ASEAN Journal of Science and Engineering

Journal homepage: http://ejournal.upi.edu/index.php/AJSE/

Research Performance in Higher Education: A PLS-SEM Analysis of Research Atmosphere, Collaboration, Funding, Competence, and Output, Especially for Science and Engineering Facilities in Indonesian Universities

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ABSTRACT

Research performance is essential for universities because it drives scientific and technological advancement, institutional rankings, and global competitiveness. However, Indonesian higher education institutions face persistent challenges, including limited funding, inadequate collaboration, and an unsupportive research environment, which hinder their ability to produce high-quality research. This study examines how research atmosphere, collaboration, funding, competence, and output influence research performance because understanding these dynamics can help universities develop targeted strategies to enhance faculty productivity. Data were collected from 250 faculty members using a purposive sampling method and analyzed with Partial Least Squares Structural Equation Modeling (PLS-SEM). Results indicate that a strong research atmosphere fosters collaboration and funding access, while competence and research output significantly improve research performance. However, research funding does not directly enhance competence because financial resources alone do not develop research skills. These findings emphasize the need for greater institutional support, particularly in science and engineering fields, to strengthen research ecosystems and drive innovation in Indonesian universities.

ARTICLE INFO

Article History:
Submitted/Received 28 Nov 2024
First revised 30 Dec 2024
Accepted 28 Feb 2025
First available online 27 Feb 2025
Publication date 01 Mar 2025

Keyword:
Higher education,
Ipma,
PLS-SEM,
Research performance.

1. INTRODUCTION

Research performance is a fundamental measure of academic success because it determines institutional rankings, funding acquisition, and scholarly impact [1,2]. It plays a crucial role in scientific and technological advancement, driving innovation and strengthening global competitiveness. Universities are increasingly evaluated based on research output, collaboration, and funding, which contribute to knowledge creation and industry-relevant discoveries [3]. Many reports regarding institution rankings as well as progress for improving research and academic successfulness has been reported [4-6]. Achieving high research performance remains a challenge because multiple factors, including research atmosphere, competence, and institutional support, interact in complex ways to influence academic productivity [7,8].

In Indonesia, faculty members face additional obstacles because of limited research funding, weak interdisciplinary collaboration, and an unsupportive research environment, which hinder their ability to produce high-quality research [1,9,10]. These challenges are particularly significant in science and engineering disciplines, where research often requires advanced facilities, technical resources, and sustained funding. Addressing these barriers is crucial because Indonesian universities may struggle to compete globally and contribute to national development without targeted institutional support [11].

A supportive research atmosphere fosters collaboration and funding acquisition because it provides faculty with mentorship, institutional resources, and access to research networks [12]. Studies suggest that a strong academic climate enhances collaboration, but its direct impact on funding remains uncertain because external factors such as grant competition and policy restrictions influence funding accessibility [13]. Similarly, research collaboration strengthens research competence because it facilitates knowledge exchange and exposure to new methodologies [2,14]. However, collaboration does not always lead to higher research output because factors such as coordination difficulties, administrative burdens, and mismatched research goals can limit its effectiveness [15,16].

Research funding is essential for supporting research activities, yet its direct effect on research competence is often limited because financial resources alone do not automatically enhance researchers' skills [17]. In science and engineering fields, access to advanced laboratories, high-cost equipment, and skilled research assistants is often dependent on sufficient financial investment. However, disparities in funding allocation remain a major barrier because well-established institutions typically receive a larger share of available grants, leaving emerging universities at a disadvantage [18,19]. This uneven distribution limits opportunities for faculty in developing institutions to engage in cutting-edge research, thereby widening the gap in scientific output.

Although previous research has explored the individual determinants of research performance, many studies have examined these factors in isolation rather than considering their interdependencies [20-23]. For example, prior studies confirm that research collaboration strengthens competence, but they do not assess whether research funding moderates this relationship [12]. Additionally, most research relies on qualitative or descriptive methods, leaving a gap in the use of advanced quantitative techniques, such as Partial Least Squares Structural Equation Modeling (PLS-SEM), which provides deeper insights into complex research interactions. This methodological gap is particularly relevant in Indonesia, where institutional constraints and limited funding significantly impact research productivity. Addressing these gaps is critical because an integrated analysis can offer

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

practical recommendations for improving research performance at both faculty and institutional levels.

This study investigates the interrelationships between research atmosphere, collaboration, funding, competence, and performance among university faculty members in Indonesia. By employing PLS-SEM, this research quantitatively evaluates how these factors collectively shape research performance in science and engineering disciplines. The findings contribute to existing literature because they demonstrate how research atmosphere and funding simultaneously influence collaboration and research output, ultimately affecting research competence and performance. Unlike previous studies that focus on single variables, this study adopts a holistic approach, offering a comprehensive understanding of what drives research success in higher education institutions.

Beyond its theoretical contributions, this research has significant practical implications because it provides evidence-based recommendations for policymakers, university administrators, and funding agencies. By identifying the most influential factors and their interactions, this study informs strategies for enhancing institutional support, improving funding mechanisms, and fostering collaborative research cultures. The Importance-Performance Matrix Analysis (IPMA) further highlights key areas requiring improvement, guiding universities in optimizing research policies and resource allocation [24]. These insights are especially valuable for science and engineering faculties, where technological advancements and innovation depend on continuous investment in research and development.

Furthermore, this study lays the groundwork for future research by encouraging comparative analyses of research performance models across different academic contexts. Future studies should explore institutional policies that promote research ecosystems, particularly in science and engineering fields, where technological infrastructure, administrative efficiency, and interdisciplinary collaboration play a pivotal role. Expanding research on barriers to research productivity, funding allocation strategies, and long-term performance tracking will contribute to a deeper understanding of how universities can strengthen their research capabilities on a global scale.

2. LITERATURE REVIEW

2.1. Research Atmosphere

The research atmosphere is essential for understanding how institutional environments shape academic productivity because it encompasses institutional support, resource availability, and a culture that fosters academic collaboration [25]. Universities that prioritize a strong research climate tend to enhance internal collaboration and increase their ability to secure research funding because they create an environment that encourages scholarly engagement [26].

Previous studies indicate that institutions with a robust research culture are more competitive in obtaining grants because a strong academic environment attracts funding bodies [23,27,28]. Universities that provide adequate resources, encourage interdisciplinary collaboration, and uphold academic freedom are more likely to see higher faculty research productivity. However, fostering a supportive research atmosphere extends beyond institutional support; it also requires addressing regional disparities to ensure equitable access to research opportunities across diverse educational settings.

Despite the acknowledged importance of the research atmosphere, previous literature has not fully explored how it simultaneously influences research collaboration and funding, particularly in developing regions. This study addresses this gap by hypothesizing that a

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

positive research atmosphere directly influences research collaboration (H1) and research funding (H2). Investigating these relationships provides insights that can help academic institutions develop strategies to enhance research productivity and create institutional policies that support faculty research performance.

2.2. Research Atmosphere

Research collaboration has long been regarded as a key driver of academic productivity because partnerships—whether institutional, national, or international—enhance both research quality and quantity [29]. Collaborative research allows scholars to pool resources, exchange expertise, and adopt new methodologies, which in turn strengthens research competence and output [30]. Furthermore, collaborative teams often achieve higher publication rates because they can divide tasks efficiently and tackle complex research questions [10,31].

Prior studies highlight that collaboration enhances research competence by fostering knowledge-sharing environments. For instance, co-authorship promotes knowledge transfer, enabling researchers to refine their methodological skills and gain access to advanced techniques [32]. This is particularly beneficial for early-career researchers, as it allows them to learn from experienced scholars and expand their research networks [33,34]. However, despite the clear benefits, existing research has not sufficiently examined the impact of different types of collaborations (e.g., cross-disciplinary vs. international partnerships) on research competence and output in developing countries like Indonesia.

To address this research gap, this study hypothesizes that research collaboration positively affects research competence (H3) and research output (H4). Understanding these relationships is crucial for shaping policies that promote productive collaborations, ultimately enhancing academic impact and global competitiveness.

2.3. Research Funding

Research funding plays a critical role in academic performance because financial resources enable researchers to pursue ambitious projects, utilize advanced technologies, and expand their research scope [35]. Theoretical models suggest that access to financial resources strengthens research competence because it allows scholars to attend conferences, engage in professional development, and participate in international collaborations [21]. Furthermore, funding is directly linked to research output because well-supported researchers are more likely to publish high-quality papers and secure [36].

In Indonesia, equitable distribution of research funding is crucial because it helps reduce disparities between urban and rural universities, ensuring that all faculty members have access to resources that drive academic excellence. Previous studies confirm that public grants significantly increase the quantity and impact of scientific output, as reflected in higher publication rates and citation counts [21,36,37]. However, funding disparities persist because financial resources are often concentrated in elite universities, limiting opportunities for faculty in less-established institutions [18,19].

Given these disparities, this study hypothesizes that research funding positively affects research competence (H5) and research output (H6). By investigating these relationships, the study aims to provide data-driven insights for optimizing funding allocation strategies, particularly in developing academic environments.

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2.4. Research Competence

Research competence refers to the technical and cognitive skills required to conduct high-quality research [38]. These skills include statistical analysis, research design, and data interpretation, all of which contribute to higher academic performance [39]. Studies consistently link higher research competence to better academic outcomes, including higher publication rates and greater citation impact [40].

Prior research suggests that competence is particularly vital for early-career academics, as their methodological expertise directly influences research quality [41,42]. Additionally, faculty members with strong research competence are more likely to secure research funding, because their proposals demonstrate methodological rigor and innovation. However, in Indonesia, limited access to research training and development programs constrains faculty members from fully developing these skills, reducing overall research productivity.

Despite its importance, previous studies have not fully explored how different types of competence (e.g., technical vs. cognitive skills) affect research performance. This study hypothesizes that research competence positively influences research performance (H7). By examining this relationship, universities can develop professional development programs that enhance faculty research skills, ultimately strengthening institutional research capacity.

2.5. Research Output

Research output is a key indicator of academic performance because it includes journal publications, conference proceedings, books, and patents [43,44]. A high level of research output enhances the visibility of individual researchers and the reputation of their institutions [45,46]. Furthermore, the impact factor of journals where research is published significantly influences academic recognition and visibility [47].

In Indonesia, research output remains limited due to inadequate research infrastructure and weak institutional support systems, affecting the academic visibility and global rankings of universities. Although prior studies establish research output as a crucial determinant of research performance, there is a need to explore how variations in output affect career advancement and institutional reputation.

This study hypothesizes that increased research output positively affects research performance (H8). Understanding this relationship provides insights for academic policies aimed at increasing faculty productivity, ensuring that universities enhance their research contributions at both national and international levels.

2.6. Research Performance and Model Specification

Research performance is a multifaceted construct that includes publication rates, citation impact, and recognition within the academic community [48]. It is shaped by individual competence, institutional support, and funding accessibility [1,2].

Although prior research explores various aspects of research performance, few studies integrate multiple influencing factors into a single framework. This study develops a comprehensive model (**Figure 1**) to predict research performance based on atmosphere, collaboration, funding, competence, and output.

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

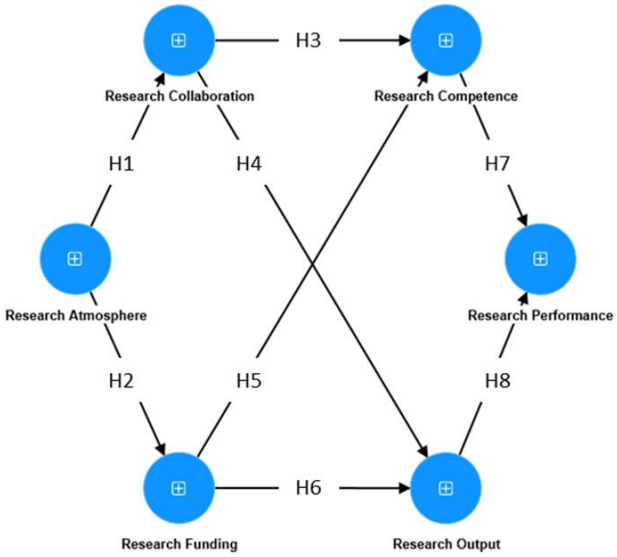

Figure 1. Model Specification.

3. METHODS

3.1. Research Design

This study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the relationships between research atmosphere, collaboration, funding, competence, output, and research performance. PLS-SEM was selected due to its capability to handle complex models and test hypothesized relationships between latent and observed variables. It is particularly suitable for studies with small to medium sample sizes and effectively manages multiple interrelated factors. Additionally, its flexibility regarding distribution assumptions made it an appropriate tool for investigating the factors influencing research performance among public university lecturers in Indonesia.

3.2. Research Instrument

The research instrument was developed based on a comprehensive literature review of previous studies [49,50] and expert discussions. Focus Group Discussions (FGDs) were conducted with two professors specializing in education management and other field experts to tailor the constructs to the Indonesian academic context. The study focused on six primary constructs: Research Atmosphere, Research Collaboration, Research Funding, Research Competence, Research Output, and Research Performance.

To ensure the instrument's validity and reliability, a linguistics professor reviewed and refined the construct indicators, particularly for Research Competence and Research Collaboration. A pilot study involving 30 respondents was conducted to further refine the questionnaire. Reliability analysis, performed using SPSS 23, yielded a Cronbach's Alpha value of 0.819, indicating strong internal consistency. The *R*-values ranged from 0.335 to 0.433, exceeding the critical *R*-table value of 0.296, confirming the instrument's reliability [51]. Furthermore, a factor loading analysis was conducted using SmartPLS 4.0 [52] to verify that each indicator reliably measured its respective construct. Detailed information regarding the use of SPSS is described elsewhere [53].

3.3. Data Collection Procedure

Data were collected through an online questionnaire distributed via Google Forms, with ethical clearance obtained through research administration institutes (LPPM) at the

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p- ISSN 2776-6098 e- ISSN 2776-5938

participating universities. This method was chosen for its efficiency and ability to maintain respondent anonymity. The study targeted faculty members from public universities who had a Scopus h-index of at least two, ensuring that participants were active and experienced researchers. Purposive sampling was employed to select researchers with relevant experience.

Following structural equation modeling (SEM) guidelines for 12 paths, a minimum sample size of 120 respondents was required. A total of 250 responses were collected, providing robust statistical power for PLS-SEM analysis.

Table 1 presents the demographic breakdown of respondents. Of the participants, 44% were male and 56% were female. The majority specialized in social sciences (57%), while 43% belonged to the hard sciences. More than half (54%) had 5 to 10 years of work experience, and the majority (78%) were based in Java. Additionally, 67% of respondents published at least two Scopus-indexed papers per year.

Table 1. Demographic Information of Respondents.

Category		Number	Percentage (%)
Gender	Male	110	44
	Female	140	56
Discipline	Hard Sciences	108	43
	Social Sciences	142	57
Years of Work Experience	1-4 years	30	12
	5-10 years	135	54
	>10 years	85	34
Location	Java	195	78
	Other regions	55	22
Number of Scopus-Indexed Publications (yearly)	1 publication	82	33
	2 publications	168	67

3.4. Data Analysis Procedure

The data analysis followed a stepwise approach, beginning with the assessment of the measurement model and progressing to the structural model. This involved evaluating indicator loadings, internal consistency reliability, and convergent validity. Discriminant validity was also assessed to ensure distinct constructs.

For structural model analysis, multicollinearity, path coefficients, the coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2) were examined. Additionally, an Important-Performance Matrix Analysis (IPMA) was conducted to identify the constructs with the most significant influence on research performance. These analytical procedures, supported by PLS-SEM, provided valuable insights into the determinants of research performance at Indonesian public universities.

4. RESULTS AND DISCUSSION

This section presents the findings from the data analysis, including assessments of both the measurement model and structural model. The reliability and validity of the constructs were evaluated first, followed by the structural model analysis. This included tests for multicollinearity, path analysis for hypothesis testing, an examination of the model's predictive accuracy, the effect of sizes, and an Importance-Performance Matrix Analysis (IPMA). These findings provide insights into the factors influencing research performance

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p- ISSN 2776-6098 e- ISSN 2776-5938

among university faculty in Indonesia, focusing on the roles of research atmosphere, collaboration, funding, competence, and output.

4.1. Publication trend

Before understanding the strategies for improving publication in Indonesia, **Figure 2** shows an analysis of publication numbers in Indonesia. The number of research documents has shown a steady and exponential increase from 2004 to 2024. The total number of documents has reached 249,202, with the most significant growth occurring in the last decade. The data reveal a rapid surge in research output, particularly from 2016 onward, where the number of published documents increased significantly each year. In 2024, the highest recorded output stands at 41,846 documents, showing a continuous upward trajectory from 36,247 in 2023 and 31,174 in 2022. This sharp increase suggests that research activity has intensified in recent years, likely due to improved institutional support, funding opportunities, and digital accessibility to publication platforms. However, a slight stagnation is observed around 2020-2021, which may correspond to disruptions caused by the global pandemic, affecting research productivity temporarily. Despite this, the overall trend indicates sustained growth in research performance, emphasizing the increasing role of academic publications in higher education. However, Indonesia is still struggling to improve a number of publication documents, compared to other countries in the world.

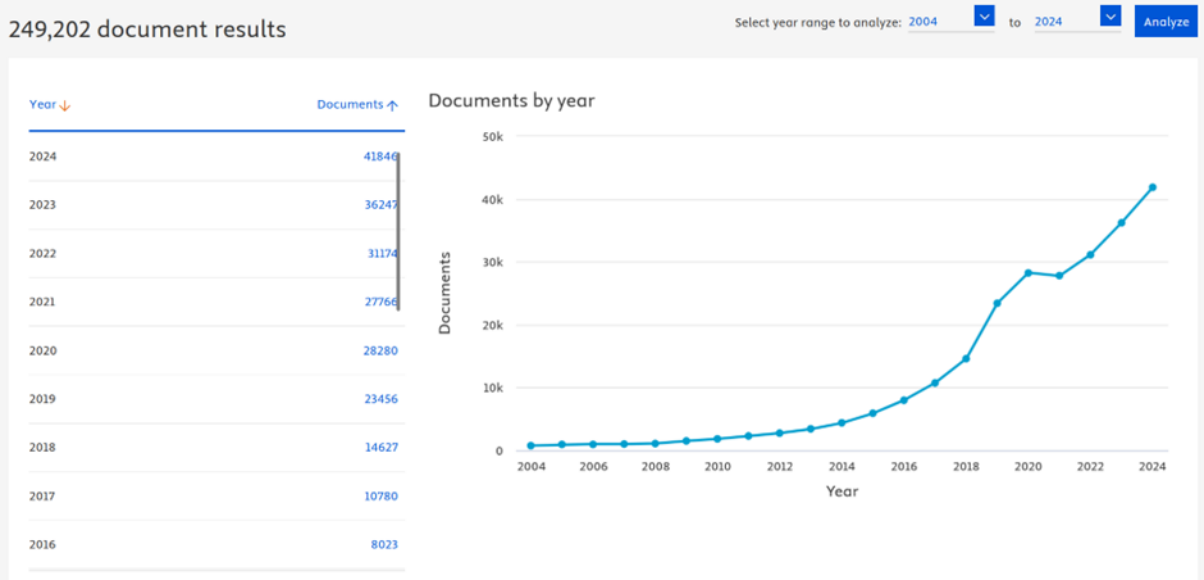

Figure 2. The trend of Research Document Publications (2004–2024) based on the Scopus database, selecting country "Indonesia", limited access only for "article" and "review", as well as taken and updated data on 3 March 2025.

4.2. Measurement Model Assessment

To evaluate the reflective measurement model, the indicator loadings, internal consistency reliability, and convergent validity were analyzed (**Table 2**). Most indicator loadings exceeded the recommended threshold of 0.70, confirming adequate indicator reliability [54]. Specifically, items under Research Atmosphere (RA), Research Competence (RC), Research Funding (RF), and Research Output (RO) demonstrated loadings ranging from 0.713 to 0.891, indicating strong factor loadings. However, in Research Collaboration (RCL), item RCL_4 had a loading of 0.639, and in Research Performance (RP), items RP_1 and RP_3 had loadings of 0.672 and 0.651, respectively. These values were slightly below the threshold. Despite this,

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p- ISSN 2776-6098 e- ISSN 2776-5938

these items were retained because their removal did not significantly improve the overall model fit, ensuring theoretical comprehensiveness.

Table 2. Indicator Loadings, Internal Consistency Reliability, and Convergent Validity

Construct	Outer Loadings	α	CR	AVE
RA_1	0.847	0.803	0.804	0.63
RA_2	0.817			
RA_4	0.790			
RA_5	0.713			
RCL_1	0.811	0.757	0.77	0.583
RCL_2	0.724			
RCL_4	0.639			
RCL_5	0.861			
RC_1	0.814	0.742	0.747	0.658
RC_2	0.804			
RC_3	0.816			
RF_1	0.845	0.882	0.885	0.739
RF_3	0.862			
RF_4	0.891			
RF_5	0.839			
RO_2	0.736	0.800	0.800	0.628
RO_3	0.728			
RO_4	0.819			
RO_5	0.878			
RP_1	0.672	0.872	0.877	0.57
RP_2	0.744			
RP_3	0.651			
RP_5	0.737			
RP_6	0.778			
RP_7	0.819			
RP_8	0.859			

Note: RA = Research Atmosphere; RCL = Research Collaboration; RC = Research Competence; RF = Research Funding; RO = Research Output; and RP = Research Performance

Internal consistency reliability was assessed using Cronbach's alpha (α) and composite reliability (CR). All constructs met the recommended threshold of 0.70, confirming acceptable reliability because the α values ranged from 0.742 (RC) to 0.882 (RF), and the CR values ranged from 0.747 to 0.885, demonstrating strong internal consistency. Convergent validity was confirmed because the average variance extracted (AVE) values exceeded the 0.50 threshold, ranging from 0.57 (RP) to 0.739 (RF). These results indicate that the constructs adequately explain variance in their respective indicators.

To confirm discriminant validity, the Heterotrait-Monotrait (HTMT) ratio was examined (**Table 3**). This ratio ensures that constructs are distinct, with recommended thresholds of below 0.85 for conceptually distinct constructs and below 0.90 for conceptually similar constructs [55]. Because all HTMT values ranged from 0.186 to 0.812, they were within acceptable limits, supporting the distinctiveness of the constructs. The highest HTMT value (0.812) was found between RA and RCL, indicating conceptual relatedness but maintaining distinctiveness.

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

Table 3. Heterotrait-Monotrait Ratio (HTMT).

	RA	RCL	RC	RF	RO	RP
RA						
RCL	0.812					
RC	0.707	0.783				
RF	0.509	0.485	0.222			
RO	0.365	0.34	0.186	0.423		
RP	0.468	0.525	0.625	0.392	0.448	

Note: RA = Research Atmosphere; RCL = Research Collaboration; RC = Research Competence; RF = Research Funding; RO = Research Output; and RP = Research Performance

4.3. Structural Model Assessment

Before evaluating the structural model, multicollinearity was assessed using the Variance Inflation Factor (VIF) (see **Table 4**). A VIF value below 3 indicates that multicollinearity is not a concern because it ensures that predictor variables are sufficiently independent [56]. Because all VIF values ranged from 1.000 to 1.206, no multicollinearity issues were detected, confirming the reliability of the structural model.

Table 4. Variance Inflation Factor (VIF).

	RA	RCL	RC	RF	RO	RP
RA		1.000		1.000		
RCL			1.206		1.206	
RC						1.004
RF			1.206		1.206	
RO						1.004
RP						

Note: RA = Research Atmosphere; RCL = Research Collaboration; RC = Research Competence; RF = Research Funding; RO = Research Output; and RP = Research Performance

Subsequently, the proposed relationships between constructs were tested through path coefficients and their significance levels, as depicted in **Figure 3** and **Table 5**. A t-statistic greater than 1.96 indicates statistical significance.

Because the path coefficient for Hypothesis 1 (H1) was $\beta = 0.655$, $t = 10.943$, $p < 0.001$, it was supported. This suggests that a conducive research atmosphere enhances collaboration among faculty members. Similarly, Hypothesis 2 (H2) was supported because the path coefficient was $\beta = 0.434$, $t = 5.020$, $p < 0.001$, indicating that a supportive research environment increases access to funding opportunities.

The structural model was tested using path analysis, evaluating path coefficients (β), t-statistics, and p-values to determine the significance of hypothesized relationships (**Table 5**). A t-statistic greater than 1.96 indicated statistical significance because it confirmed the robustness of the relationship.

Furthermore, Hypothesis 3 (H3), which examined the effect of Research Collaboration (RCL) on Research Competence (RC), was supported because the path coefficient was β = 0.640, t = 8.996, p < 0.001. This finding indicates that collaborative research activities among faculty members enhance their research skills and competencies. However, Hypothesis 4 (H4), which posited a positive relationship between Research Collaboration (RCL) and Research Output (RO), was not supported because the path coefficient was β = 0.140, t =

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p- ISSN 2776-6098 e- ISSN 2776-5938

1.078, p = 0.281, which is not statistically significant. This result suggests that increased collaboration does not directly translate into higher research output in this study's context.

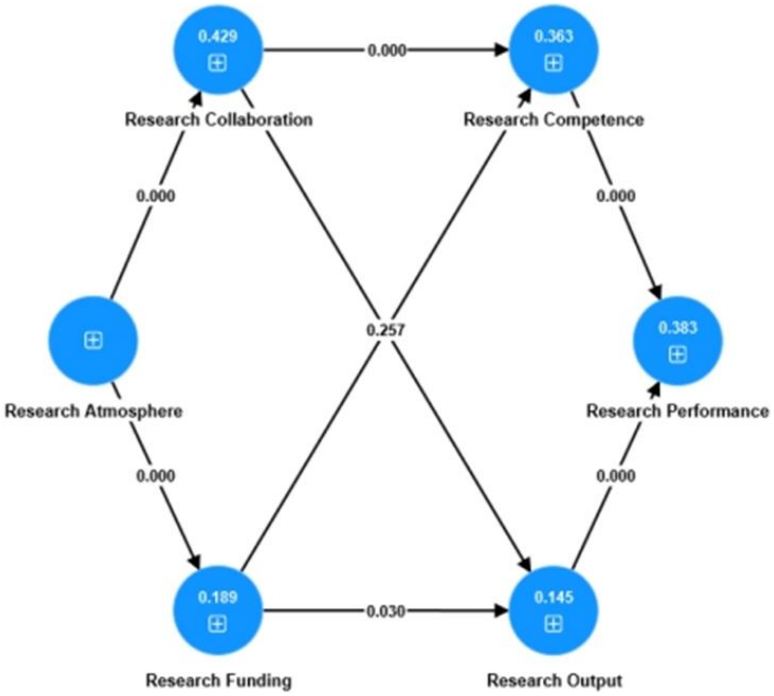

Figure 3. Final Structural Model.

Table 5. Path Coefficients and Hypothesis Testing Results.

	Path	β	Mean	SD	T Statistics	P Values	Significance
H1	RA -> RCL	0.655	0.670	0.060	10.943	0.000	Supported
H2	RA -> RF	0.434	0.446	0.086	5.020	0.000	Supported
H3	RCL -> RC	0.640	0.652	0.071	8.996	0.000	Supported
H4	RCL -> RO	0.140	0.145	0.130	1.078	0.281	Rejected
H5	RF -> RC	-0.111	-0.114	0.098	1.134	0.257	Rejected
H6	RF -> RO	0.301	0.315	0.139	2.170	0.030	Supported
H7	RC -> RP	0.489	0.491	0.083	5.910	0.000	Supported
H8	RO -> RP	0.350	0.361	0.100	3.485	0.000	Supported

Note: RA = Research Atmosphere; RCL = Research Collaboration; RC = Research Competence; RF = Research Funding; RO = Research Output; and RP = Research Performance

These findings highlight the crucial role of a conducive research atmosphere, funding availability, and collaboration in enhancing research competence. However, collaboration alone does not necessarily lead to higher research output, suggesting that additional factors such as institutional support, publication opportunities, and research incentives may influence research productivity.

Hypothesis 1 (H1) was supported because the path coefficient for Research Atmosphere (RA) positively influencing Research Collaboration (RCL) was β = 0.655, t = 10.943, p < 0.001, indicating that a conducive research atmosphere fosters collaboration among faculty members.

Similarly, Hypothesis 2 (H2) was supported because RA positively affected Research Funding (RF) (β = 0.434, t = 5.020, p < 0.001), confirming that a supportive research environment increases access to funding opportunities.

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Hypothesis 3 (H3) proposed that RCL positively influences Research Competence (RC). The results supported this hypothesis because the path coefficient was β = 0.640, t = 8.996, p < 0.001, demonstrating that collaborative research activities enhance faculty research skills and competencies.

Conversely, Hypothesis 4 (H4) was not supported because the path coefficient for RCL to Research Output (RO) was β = 0.140, t = 1.078, p = 0.281, suggesting that increased collaboration does not directly translate into higher research output.

Hypothesis 5 (H5) was not supported because the path coefficient for RF to RC was β = –0.111, t = 1.134, p = 0.257, indicating that availability of research funding does not necessarily improve research competence.

In contrast, Hypothesis 6 (H6) was supported because the path coefficient for RF to RO was β = 0.301, t = 2.170, p = 0.030, demonstrating that sufficient funding leads to increased research output.

Hypothesis 7 (H7) was supported because the path coefficient for RC to Research Performance (RP) was β = 0.489, t = 5.910, p < 0.001, confirming that higher research competence significantly enhances faculty research performance.

Lastly, Hypothesis 8 (H8) was supported because the path coefficient for RO to RP was β = 0.350, t = 3.485, p < 0.001, indicating that higher research output positively impacts overall research performance.

The coefficient of determination (R^2) was calculated for each endogenous construct to assess the model's predictive power (see **Table 6**). Because R^2 values of 0.75, 0.50, and 0.25 indicate substantial, moderate, and weak predictive power, respectively, these findings suggest that the model explains a reasonable proportion of variance in key constructs.

Table 6. Coefficient of Determination (R^2).

Construct	R Square	R Square Adjusted	Consideration
Research Collaboration (RCL)	0.429	0.422	Moderate
Research Competence (RC)	0.363	0.346	Moderate
Research Funding (RF)	0.189	0.178	Modest
Research Output (RO)	0.145	0.122	Modest
Research Performance (RP)	0.383	0.367	Moderate

The R^2 values for RCL (0.429) and RC (0.363) were moderate, indicating that RA and RCL moderately explained research collaboration and competence. Meanwhile, RF (0.189) and RO (0.145) had lower R^2 values, suggesting that external factors beyond those examined in this study may also influence these constructs. RP had an R^2 of 0.383, reflecting a moderate level of predictive power for research performance.

Effect sizes (f^2) were calculated to determine the impact of predictor variables on dependent variables (see **Table 7**). Because f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effect sizes, respectively, this analysis provides insights into the relative importance of various relationships [55-56].

Large effect sizes were observed for the paths from RA to RCL (f^2 = 0.751), RCL to RC (f^2 = 0.532), and RC to RP (f^2 = 0.386). This suggests that research atmosphere and collaboration play critical roles in shaping research competence and overall performance.

Conversely, very small effects were found for RF to RC (f^2 = 0.016) and RCL to RO (f^2 = 0.019), indicating that funding does not strongly impact research competence, and collaboration alone does not significantly drive research output.

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

Table 7. Effect Size (f^2).

Path	f^2	Effect size
Research Atmosphere -> Research Collaboration	0.751	Large
Research Atmosphere -> Research Funding	0.232	Medium
Research Collaboration -> Research Competence	0.532	Large
Research Collaboration -> Research Output	0.019	Very Small
Research Competence -> Research Performance	0.386	Large
Research Funding -> Research Competence	0.016	Very Small
Research Funding -> Research Output	0.088	Small
Research Output -> Research Performance	0.197	Medium

4.4. Importance-Performance Matrix Analysis (IPMA)

An Importance-Performance Matrix Analysis (IPMA) was conducted to identify the most influential constructs for research performance (**Figure 4** and **Table 8**). Because IPMA highlights both importance and performance, these results provide valuable insights into prioritizing improvements in research success [24].

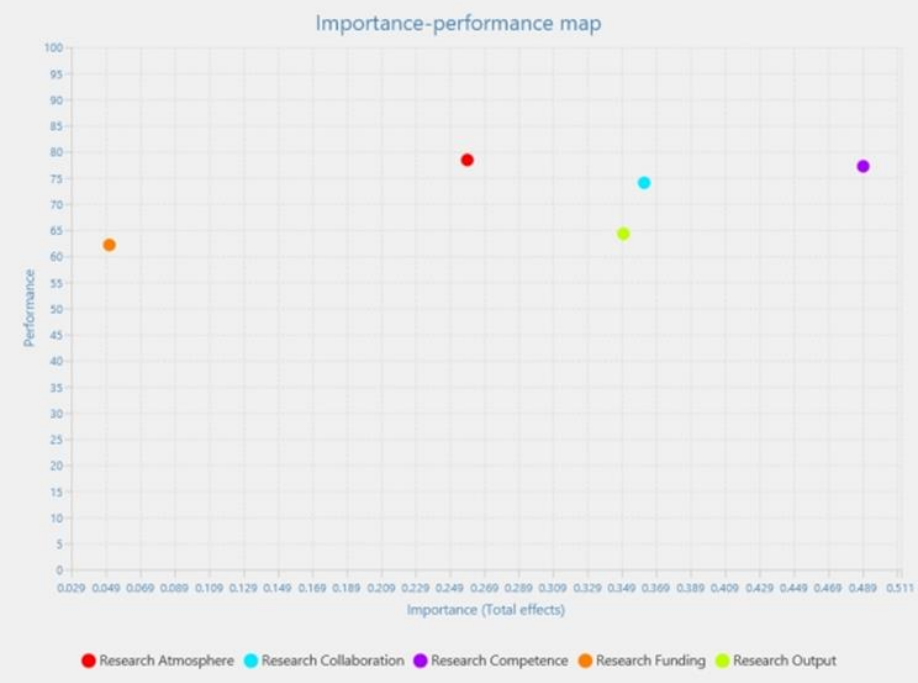

Figure 4. IPMA Map

Table 8. IPMA Results

Construct	Importance	Performance
Research Atmosphere	0.259	78.395
Research Collaboration	0.362	74.030
Research Competence	0.489	77.191
Research Funding	0.051	62.145
Research Output	0.350	64.289

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

The findings showed that Research Competence (RC) had the highest importance score (0.489) and relatively high performance (77.191), suggesting that faculty members perceive research competence as a crucial contributor to their success and that it is relatively well-developed.

Research Output (RO), while important (0.350), had lower performance (64.289), indicating that efforts to increase tangible research outputs could significantly enhance research performance. Research Collaboration (RCL) was important (0.362) but had moderate performance (74.030), suggesting room for further improvement in collaborative activities.

Conversely, Research Funding (RF) had the lowest importance (0.051) and performance (62.145). This suggests that while financial resources are necessary, they may not be the most critical driver of research success in this context.

These findings suggest that increasing research output and strengthening collaboration could yield significant improvements in faculty research performance. Additionally, maintaining high levels of research competence is essential because of its strong influence on research success. These insights provide valuable guidance for university administrators and policymakers in Indonesia to strategically allocate resources and implement initiatives that enhance collaboration and research productivity.

4.5. Discussion

This study explored the relationships between research atmosphere, collaboration, funding, competence, output, and research performance among university faculty in Indonesia. The findings confirmed several key hypotheses, revealing significant pathways that contribute to enhanced research performance. A supportive research atmosphere positively influenced research collaboration and funding opportunities, which in turn impacted research competence and output, ultimately leading to improved research performance. These results highlight the importance of institutional support for collaborative efforts and output-focused initiatives because strengthening these factors can significantly enhance research productivity in universities [57-58].

The strong positive relationship between research atmosphere and research collaboration ($\beta = 0.655$; $t = 10.943$; $p < 0.001$) suggests that a conducive research environment encourages faculty members to engage more actively with peers. This is because a supportive atmosphere fosters open communication, resource sharing, and teamwork, which are essential for successful collaborations [59-60]. Universities that prioritize research support systems and provide adequate institutional resources make it easier for faculty members to form research partnerships and tackle complex projects [61-63]. Similarly, the positive effect of research atmosphere on research funding ($\beta = 0.434$; $t = 5.020$; $p < 0.001$) indicates that a well-supported research environment improves access to funding opportunities because faculty members receive better guidance on grant applications and funding sources. Institutions that invest in administrative support and grant-writing training help faculty secure financial resources for their research, reinforcing the critical role of institutional investment in research infrastructure [64].

The positive relationship between research collaboration and research competence ($\beta = 0.640$; $t = 8.996$; $p < 0.001$) underscores the importance of teamwork in enhancing faculty skills. This is because collaborative projects expose researchers to diverse methodologies and interdisciplinary perspectives, helping them develop their expertise [65-66]. These interactions are particularly valuable for early-career researchers, who benefit from mentorship and exposure to advanced research practices [2,14]. However, the non-significant link between research collaboration and research output ($\beta = 0.140$; $t = 1.078$; $p = 0.281$)

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

suggests that while collaboration fosters competence, it does not always lead to higher productivity. This may be because coordination issues, conflicting priorities, and time constraints limit the effectiveness of collaborative research projects [15-16]. Effective project management and structured communication are necessary to ensure that collaborations result in tangible academic contributions [16].

The relationship between research funding and research competence was not significant ($\beta = -0.111$; $t = 1.134$; $p = 0.257$), suggesting that financial resources alone do not necessarily enhance faculty members' research skills. This may be because funding is often allocated to operational expenses rather than professional development initiatives [17]. However, the positive relationship between research funding and research output ($\beta = 0.301$; $t = 2.170$; $p = 0.030$) highlights the importance of financial support in facilitating research productivity because funding allows researchers to acquire necessary equipment, hire assistants, and conduct fieldwork [2,67,68]. These findings suggest that while funding significantly boosts research output, institutions must also invest in faculty development programs to enhance research competence and long-term academic success.

Both research competence and research output significantly influenced research performance (competence: $\beta = 0.489$; $t = 5.910$; $p < 0.001$; output: $\beta = 0.350$; $t = 3.485$; $p < 0.001$). Faculty members with strong research skills and high research output tend to achieve better performance because competence enables them to conduct rigorous studies, while higher research output improves their academic reputation [69-70]. Increased publication rates and patents also enhance the prestige of universities, further motivating faculty members to increase their research productivity [71,72]. Because of this, institutions should prioritize faculty training programs and research incentives to maximize research performance [73].

The Importance-Performance Matrix Analysis (IPMA) revealed that while research competence had the highest importance and strong performance, research output and collaboration, though important, had lower performance scores (see **Figure 4** and **Table 8**). This suggests that faculty members recognize the importance of output and collaboration but face challenges in improving these areas. One possible reason is that limited access to high-impact journals and difficulties in the publication process hinder higher research output [74,75]. Additionally, research collaboration may be constrained by limited institutional support for interdisciplinary teamwork, affecting its overall effectiveness [47].

Addressing these barriers in research output and collaboration is crucial because faculty members require institutional support to improve their research contributions. Universities should offer training on the publication process, establish partnerships with reputable journals, and provide incentives for high-quality research output [76,77]. Strengthening institutional collaboration programs and funding interdisciplinary research initiatives can further improve faculty research engagement and productivity.

4.6. Implications and Future Research

To enhance research performance, universities should prioritize creating a supportive research atmosphere, which improves collaboration and funding access. Policies that encourage interdisciplinary projects, mentorship programs, and simplified funding application processes could be highly beneficial. Additionally, investing in faculty development programs, research training, and writing workshops may help increase research competence and output, leading to improved overall performance.

A limitation of this study is its focus on Indonesian universities, which may restrict the generalizability of the findings to other academic contexts. Future research should examine

DOI: https://doi.org/10.17509/ajse.v5i1.81224
p- ISSN 2776-6098 e- ISSN 2776-5938

similar relationships in different regions to validate these results. Additionally, longitudinal studies could provide insights into how these factors evolve and their long-term impact on faculty research performance.

5. CONCLUSION

This study examined the relationships between research atmosphere, collaboration, funding, competence, output, and performance among university faculty in Indonesia. The findings demonstrated that a supportive research environment plays a crucial role in enhancing both research collaboration and access to funding, which subsequently contribute to higher research competence and output. However, research collaboration did not directly lead to increased research output, indicating that collaboration alone is not sufficient to enhance productivity. Instead, research competence and research output were the strongest predictors of research performance, emphasizing the importance of skill development and tangible research contributions in academic success.

These findings have important implications for universities and policymakers seeking to improve research productivity. Institutions should focus on fostering a supportive research atmosphere, as it serves as the foundation for collaboration and funding accessibility. Additionally, breaking down barriers to cross-disciplinary collaboration and improving project management skills can help researchers translate partnerships into tangible research outcomes. Providing training programs and mentorship opportunities will enhance faculty research competence, ensuring that they can effectively conduct and publish high-quality research.

Securing research funding remains a critical factor in academic productivity. Universities should support faculty in grant applications, streamline administrative processes, and allocate resources equitably to ensure that funding opportunities are accessible to a broader range of researchers. Reducing bureaucratic obstacles will enable faculty members to focus more on their research rather than administrative burdens.

This study contributes to the broader understanding of how research environments influence academic productivity, particularly in developing countries. Future research should explore these dynamics in different academic contexts, including universities in emerging economies. Longitudinal studies could provide deeper insights into how research atmosphere, collaboration, and funding impact performance over time. Additionally, further research should investigate barriers to collaborative productivity and examine factors such as technological support and administrative workload, which may also play a role in shaping research success.

6. ACKNOWLEDGMENT

We would like to express our deepest gratitude to The Ministry of Education, Culture, Research, and Technology of Indonesia for their funding through Penelitian Fundamental scheme with contract number T/105.1.25 /UN34.9/PT.01.03/2024. Our sincere thanks also go to the esteemed professors from Universitas Negeri Yogyakarta who lent their expertise to validate the scale used in this study. Lastly, we extend our heartfelt appreciation to the Indonesian lecturers who participated as respondents in this study.

7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

DOI: https://doi.org/10.17509/ajse.v5i1.81224
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