, and five-year block fixed effects. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	LCIT	AC	LCIT	AC
(1)	(2)	(3)	(4)	(5)
TS	0.225*** (0.046)	0.492 (0.314)	0.247*** (0.047)	0.568* (0.325)
TS ²	-0.011 (0.008)	0.039 (0.048)	-0.013* (0.008)	0.031 (0.048)
HOCB	0.141** (0.068)	0.695* (0.415)		
HOIB	0.390** (0.181)	1.372* (0.773)		
HOCW			0.209*** (0.067)	0.861** (0.425)
HOIW			0.279 (0.319)	1.420 (1.158)
TS × HOC	-0.043* (0.022)	-0.189 (0.166)	-0.070*** (0.020)	-0.263 (0.176)
TS × HOI	-0.045 (0.050)	-0.041 (0.348)	0.028 (0.093)	0.177 (0.541)
AGE	0.253*** (0.025)	0.500*** (0.077)	0.253*** (0.025)	0.500*** (0.077)
PAGES	0.021*** (0.003)	0.085*** (0.017)	0.021*** (0.003)	0.086*** (0.017)
FUND	0.112*** (0.024)	0.346*** (0.133)	0.112*** (0.025)	0.348*** (0.134)
OA	0.244*** (0.024)	1.113*** (0.174)	0.242*** (0.023)	1.110*** (0.166)
N	60,403	60,403	60,403	60,403
R ²	0.4816	0.1254	0.4815	0.1254
Adjusted R ²	0.4810	0.1244	0.4810	0.1244
F-statistic	812.34	125.34	812.15	125.33
F df	(69, 60333)	(69, 60333)	(69, 60333)	(69, 60333)

Source: Authors' Calculation.

Table 10: Estimator Sensitivity of the Baseline Collaboration Model — NB2, Poisson, and OLS

Table 10 compares three estimators using the same set of explanatory variables. Column (2) estimates the primary NB2 model with CIT as the dependent variable and a log link. Column (3) estimates a Poisson count model using CIT, while Column (4) estimates an OLS model using LCIT along with journal fixed effects, and five-year block fixed effects. The Poisson deviance-to-degrees-of-freedom ratio is 62.78, and the estimated NB2 dispersion parameter is 1.291. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	NB2 (primary)	Poisson	OLS, LCIT
(1)	(2)	(3)	(4)
TS	0.126*	0.085	0.197***
	(0.069)	(0.060)	(0.055)
TS ²	-0.001	0.001	-0.013
	(0.010)	(0.009)	(0.008)
CDH	0.175*	0.088	0.103*
	(0.089)	(0.061)	(0.061)
ADH	-0.015	0.009	0.015
	(0.048)	(0.046)	(0.047)
AGE	0.282***	0.107***	0.253***
	(0.036)	(0.012)	(0.025)
PAGES	0.018***	0.019***	0.021***
	(0.002)	(0.003)	(0.003)
FUND	0.105***	0.058**	0.110***
	(0.032)	(0.028)	(0.025)
OA	0.276***	0.199***	0.236***
	(0.041)	(0.027)	(0.023)
N	60,403	60,403	60,403
Log-likelihood	-277,364.3	-2,033,484.2	-92,835.9
AIC	554,866.7	4,067,104.5	185,809.8
BIC	555,488.3	4,067,717.1	186,431.4

Source: Authors' Calculation.

Table 11: Temporal Robustness

Table 11 presents four NB2 specifications with CIT as the dependent variable and a log link. Column (2) uses saturated year fixed effects and omits AGE because it is determined by publication year. Column (3) applies the baseline journal and five-year block fixed-effects structure to the full sample. Columns (4) and (5) re-estimate that baseline structure for the pre-1996 and 1996-and-later subsamples, respectively. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

	Year FE	Block FE (=M1)	Pre-1996	≥ 1996
(1)	(2)	(3)	(4)	(5)
TS	0.041 (0.068)	0.126* (0.069)	-0.277 (0.304)	0.144** (0.068)
TS ²	0.014 (0.010)	-0.001 (0.010)	0.060 (0.053)	-0.003 (0.010)
CDH	0.104 (0.063)	0.175* (0.089)	0.080 (0.149)	0.180** (0.088)
ADH	0.010 (0.047)	-0.015 (0.048)	0.039 (0.118)	-0.034 (0.045)
AGE		0.282*** (0.036)	-0.059*** (0.016)	0.314*** (0.036)
PAGES	0.020*** (0.003)	0.018*** (0.002)	0.038*** (0.005)	0.015*** (0.002)
FUND	0.094*** (0.033)	0.105*** (0.032)	0.130* (0.078)	0.106*** (0.032)
OA	0.190*** (0.026)	0.276*** (0.041)	0.240** (0.108)	0.275*** (0.039)
N	60,403	60,403	4,427	55,976
LR χ^2	1,934.4 (df=7)	7,894.5 (df=8)	258.5 (df=8)	8,634.7 (df=8)
McFadden's pseudo- R ²	0.0035	0.0140	0.0059	0.0167

Source: Authors' Calculation.

Table 12: Functional-Form and Outlier Sensitivity of the Baseline Citation Model

Table 12 presents two NB2 sensitivity specifications with CIT as a dependent variable and a log link. Column (2) replaces TS and TS² with ln (TS) and uses the full sample of 60,403 observations. Column (3) retains TS and TS² but excludes articles with CIT above 500, producing a sample of 59,641 observations. Both specifications include journal fixed effects, and five-year block fixed effects. Coefficients are reported with Journal-clustered robust standard errors in parentheses. Statistical significance is denoted as * p < 0.10, ** p < 0.05, and *** p < 0.01.

	ln (TS)	Trim >500
(1)	(2)	(3)
ln (TS)	0.342*** (0.041)	
TS		0.130** (0.060)
TS ²		-0.003 (0.009)
CDH	0.176** (0.089)	0.170** (0.084)
ADH	-0.017 (0.048)	0.000 (0.043)
AGE	0.282*** (0.036)	0.271*** (0.036)
PAGES	0.018*** (0.002)	0.016*** (0.002)
FUND	0.106*** (0.032)	0.106*** (0.030)
OA	0.276*** (0.041)	0.243*** (0.037)
N	60,403	59,641
LR χ^2	7,887.0 (df=7)	7,353.1 (df=8)
Mcfadden's pseudo-R ²	0.0140	0.0135

Source: Authors' Calculation.

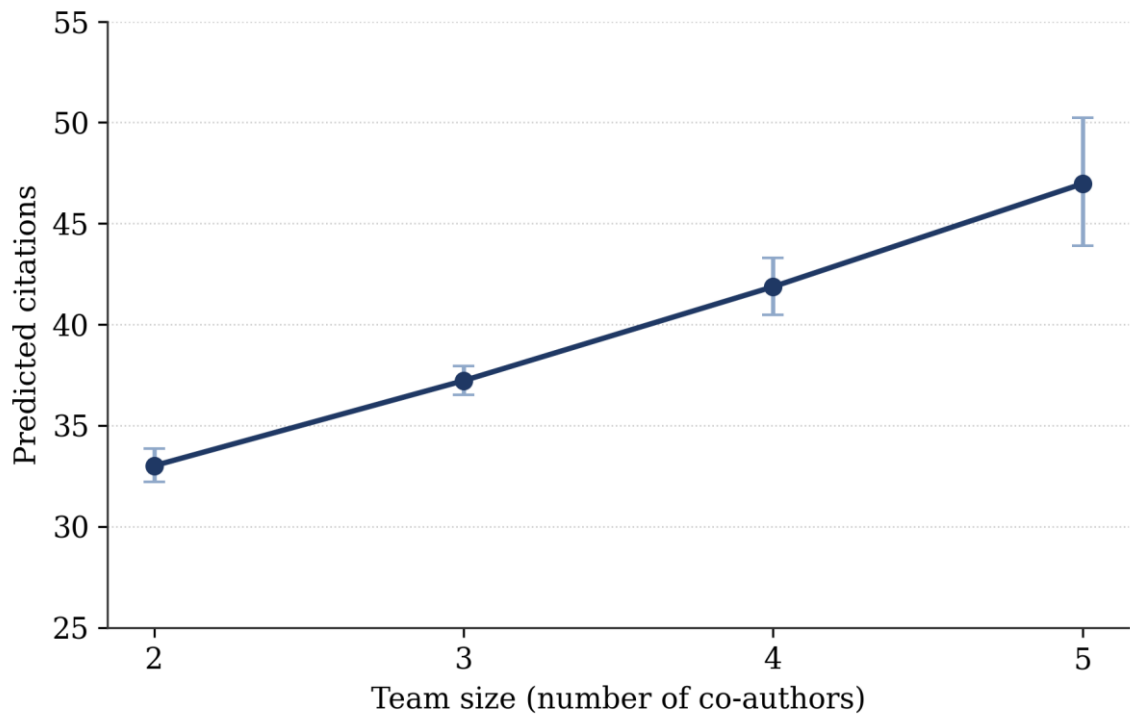


Figure 1. Predicted citations by TS (Model 1), with 95% confidence intervals.

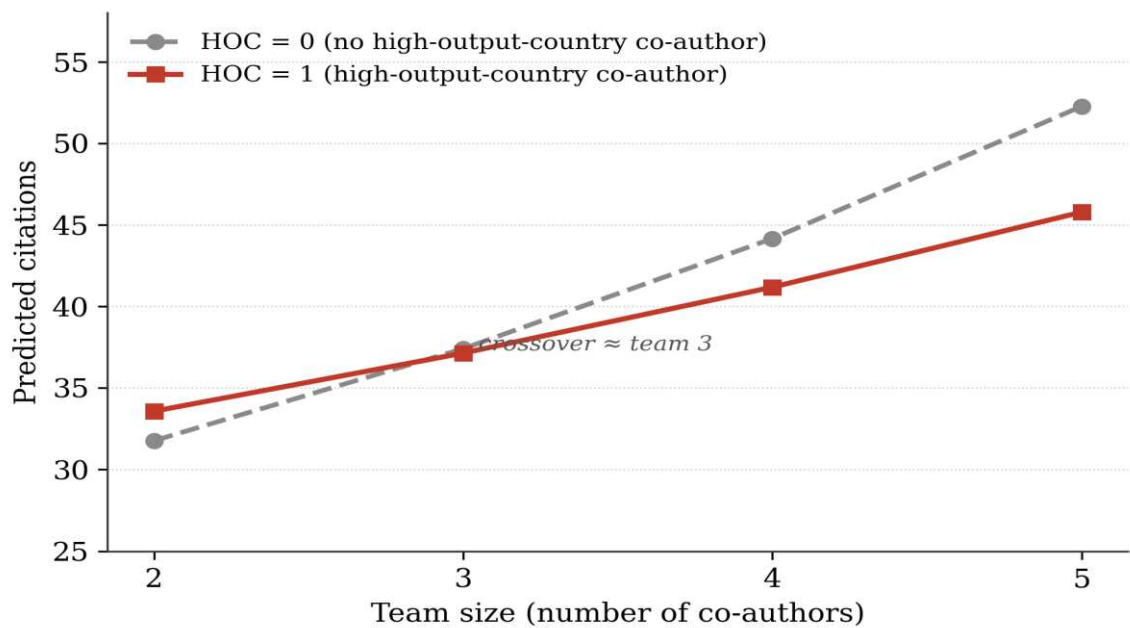


Figure 2. Predicted citations by TS and HOC status. The crossover near TS = 3 illustrates the dilution pattern underlying H3.

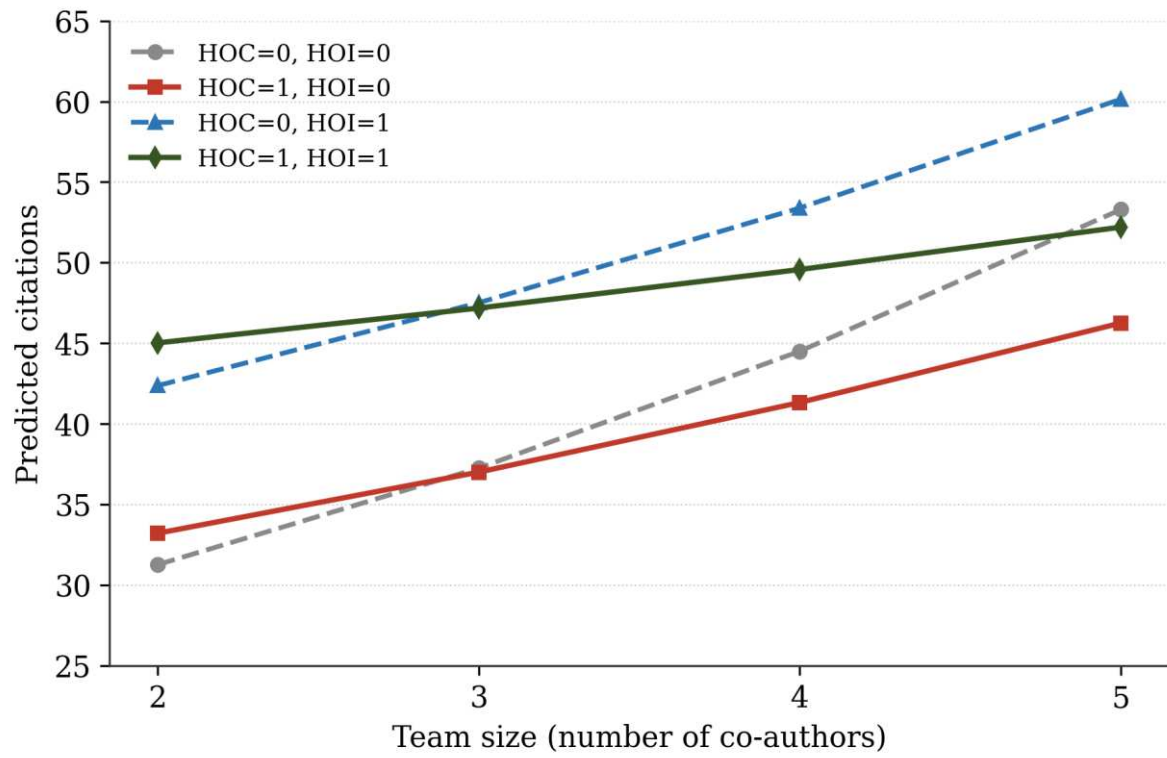


Figure 3. Predicted citations by TS, jointly by HOC and HOI status